

CHAPTER 1

Introduction

Airport passenger terminal operations have several problems frequently observed in many airports. What are some of the common problems of terminal operations? Based on growth and development, increases in the number of passengers' and aircraft movements, airport terminal operations have had to adjust many of their procedures and implement different services for passengers, especially when they are being processed at airport terminals (Sorenson, 2015; Tošić, 1992). Problems that are commonly observed inside airport terminal buildings as a result of these increases in passenger's numbers are found in the terminals' check-in process, security procedures, and passenger walking distances, gates, and baggage claim (Hsu et al. 2012; Tošić, 1992).

The purpose of this research is to identify the specific problems that impact airport terminal operations. It also seeks to explore the impacts that these problems have on specific aspects of passenger terminal operations. The question guiding this research is: What factors impact airport passenger terminal operations? Numerous factors can be considered problematic in affecting airport terminal operations. There are some problems which are consistently shown to cause the most concern and pose the most difficulty for airport passenger terminal operations. Since operating passenger flight is the airports' essential duty, defining and investigating the problems that affect flight operations and finding adequate solutions for these problems is fundamental for improving airport terminal operations.

Exploring this research question, this research is organized as follows. Following chapter one of introduction, in the second chapter, the literature review presents a background of the related aspects that involve in the problems of airport terminal operations. Through the different

sources used in this research paper, an introduction can be provided for each discussed problems clarifying what are the areas where problems of airport passenger terminal operations can be observed. In the third chapter, the common problems of airport terminal operations can be identified and explained. The outcomes and suggestions or recommendations for solving each problem have also been addressed. In the fourth chapter, a case study about examining gate availability issues at Dallas Love Airport has been presented. The case study indicates how limiting airport terminal gates affect passenger terminal operations. The fifth chapter of this research paper is the conclusion. In the last section, a list of different reliable sources has been shown in the reference section.

This research paper can be important for airport operators and airlines since it presents the commonly observed problems of airport terminal operations. Through introducing each of these common problems, airport operators, including the managers or executives, and airline personnel can be more familiarized with these problems and encouraged to find more solutions. This research paper is a well-documented collection of airports terminals' common operational problems, outcomes, and given recommendations from many professional sources. Since many of the world's airports are public organizations, dealing with any of the airport's operational problems means a concern(s) for problems of public administration. In spite of giving all of the factual observations within airport terminal operations, this research paper can raise many questions regarding what can be the main reasons behind existing the common problems of airport terminal operations. This should encourage public administrators to look for the best recommendations through implementing the most suitable organizational theories for airport management as part of the public service management.

CHAPTER 2

Literature Review

Airport Terminal and Terminal Operations

Airport terminals are buildings that contain many essential facilities. According to Price and Forrest (2016), the airport terminal is the airport's main passenger building; it starts from the terminal curbside and extends to the screening checkpoint, including the concourse beyond the screening checkpoint. Through a variety of procedures, airport passenger terminals can provide numerous services for the airlines and their passengers. Graham (2014) reports that terminal services provided by airports include such things as security, customs, and immigration; they may also contain commercial or non-aviation facilities like retail stores, food and beverage areas, places for entertainment, and internet facilities. Price and Forrest (2016) indicate that airport terminals contain facilities for airport passengers and baggage processes, airport maintenance and operational activities, airport and airline administration, and airport cargo handling.

Based on their prominence as the airports' main structure, the terminal buildings often house operations that provide special roles or services to the airlines and their passengers. Price and Forrest (2016) report that the most important role and function of airport passenger terminals involve transferring passengers from ground transportation to air transportation and then vice versa. Moreover, the airport terminal is the area that connects the airfield to the rest of the airport; it is the area that creates a linkage between landside and airside operations (Price and Forrest, 2016).

As the fundamental part of an airport's landside services, terminals can be managed and operated by different parties. Hamzawi (1992) states that airport landside is the area that consists of various zones like apron/gates area, air terminal building(s), ground access area, and vehicle

parking areas. Price and Forrest (2016) report that airport terminal operations can be managed by either the airport operators through the airport-dominant approach, or European model, or by the airlines through the airline-dominant approach. Both of these approaches concentrate on providing staff to supervise terminal services and baggage and passenger handling services. Large airports often use a combination of these models in order to implement service delivery. This means that they use some aspects from each of these two approaches (Price and Forrest 2016).

The consistent increase in the volume of air traffic has impacted airport operations. Perhaps, most importantly has been the recognition on the part of airport operators to engage in more planning and analysis of their airport terminal operations. According to Hamzawi (1992), there are certain times of the day when air traffic peaks or is at its highest and busiest volume. This “daily” phenomenon often results in congestion at the airports' airside and terminal buildings; the arrival of a huge number of passengers may strangle the activities of immigration, customs, security control facilities, and many of the terminal services like baggage handling. Sorenson (2015) suggests that more effective airport terminal operations can be achieved by improving data collection and analysis measures. This means that airport managers can improve their overall performance by increasing their understanding of traffic flows and passenger data which can then be used to influence terminal planning; planners are supposed to focus on the larger perspective of terminals as their essential mission.

Airport Terminal Design

There are different kinds of airport passenger terminal buildings in terms of design and operations. de Neufville and Odoni (2003) show that there are five basic configurations of airport passenger buildings. These five design types are called finger piers, satellites, midfield, Linear,

and transporters. These configurations can be suitably made for major airports by the attempts of designers. Consequently, airport terminal designers use several ways to make different shapes by taking different possibilities into considerations (de Neufville and Odoni, 2003).

