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Managing Congestion in Public Areas to Mitigate Security Vulnerabilities

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Sponsored by the Federal Aviation Administration

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NOTICE

The project that is the subject of this report was a part of the Program for Applied Research in Airport Security (PARAS), managed by Safe Skies and funded by the FAA.

The members of the technical panel selected to monitor this project and to review this report were chosen for their special competencies and with regard for appropriate balance. The report was reviewed by the technical panel and accepted for publication according to procedures established and overseen by Safe Skies.

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EXECUTIVE SUMMARY

The vulnerability of travelers and personnel at airports across the county is distinct due to the separation of secure and non-secure areas of the terminal. The secure area of the terminal provides enough square-footage for travelers to spread out among different gates. Conversely, airport curbside, ticketing, traveler security screening checkpoints, and baggage claim are all loosely controlled areas that are susceptible to congestion as travelers and their guests journey through the non-secure side of the airport. As a result, processing bottlenecks may occur pre-security and cause congestion and long queues before travelers reach the secure area.

The rate of attacks on travelers and their guests in public places has increased. The recent attacks at the Fort Lauderdale-Hollywood International Airport (FLL) in 2017 and Brussels Airport in 2016, and the Los Angeles International Airport (LAX) active shooter incident in 2013 highlight the need to reduce crowds in non-secure areas of airports.

The normal flow of travelers and their guests create distinct peak-hour curves as they check in for a flight at a curbside or ticket counter kiosk, and process through the traveler security screening checkpoint for their flights. There is also distinctive peak activity as the travelers' flights arrive and they wait for checked baggage to arrive in the baggage claim hall. These patterns are specific for each airport and their air carriers' flight schedules, but the rise-and-fall demand pattern is found at every airport.

Unfortunately, it's during these peak periods of high congestion that travelers and their guests create an inviting target for those with malevolent intent who may cause massive disruptions and, possibly, mass casualties. As airports and air carriers add more flights, the congestion caused by longer peak periods will continue to grow.

Air carriers, airports, and the TSA have tested several innovations in technology and design in an attempt to improve the throughput of travelers and alleviate congestion and chokepoints. Enhancements at the ticket counter, including self-service bag drop, self-ticketing, and mobile device boarding passes, have improved the flow-through in the ticket counter and curbside check-in. Implementation of the TSA PreCheck program has helped alleviate some of the wait times at security screening checkpoints, reducing the wait time to less than 5 minutes for nearly all PreCheck travelers and less than 20 minutes for most non-PreCheck travelers. Advances in technology, such as Advanced Technology X-Ray, Advanced Imaging Technology and other enhancements have been provided as tools for improved efficiency as well as security.

Additionally, existing strategies and emerging technologies are available to help mitigate congestion, including notification tools, electronic signage and wayfinding, social media alerts, surveillance, emergency backup systems, and the National Incident Management System. Using new data mining techniques, analytics and simulation can give airports a new look into travelers behavior and characteristics useful for planning facilities, systems, and response strategies.

Fortunately, technology is not the only viable solution to balance safety and customer service. Various design options and tools—when coupled with the willingness to implement creative, location-specific solutions—can be employed to identify and mitigate congestion through a combination of operational protocols and/or facility modification. While it is not a new approach, crime prevention through environmental design provides a good strategy for airports looking to improve safety and security without reducing the overall customer experience and level of service. Frequently, if planned properly, these solutions can be implemented without an increase in operational costs.

For some airports, additional technology and terminal redesign is not possible in the near future for budgetary or political reasons. For all airports, but especially for resource-constrained airports, it is important to understand how policies and procedures can enhance their security program and help manage congestion. This can involve small changes, such as training, or large improvements, such as the creation or update of current Airport Emergency Programs. At a minimum, airports should be able to identify their stakeholders, understand the legal requirements in their jurisdiction, and implement crowd management actions during regular and emergency situations.

This research project addresses all of these concerns while identifying solutions and strategies suitable for all sizes of airports to minimize areas of congestion, reducing the potential for casualties during a terrorist attack. This Guidebook complements and enhances the research resulting from PARAS 0014: *Blast Mitigation Strategies for Non-Secure Areas at Airports*, since both projects address vulnerabilities of crowds.

PARAS ACRONYMS & ABBREVIATIONS

The following acronyms and abbreviations are used without definitions in PARAS publications:

ACRP	Airport Cooperative Research Project
AIP	Airport Improvement Program
AOA	Air Operations Area
ARFF	Aircraft Rescue and Fire Fighting
CCTV	Closed Circuit Television
CEO	Chief Executive Officer
CFR	Code of Federal Regulations
COO	Chief Operating Officer
DHS	Department of Homeland Security
DOT	Department of Transportation
FAA	Federal Aviation Administration
FBI	Federal Bureau of Investigation
FSD	Federal Security Director
GPS	Global Positioning System
ID	Identification
IED	Improvised Explosive Device
IP	Internet Protocol
IT	Information Technology
MOU	Memorandum of Understanding
ROI	Return on Investment
SIDA	Security Identification Display Area
SOP	Standard Operating