The five configurations of terminal buildings offer different shapes and designs to passenger terminals. The Finger pier configuration can be visualized or imagined as fingers attached to the palm of the hand; they are narrow extended areas from the central point of the passenger facility where aircraft can be parked and surrounded on both sides (de Neufville and Odoni, 2003). The Satellites configuration resembles the extension of T-shaped finger piers. In this design the gates are usually located at the end of the fingers (de Neufville and Odoni, 2003). According to de Neufville and Odoni (2003), midfield concourses can be either linear or X-shaped. They often have separate passenger buildings approximately a kilometer long and have around 50 gates. These gates can be accessed by the passengers from the groundside. A linear building is a narrow structure with one side designed for aircraft parking and the other side faces roads and parking lot areas (de Neufville and Odoni, 2003). Transporters can include the busses that transfer passengers from certain terminal gates to the aircrafts that have been parked in the remote stands. These busses have been specially designed for passengers' movement, access, and baggage transfer (de Neufville and Odoni, 2003).

In terms of functions and operational systems, airport passenger terminals can also be classified into different groups. Bandara and Wirasinghe (1992) present two categories of terminals: centralized terminals and semi-centralized terminals. In centralized terminals, passenger services such as ticketing, and baggage claim, and other passenger processing zones are located in the center of the terminal building(s) (Bandara and Wirasinghe, 1992). In the semi-

centralized terminals, passenger processing facilities have been separately distributed according to groups of aircraft gates (Bandara and Wirasinghe, 1992).

There are some factors that have their own impact on the configuration of airport terminals. One common factor is the distances passengers have to walk between flights or to the main terminal building: terminal walking distance. de Neufville and Odoni (2003) describe two matrices that are used by designers to analyze walking distances in the terminals. These two “matrices” are impedance and flow matrices. The impedance matrix is defined as the level of difficulty passenger’s face while transferring between two gates inside the terminal building. This analysis measure basically gives a description about the facility's physical aspects or geometry (de Neufville and Odoni, 2003). On the other hand, the flow matrix delineates the volume of passengers based on information about their origin points and destinations. The flow matrix also identifies and analyzes such issues as the volume at specific gates or other access points in the terminal. This information provides designers, planners, and managers with the necessary data they need to improve operational performance (de Neufville and Odoni, 2003).

Bandara and Wirasinghe (1992) suggest that airport terminal passengers can be categorized according to terminal design or walking distances. In their study they report that there are two main groups of passengers. They divide these categories into those: arriving (terminating) passengers and departing (originating) passengers, and a second category of transferring passengers. The latter group can be sub-divided into hub and non-hub transfer passengers. Other researchers like Bandara and Wirasinghe (1992) define “Arriving passengers” as those passengers who arrive at the terminal by aircraft and move from the arrival gate to the ground transportation area. Normally, this is done after they walk through the baggage claim area and retrieve their luggage. Departing passengers are those who arrive at the terminal from the ground

transportation facility to the departure gate by moving through each of the necessary security checks and check-in counters. In addition, Bandara and Wirasinghe (1992) identify transferring passengers as those who move from one aircraft to another without leaving the airport terminal.

Additionally, some researchers continue their analysis of airport terminals by examining the flow or process of passengers walking through airport terminals. In these analyses, transferring passengers are divided into hub transfers and non-hub transfers (Bandara and Wirasinghe, 1992). Hub transfers are the passengers who move directly from the arrival gate to the departure gate. These passengers can be pre-ticketed if their boarding passes have been issued before starting their connected flight, or they can be processed from the departure gate, after moving through a short connecting time (Bandara and Wirasinghe, 1992).

Federal Funding for Airport Terminals Development

The Federal Government is the main sponsor for funding airports including the costs associated with the development of airport terminals. According to the FAA Advisory Circular (1988), as the successor to the Airport and Airway Development Act of 1970, the 1982 Act (P.L. 97-248) financially supports United States' airports and airway systems for necessary improvements. Through the Airport Improvement Program (AIP) of the 1982 Act, section 513, eligible public-use airports are provided with federal funds for airport terminal developments (FAA Advisory Circular, 1988). The development of airports' different structures may be given by Federal financial assistance according to their eligibility. The FAA Advisory Circular (1988) indicates that Federal grant-in-aid monies may be provided for developing different airport facilities such as airports' different facilities like airport surface access, multimodal terminals, and other terminal areas. This grant-in-aid program also covers many AIP eligible projects

related to the movements of passengers and baggage through the use of the Passenger Facility Charge (PFC) programs.

The U.S. Federal government has its own requirements for considering certain airports eligible or ineligible to receive funds for their terminal development costs. According to the FAA Advisory Circular (1988), in reference to dealing with prorating terminal building development, the determination of eligibility for federal share is made by the Federal Aviation Administration (FAA). Based on engineering justifications and by reviewing the devoted areas of passenger flows and baggage, the FAA makes its determinations about terminal development funds. Other related procedures required for making these decisions are discussed in the FAA Airports office FAA Advisory Circular (1988).

Airport Passenger Terminal Check-in

Throughout the check-in system of airport terminals, the passenger check-in process uses both traditional and contemporary forms of check-in counters. According to Wells and Young (2011), the process of passenger check-in has significantly improved in recent years. They maintain that this obvious progress has been achieved by preserving some of the airport's traditional policy and models like ticketing. Wells and Young (2011) define the traditional check-in counters as the specific areas or facilities that are being operated by the air carriers' staff. The usage of passenger check-in counters can be different based on their configurations. Wells and Young (2011) report that check-in counters can be configured for exclusive use or common use. The exclusive use of counters can often be identified according to certain configurations of information systems, computers, and equipment. For example, some check-in counters are provided specifically for one airline. Whereas, common check-in counters are configured to be used by multiple air carriers (Wells and Young, 2011). According to Wells and Young (2011),

common use ticketing facilities are often provided with common-use terminal equipment (CUTE) which is a computer-based system designed for operating systems of any airline that take part in the check-in facility. Bellioti et al. (2010) define the "common use" as the technological approach used by air carriers to process passengers at the check-in counter area, self-service check in counters, or at the gates.

In addition, airport terminal check-in facilities may vary according to an airline's operations and available services. Hsu et al. (2012) indicate that check-in passengers basically need to be provided with four types of services: ticket purchase, check-in, boarding pass, and checking baggage. According to Hsu et al. (2012), four standard check-in facilities exist in the operations of air carriers among airport passenger terminals. These are the counter check-in, self-service check-in kiosks, online check-in, and barcode check-in. The counter check-in system seems to be the most all-around or adaptable processing method since it is able to combine all the offered services. The Barcode check-in system is capable of only issuing a barcode boarding pass (Hsu et al., 2012). Other options like the Kiosk systems are automated self-service check-in devices and are not able to offer ticket purchases, while online check-in systems cannot be applicable for checking baggage service (Hsu et al., 2012).

Baggage Handling

With its structure and multiple functions, baggage handling plays a crucial role in processing airport terminal passengers. Wells and Young (2011) state that baggage handling services consist of a number of activities like collection, sorting, and distribution of baggage. Moreover, they maintain that efficient baggage handling can be a prominent element for improving overall passenger satisfaction with the terminals performance. According to Robuste and Daganzo (1992), baggage is collected in the check-in area upon the arrival of departing passengers.

Through the check-in process, passengers' baggage will be weighed, tagged according to final destination, and then transferred via a mechanical conveyer belt to the sorting area.

The process of sorting involves moving baggage through an adaptable electronic system. Through this type of sorting facility, bags will normally be classified according to the flight's destinations (Robuste and Daganzo, 1992). Wells and Young (2011) report that several different types of technology and innovative techniques are involved in sorting and distributing baggage. For example, high-speed conveyer belts can transfer baggage between airport terminals and different flight lines. Often these systems are connected or jointed together with containers that are able to be put on and taken off the aircraft (Wells and Young, 2011). In addition, the distribution of bags can be done using machine-readable tags. This type of computerized baggage sorting equipment has been installed at many airports (Wells and Young, 2011).

These types of systems allow arriving passengers to retrieve their bags at the baggage claim facilities through the carousals. Wells and Young (2011) report that baggage claim facilities are usually located in the related areas of airport ground transportation, like parking lots, shuttle vans, taxi cabs, and car rental counters. Arriving passengers can get their bags from the carousals that have been suitably designed for easy access and designated based on specific flights operated by certain air carriers (Wells and Young, 2011).

Passenger Terminal Gates

Airport terminal gates are the main areas for moving passengers and cargo to and from the aircraft. According to Wells and Young (2011), terminal gates are the places where passengers arrive from or depart to the aircraft. These are also the locations at which the loaded and unloaded cargo is exchanged between terminals and aircrafts. Tošić (1992) defines "gate" as the

term used for an aircraft parking position on the apron and the part of the terminal building devoted to the parked aircraft. Tošić (1992) introduces a module that has been set to identify two types of terminal buildings based on the number of gates. These are single-level and two-level terminals. Single-level terminals have 8 gates with the capability of receiving 1 million passengers per year. Two-level terminals have 16 gates with the capacity of receiving 2 million passengers per year (Tošić, 1992).

Many attempts have been made by different users for achieving different goals and dealing with gate usage problems. Bouras et al. (2014) report that airport owners and airlines have different objectives and consequently many different ways for dealing with the efficient use of airport terminal gates. Airport owners, who represent the government, often attempt to increase the utilization of the available gates by decreasing the number of gate conflicts and minimizing the number of ungated flights and unnecessary delays (Bouras et al., 2014). In addition, many airline owners attempt to minimize the walking distances between the gates in order to maximize customers' satisfaction and minimize the distance between runways and the assigned gates (Bouras et al., 2014).

Many factors may affect the number of the gates used at an airport terminal. According to Wells and Young (2011), the number of commercial gates operated a day depends on a variety of factors. These include the number and type of aircraft scheduled to use a gate, turnaround time or gate occupancy time, and gate-usage agreements. Based on the planning of gate facilities, for each aircraft type, there should be at least one parking position available to accommodate the aircraft (Wells and Young, 2011). Turnaround time, or turn, is defined as the period that an aircraft spends on the ground between the arriving and departing times of a flight (Bielaire and

Kumar, 2013). Gate-usage agreement refers to the agreement(s) that an airline has with airport management for using certain numbers of gates (Wells and Young, 2011).

Airport Security

Through its various procedures, airport security involves all the actions that are taken to protect airports from any criminal actions that affect airport safety. According to Wells and Young (2011), the procedures of airport security have been designed to prevent crimes and react to the criminal acts that affect the travelling public in terms of safety and security. Graham (2014) believes that airport security is involved in preventing illegal acts including terrorist activities. Dealing with airport security, certain criminal acts and activities are specifically identified. These include such things as the hijacking of aircraft, also called air piracy, destroying or afflicting plane(s) with explosives, and terrorist acts, which are defined as organized activities unexpectedly carried out against the public or individuals to gain political goals (Wells and Young, 2011). Acts like assault, theft, vandalization against passengers, aircraft, or airport facilities are also considered criminal activities (Wells and Young, 2011).

Throughout the history of civil aviation, there have always been concerns about airport security. Over the years these concerns have evolved and grown along with incidences of terrorist attacks or crimes committed against airports in the United States and other countries. According to Wells and Young (2011), more than 600 aircraft hijackings and more than 100 aircraft bombings have been recorded in world history in relation to commercial aviation. The world's first catastrophic aircraft hijacking happened in July 1947 where a flight attendant was killed by three Romanians (Wells and Young, 2011).

Severe terrorist actions of hijacking have defined specific eras and resulted in drastic changes in the world's airport security policies and procedures. Wells and Young (2011) report

that the event of 9/11 has been the worst terrorist attack in the history of commercial aviation. In this attack four separate aircrafts were hijacked and exploded by a group of Al-Qaida terrorists in September 11, 2001. According to Graham (2014), following the 9/11 events, many security measures were introduced within airport security operations. Particularly in the United States, airport security became the focus of national concerns as a considerable issue (Graham, 2014). One consequence of the attacks was the signing of the Aviation and Transportation Security Act (ATSA) which provided airport security with fundamental changes (Wells and Young, 2011). In terms of global concerns, in 2002, airport security was adopted by the International Civil Aviation Organization (ICAO) through Aviation Security Plan of Action (Graham, 2014).

The 9/11 attacks have not been the last terrorist acts against aircrafts or airports. Airport passenger terminals, for instance, are still being targeted by terrorist attacks. On March 22, 2016, two explosions struck the Zaventem International Airport's main terminal ('BBC News', 2014). This attack was committed by two terrorists suicide attackers who targeted the airport's check-in area killing 11 people and injuring 81 ('BBC News', 2014). Another explosion on the same day in the same city's metro station was also carried out by the terrorist group of the Islamic State in Iraq and Syria (ISIS). This group declared its responsibility for committing this act ('BBC News', 2014). This recent terrorist attack indicate that the fact that airports are still being widely targeted by terrorists; it obligates airports to always make plans for efficient airport security.

Based on all the possibilities of criminal attacks that threaten the airports and airport terminals, several security activities and procedures have been adopted by all major airports. Graham (2014) introduces some of the activities affiliated with airport security. For example, today there are new security badge systems, baggage reconciliation, armed protection for landside and airside, video supervision, and checks on staff who have access to the restricted

areas. Wells and Young (2011) define some of the common security-related areas at the commercial airport services, such as passenger screening, baggage screening, and biometrics.

Wells and Young (2011) explain that passenger screening facilities are often automated checking processes that can be done through magnetometer or walk-through metal detectors (WTMD), which are able to detect weapons if carried by passengers. These devices are located in the security screening zones where passengers' carry-on bags are inspected through X-ray machines to find prohibited items like firearms, sharp objects, volatile liquids, or plastic or chemical-based trace explosives (Wells and Young, 2011). Further inspections can be conducted for suspected bags or for bags selected randomly through the explosive trace detection (ETD) equipment (Wells and Young, 2011). Other technologies like Biometrics are used to identify and recognize certain human body features like fingerprints, eye retinas and irises, voice and facial patterns, and hand measurements (Wells and Young, 2011). Graham (2014) introduces two types of biometric identification: psychological and behavioral biometrics. Psychological biometrics is used for recognizing fingerprints, retina, or iris patterns; behavioral biometrics is used for investigating aspects of behavior like voice and signature (Graham, 2014).

CHAPTER 3

Recommendations for Addressing Problems of Airport Terminal Operations

Airport terminal operational problems can be observed among various airport services. Tošić (1992) reports that passenger terminal issues are increasingly connected with the tangled airport planning and their solutions are important to airport terminals in terms of expansion and operations. Based on numerous research findings there are several airport terminal operation problems that can be identified. The issues include factors such as the demand for space and services, single service counter-type facilities, waiting areas facilities, baggage processing

facilities, terminal buildings, gate number and utilization, and passenger orientation (Tošić, 1992). Bellioti et al. (2010) specify some specific operational problems within airport passenger terminals regarding check-in counter assignments, gate area assignments, airline back offices, terminal security, and curbside.

The literature review provides us with insight on the numerous factors that that can affect airport passenger terminal operations. Moreover, the literature shows many of the outcomes and reports about many solutions to these problems. In terms of design, de Neufville and Odoni (2003) report that passenger terminal designers may face many problems regarding distributing passengers within the designated terminal areas. Many airports have major financial and operational issues that affect passenger buildings due to selecting improper design and configuration (de Neufville and Odoni, 2003). According to Sorenson (2015), the consistent increases in the number of passengers within the airline industry requires terminal design and its related aspects to be necessarily dealt with along with the subsequent changes. *Table 1* shows the impacts of several factors related to airport passenger terminal design on terminal operations.

Limited government funding for airport terminal planning and design may limit terminal building improvements and operational activities. The FAA Advisory Circular (1988) reports that in addition to considering maintenance and operating costs, the ultimate terminal plan should seriously attempt to meet its functional objectives within acceptable levels of funding. Federal grant funds may not pay for debt services for the bonds that are issued for airport terminal development. There are only few exceptions taken into account by meeting some specific criteria like definition of the airport under the Airport and Airway Improvement Act, the time window of the improvement, after July 1, 1970 and before July 12, 1976, and provision of safety and security equipment by the airport sponsor (FAA Advisory Circular, 1988). As a result, the

Table 1
The Impacts of Terminal Design Problems on Terminal Operations

Problems (Factors)	Outcomes	Solutions	
Terminal Design	Long passenger walking distances	1) Time pressure for arriving, departing, and transfer passengers walking in the terminals. 2) Increasing transfer time.	1) Minimizing the walking distances: a) From terminal check-in area to the gates for departing passengers. b) From arriving gates to baggage claim area for arriving passengers. 2) Minimizing each of the connection time, walking distance, and ungated flights for transfer passengers.
	Narrow passage ways	Passenger congestion inside the terminals; arriving and departing passengers mix to each other	1) Providing additional immigration areas for international arriving passengers. 2) Using the parameters of persons/ meters/ minute (PMM) and deducting the elements of <i>edge effects</i> , <i>counter-flow effect</i> , and <i>obstacles</i> from the geometric width of the terminal passage ways.
	Limited federal funding	Limited passenger terminal improvement	Encouraging the Federal government to increase airport funding through the use of user charges, including the use of Passenger Facilities Charge (PFC).

Source: de Neufville and Odoni, 2003; Kusumaningtyas et al., 2007; Tošić, 1992; Drexl and Nikulin, 2008; Advisory Circular, 1988; NPIAS, 2015).

design of the airport terminal faces many demands, restrictions, and constraints due to limitations of Federal funds (FAA Advisory Circular, 1988).

Many attempts have been made for funding airports and airport terminal improvements. Congress has made many changes to make more financial assistance available to airports like expanding the AIP eligibility for financial assistance. This program uses some sources of

financing, like the Passenger Facility Charges (PFC) (FAA Advisory Circular, 1988). According to de Neufville and Odoni (2003), in addition to existing airport user charges the Passenger Facility Charges program is part of the airport-related taxes that are collected from airport passenger ticket prices under the authorization of the Federal Aviation Administration and used to fund airport improvements. Through its annual report for the fiscal years 2015-2019, the National Plan of Integrated Airport Systems (NPIAS) has reported to Congress about the depiction of desired needs for airport funds by indicating many facts about receiving PFC approval from the FAA. According to NPIAS (2015), PFC funds totaling \$2.9 billion have been received by several development programs like terminal projects at San Francisco International, a terminal project at Salt Lake City International, and an in-line baggage system at Seattle Tacoma International.

Inefficient design of airport passenger buildings can affect passenger flows in airport terminals. de Neufville and Odoni (2003) report that passenger walking distances require designers to look for better configurations since the geometrical measures of distances are mostly wrong and deceptive. Kusumaningtyas et al. (2007) explains that long walking distances can affect arriving, departing, and transfer passengers by pushing them to save time while walking among airport terminals. Any increase in passenger walking distances results in increases in passengers' transferring time which includes Minimum Connected Time (MCT) and passengers' waiting time. This is basically not desired by airlines and airport operators (Kusumaningtyas et al., 2007).

Short walking distances for arriving and departing passengers are preferable. Tošić (1992) indicates that minimizing the walking distances between the check-in areas and the gates for departing passengers and between the arrival gates and baggage claim areas for arriving

passengers, has given significant results and improved passenger walking distances. Drexl and Nikulin (2008) suggest minimizing each of the connection times, walking distances, and ungated flights. This means maximizing gate usage for connected flights and for transfer passengers.

Narrow passage ways is another problem that affects airports' terminal operations. de Neufville and Odoni (2003) illustrate that there will be major confusion between arriving and departing passengers mixed together at a 3 meters wide corridor of a linear terminal building when several aircrafts have landed at the same time. According to de Neufville and Odoni (2003), a convenient passageway width is essential for avoiding passenger congestion inside the terminals. To solve this problem it is recommended that airport designers should provide additional immigration areas for international arriving passengers (de Neufville and Odoni, 2003).

de Neufville and Odoni (2003) make several recommendations for dealing with congestion issues. They suggest the implementation of a parameter. By using this parameter with the number of passengers, unit width, and unit time will be taken into account. More specifically, the units of persons/ meters/ minute (PMM) will be calculated in setting a convenient distance for passageway width. According to de Neufville and Odoni (2003), three elements should be subtracted from the geometric width to achieve an effective width for an airport terminal's passage way. These are edge effects, counter-flow effect, and obstacles. Edge effects refer to the 0.5 m length from each of the passageway walls that a pedestrian needs to get away from. The Counter-flow effect is the 0.5 m space which a pedestrian needs to shy away from the oncoming traffic and obstacles could be video monitors, vending machines, or shopping stands that should be within a space and subtracted from the geometric width of the passageway (de Neufville and Odoni, 2003).

There are also certain problems associated with check-in procedures and check-in counters that could affect airport passenger terminal operations. *Table 2* illustrates the common problems of passenger check-in and their impacts on terminal operations. Hsu et al. (2012) report that several common problems related to the check-in process can cause passengers flight delay. These include limited timeframe for check-in before departure, limited number of available check-in counters, and special facilities for passengers with priority, like first class. Despite all

Table 2		
<i>Passenger check-in problems</i>		
Problems (Factors)	Outcomes	Solutions
Limited check-in time before departure	Flight delay	Airlines should: - Avoid using time for passengers ticketing on the check-in counters - Provide kiosks and make them used by passengers.
Passenger Check-in	Limited number of available check-in counters	Flight delay Airlines or airport operators may: - Reduce dwell times during passenger check-in utilization - Use full-service check-in counters - Install counters that can be used for specific functions like ticketing and or baggage drop off
	Special facilities for priority passengers	Flight delay - Use diversified check-in facilities, or dynamic allocation of check-in facilities
	Temporary congestion due to using kiosks	Flight delay Airlines or airport operators may use diversified check-in facilities, or dynamic allocation of check-in facilities

Source: (Bellioti et al., 2010; Hsu et al., 2012).

the assistance that kiosks can provide, temporary congestions may occur due to gathering

passengers at the check-in area when kiosks embedded to the check-in counters being used by them (Bellioti et al., 2010).

To avoid these types of check-in problems mentioned above among airport terminals, different recommendations and suggestions have been presented through conducting many research studies. According to Bellioti et al. (2010), to achieve an effective performance of the passenger check-in process, airlines can avoid using time for passenger ticketing at the check-in counters; time of using counters for ticketing should be spent before gate utilization. Hsu et al. (2012) suggest that using kiosks, as automated service check-in devices, saves time for passengers and saves space for airport terminals.

Also, making check-in counters more available can be helpful to reduce passengers waiting time and flight delays. Bellioti et al. (2010), recommend that to improve passenger processing, airlines may reduce spending time for ticketing during passenger check-in utilization. Using full-service counters, which means certain counters can be used to accommodate all airlines check-in services, or installing counters that can be used for specific functions like ticketing and or baggage drop off by the airlines can also be helpful to increase availability of check-in counters and time saving (Bellioti et al., 2010).

It has been noted by some researchers that temporary congestion around the terminal check-in area has been one of the factors that causes flight delays. Bellioti et al. (2010) found that placing the kiosks near the check-in area and designing passenger flows behind the kiosks can be one solution for reducing congestion within an airport terminal. Moreover, lining up the kiosks in the terminal lobby without creating que lines may reduce congestion (Bellioti et al., 2010). Hsu et al. (2012) suggest that using diversified check-in facilities or dynamic allocation of check-in

facilities can be helpful to prevent congestion and delays at check-in counters, as well as reduce check-in times, and enable passengers to choose their preferable seats based on their needs.

Along with these changes and progress in the airport industry, baggage handling still faces many technical and operational problems. *Table 3* illustrates several baggage handling problems with their impacts on certain terminal operations. According to Tošić (1992), from the mid-twentieth century baggage processing has become an important subject due to the increase and changes in each of an aircraft's size, passenger volume, and airport handling procedures. de Neufville and Odoni (2003) report that baggage space is one of the most problematic aspects of baggage handling for two reasons; first, the location of the Baggage Handling System (B.H.S) is usually in the basement, surrounded by huge columns that support the terminal building. Second, the system, which has conveyer belts or tilts trays, is complex and inflexible. As a result, the lack of space causes maintenance issues for the mechanical structure of the system. These technical problems will not be taken care of if there is not adequate access to the equipment (de Neufville and Odoni, 2003).

Several researchers have made recommendations for dealing with space-related problems. Some of these recommendations are found in the literature. de Neufville and Odoni (2003) report that architects should make sure that there is enough adequate height of floor-to-ceiling space accessible for people while planning for baggage and mechanical systems space. In designing baggage handling system facilitates, planners need to consult with airlines, baggage handlers, and maintenance crews who are directly involved in operating the system equipment (de Neufville and Odoni, 2003). Bellioti et al. (2010) indicate that common baggage sorting and baggage screening can be found that will work well in space-constrained areas. As a result airport operators should cooperate with the airlines to plan for common use space.

Table 3			
<i>Common Baggage Problems</i>			
	Problems (Factors)	Outcomes	Solutions
Baggage Handling	<p>Baggage Space:</p> <p>1) The location of B.H.S area is usually in the terminal basement.</p> <p>2) The system is complex and inflexible.</p> <hr/> <p>Lacking space for baggage handling system facility</p>	<p>Maintenance issues; technical problems will not be necessarily taken care of</p>	<p>1) Architects should make sure that there is enough adequate height of floor-to-ceiling accessible for people while planning for baggage and mechanical systems space.</p> <p>2) Planners need to consult with airlines, baggage handlers, and maintenance crews while designing baggage handling system facilitates</p>
	<p>Lack of standardization: industrial countries have their own devices: (diverseness of devices)</p>	<p>Reduces the availability of general rules for planning baggage systems.</p>	<p>1) Cautions should be used in the application of the rules.</p> <p>2) Planners need to consult with the security baggage handling specialists to define the adequate required space for the system.</p>
	<p>Late arrival of bags at the baggage claim facility</p>	<p>Passenger congestion in the baggage claim area</p>	<p>1) Application of IATA (1995) standards: minimum distance between the baggage claim carousals should be 9 meters or 30 feet</p> <p>2) Modification of IATA and FAA baggage claim areas according to the local realities.</p>

Source: (FAA Advisory Circular, 1988; Bellioti et al., 2010; Tošić, 1992).

Another problem identified in the literature is the lack of standardization of airports' baggage handling systems. de Neufville and Odoni (2003) explain that the design of baggage systems has not been standardized due to the impact of several factors like new security regulations, baggage handling technology, and the diverseness of devices. New security

regulations present new X-ray or scanning devices along with their evolved design and performance (de Neufville and Odoni, 2003). The progress and changes in technologies like laser readers and radio frequency identification systems (FRID) make the technology of baggage handling change difficult (de Neufville and Odoni, 2003). It is reported that many different devices are being used in baggage handling, especially on the international level among major industrial countries, and this adds to the problem of standardizing operations (de Neufville and Odoni, 2003).

It has also been recognized that the lack of standardization for baggage handling may affect baggage handling systems planning. According to de Neufville and Odoni (2003), the existence of various systems can reduce the availability of necessary general rules and regulations for planning baggage handling systems. The FAA Advisory Circular (1988) recommends that cautions should be used in the application of the rules devoted to dealing with passenger baggage handling. Due to the lack of general rules and the existence of so many diverse and dynamic technologies, planners initially need to consult with the security baggage handling specialists to determine the adequate space required for handling the baggage function and investigate how the space will enhance the function.

There are several other problems associated with baggage handling issues. For example, the late arrival of bags and congestion in baggage claims areas are often cited as significant problems. Tošić (1992) presents several factors that affect baggage claims and arriving bags, like the number of passengers, number of bags per passenger, baggage flow and delays, passenger queuing, and baggage queuing. Congestion is one of the most common problems which exist surrounding the arrival of baggage onto terminal carousals due to the gathering passengers at the baggage claim area. There are a number of recommendations for solving these problems offered

by the International Air Transportation Association (IATA) (de Neufville and Odoni, 2003). The IATA's standards (1995) require that the distance between baggage claim carousals must be at least 9 meters or 30 feet (de Neufville and Odoni, 2003). IATA and FAA baggage claim standards need to be modified based on the local realities like the average number of checked bags (de Neufville and Odoni, 2003).

Gates and gate assignments are other problematic areas within airport passenger terminal operations. Wells and Young (2011) believe that gates are the most prominent and challenging aspects of planning and management of the apron in dealing with aircraft parking positions. As a result several recommendations are required to achieve efficient operations. According to Bouras et al. (2014), airport issues related to airport gate assignment problems (AGAP) must be understood. These researchers claim that it is an essential aspect of airport operations and this explains why there has been so much research done in this area. *Table 4* shows gate assignment problems and their impacts on terminal operations. It has been recognized that gate assignment problems exist among all of the world's airports for a variety of reasons and factors. Bielaire and Kumar (2013) report that, in the United States' airports aircrafts are not allowed to be parked on the remote stands. This requirement has been established in legal codes and laws governing airport operations. Moreover, the law requires that all passengers are supposed to be enplaned and deplaned through airport gates. Unlike U.S. airports, using remote stands are allowed in many European and Asian airports. In these cases, aircrafts are parked far away from terminal gates. Then, the arriving or departing passengers are transferred from or to the terminal or aircraft, in the absence of an available gate by using shuttle busses (Bielaire and Kumar, 2013).

Using remote stands may often result in problems and it is not uncommon for these systems

Table 4			
Terminal Gate Assignment Problems (GAP)			
Problems (Factors)	Outcomes	Solutions	
Terminal Gate Assignment	Using remote stands for parking aircrafts	Aircrafts are required to wait on the runway for a very long time till all the passengers are moved from/to the aircraft(s) by shuttle buses.	Using the U.S airport models: it is illegal to park aircrafts on the remote stands and transfer passengers to/from the terminal or aircraft by using shuttle buses.
	The variety of aircraft sizes	Adjacency issue: Two large aircrafts cannot be provided with two near-by gates due to limitations in space and structure of the parking position.	FAA Regulation: Designers and planners should design gates for largest expected aircraft. Gate types have been categorized to A, B, C, and D based on different aircraft sizes.
	Last-in-first-out (LIFO) Gates	When two aircrafts are being parked in two neighboring gates, the first aircraft cannot move until the second or the last parked aircraft will move.	This issue “[neither] widely considered nor extensively studied by the researchers.”
	Unassigned turns: Gates may not be available all the times	Air carriers face a high cost and receive low customer satisfaction	Air carriers wait till a gate will be available for their flight or will borrow a gate from other airlines. These solutions are not preferred.

Source: (Bielaire and Kumar, 2013 & FAA Advisory Circular, 1988).

to experience major disruptions. Often, aircrafts are required to wait on the runway for several

hours until all the passengers are enplaned or deplaned (Bielaire and Kumar, 2013).

It has also been recognized that different sizes of aircrafts being parked in designated parking positions may cause problems for gate assignment. Bielaire and Kumar (2013) define “adjacency” as one of the issues that affects assigning two neighboring gates to adjoin two different aircraft types. Adjacency can be described as the situation when two large aircrafts cannot be provided with two near-by parking positions or gates due to limitations related to space and structure (Bielaire and Kumar, 2013). One example can explain the adjacency situation—when *Gate A1* is devoted to parking an aircraft of a certain type or size, like Boeing 747, *Gate A2*, the neighbor gate of A1, will not be able to accommodate a wide bodied aircraft like Airbus 340 since these two aircrafts have different sizes and their parking spaces are limited (Bielaire and Kumar, 2013).

According to the FAA Advisory Circular (1988), to utilize gates for serving various aircrafts, designers and planners should design them for the largest expected aircraft. Giving an efficient to the airport apron, the length of each aircraft body (fuselage) and wing spans must be taken into consideration (FAA Advisory Circular, 1988). Terminal apron gate types can be identified based on their accommodations for four aircraft size groups: the gate types have been categorized as A, B, C, and D (FAA Advisory Circular, 1988). *Table 5* displays all the four gate types according to their accommodations for certain aircraft sizes.

Assigning two adjoined terminal gates may be problematic in some certain situations. Bielaire and Kumar (2013) observe that some types of gates are called last-in-first-out (LIFO) gates. LIFO gates are described as two neighboring gates, *Gate #1* and *Gate #2*, for instance, that are often not able to accommodate two aircrafts based on expecting a gate problem.

Table 5

Terminal Gate Types and Aircraft Sizes

Gate Type	Aircraft Size	
	Wing Span Length	Fuselage Length
A	79 feet (24 m) - 118 feet (36 m)	
B	118 feet (36 m) – 171 feet (52 m)	Less than 160 feet (49 m)
C		Greater than 160 feet (49 m)
D	171 feet (52 m) – 213 (65 m)	

Source: (FAA Advisory Circular, 1988).

Locating in the right side, Gate #2 cannot be used for parking an aircraft, or the aircraft parked at Gate #2 cannot depart if there is an aircraft parked at Gate #1, even if it is free (Bielaire and Kumar, 2013). The LIFO gate situation has not been such a concern for researchers (Bielaire and Kumar, 2013).

Airport terminal gates may not be available for passenger flights at all times. According to Bielaire and Kumar (2013), airlines have specific times for their flight operations; it can often be seen that a number of aircrafts, belong to an airline, have been parked on ground but no gates are available for their next flights. Bielaire and Kumar (2013) have mentioned this situation mentioned this situation as "unassigned turns". Facing unassigned turns situation, air carriers will wait until a gate is available for their flight or will borrow a gate from other airlines. Both of these solutions are not preferred by the air carriers since they involve a high cost and affect customers' satisfaction. (Bielaire and Kumar, 2013).

Airport passenger terminal security faces its own challenges along with the obvious growth in number of airport passengers. Graham (2014) believes that improving airport security processes has become one of the most difficult tasks in passenger experience. As the number of airport passengers increases, managing security processes becomes more challenging even without enhancing passengers convenience (Graham, 2014). New types of threats have caused airport security to seek new technology (Graham, 2014). The example of a plastic bomb hidden

in the underwear of a passenger, who attempted to fly from Amsterdam to Detroit on December 25, 2009 by Northwest Airlines, without being detected by security, indicates that the recent technology of screening has been insufficient to face a new threat (Graham, 2014).

Since most of the world's airports are connected together through aircraft movements, airport security faces difficulty in globalizing certain security-related agreements. Graham (2014) indicates that it is very difficult to persuade a country to recognize and trust the security agreements that have been made somewhere else. Lastly, the future of airport security remains ambiguous and undefined since airport security protects against unknown threats (Wells and Young, 2011).

In trying to deal with and find the best solutions for preventing threats to airport security, multiple government security-related agencies have been formed and are working to address these threats, specifically in the baggage screening area. According to the Government Accountability Office (GAO) (2012), the Transportation Security Administration (TSA) has mandated that all airports checked bags must be screened through the use of explosive detection systems. To carry out this process, TSA utilizes two types of screening equipment within the airports of the United States: Explosive Detection Systems (EDS) and Explosive Trace Detection (ETD) (GAO, 2012). The EDS uses X-rays connected with computer imaging to define and detect explosives. Through the use of ETD machines, a human operator or baggage screener can carry out chemical analysis and manually recognize any explosive materials vapors and residue (GAO, 2012).

Coordinating with the airlines and airports, TSA attempts to achieve the most efficient and effective baggage screening configuration at the airports (GAO, 2012). Through the Electronic Baggage Screening Program (EBSP), 76 percent of the airports regulated by TSA have been

provided with in-line and stand-alone baggage screening configurations that can meet airport needs (GAO, 2012). Although dealing with in-line systems solutions may not be cost-effective at larger airports or the terminals with fewer bags per week to screen, TSA continues in its planning in optimizing systems through many recapitalizing projects (GAO, 2012). To provide more efficient optimal baggage screening systems, the provision of an additional \$1.15 billion will be allocated through the fiscal year 2030 (GAO, 2012).

CHAPTER 4

Case Study: An Examination of Gate Availability Issues at Dallas Love Airport

As previously indicated, the number of available gates may affect airport terminal operations. There could be several reasons behind the unavailability of gates at an airport terminal. Airlines could be the essential parties that engage in such kinds of problems since they are mainly operating certain numbers of flights by utilizing airport terminal gates. Gate preference, for instance, can be one of the factors that affect gate availability. Some airlines intend to use only specific gates based on convenience and/or utilizing their special equipment in certain gates (Wells and Young, 2011; Bielaire and Kumar, 2013).

The 1979 Amendment of the Federal Aviation Act of 1958 mandated that flights be restricted to Dallas Love Field airport to avoid competition with another newly built airport in the region: Dallas/Fort Worth International Airport (DFW) (Cohler, 2015). Under the Wright Amendment legislations for Love Field airport, commercial air transportation from Love outside of Texas State is prohibited unless a charter air transportation operates less than ten flights per month or a regional airline operates an aircraft with a capacity of 56 passengers or less (Cohler, 2015). However, if the capacity of the aircraft, operated by a commercial air carrier, for a commercial air transportation from Love Field exceeds 56 passengers, the flights will be limited

to operating non-stop flights to one or more destinations within the States of Texas, Louisiana, Arkansas, Oklahoma, and New Mexico (Cohler, 2015). This bill was passed by Congress in 1997; the Shelby amendment added the states of Alabama, Kansas, and Mississippi to the Wright Amendment (Cohler, 2015).

Also, limiting the number of operating gates may affect airport terminal operations. As an agreement among five related parties, one of the stipulations of Wright Amendment Repeal compromise in 2006 was a permanent reduction of Love Field gate capacity from 32 to 20 gates (Cohler, 2015). According to DMMJM/AECOM, (2006), based on the operational scenarios at Love Field airport, in the absence of Wright Amendment, forecasts for 2020 show significant increases in the airport's passenger and aircraft operations while all the 32 gates are being in use. Under the "no Wright Amendment Scenario", using all the 32 gates in 2020 will increase the annual enplanements by almost 100 percent, the annual airline operations by 98.6 percent, and turns per gate by 94.7 percent (DMMJM/AECOM, 2006).

This case study is an example of a relevant problem observed at Dallas Love Airport where the number of available gates has declined by law to limit the airport's competency with another nearby airport. The clear results of implementing "no Wright Amendment Scenario" can be an indicator of how limiting the number of available airport terminal gates can negatively affect airport terminal operations consistently in present and in the future. As observed through the forecast for 2020, the more Dallas Love Airport gates are being restricted in use, the less increases in the airport's passenger and aircraft operations are available (Cohler, 2015).

CHAPTER 5

Conclusion

Airport passenger terminal operations consist of a variety of terminal activities designed to

serve terminal passengers. The structure of different terminal facilities participate in the provision of these services and activities devoted to airport passengers. Based on the existence of many issues observed within airport passenger terminals, certain related problems in terminal design, check-in facilities, baggage handling, gates, and security can have their own impacts on terminal operations. Terminal design problems include long passenger walking distances, narrow passage ways, and limited federal funding. Passenger check-in problems include the related issues with number and availability of check-in counters along with the existence of temporary congestions happen as a result of using passengers' self-check in services. Space and lack of standardization and late arrival of bags are the essential problems of baggage handling. Gate assignment problems can be the use of remote stands for parking aircrafts, the variety of aircraft sizes, the situation of facing the last-in-first-out in parking aircrafts, and unassigned turns. Lastly, consistent security threats from different sources of criminals and terrorists like hijacking and bomb attacking are other problems that affect airport passenger terminal operations.

The impacts of these problems can be found when they have a variety of outcomes affecting passenger flight operations in terms of travel time, convenience, and security. Although many recommendations or suggestions have been made to remedy these problems many of them still exist and remain common. Further research studies can be conducted to investigate whether the current terminal operational problems require more efficient solutions or to find out whether these operations themselves are inefficient and need drastic measures for improvement.

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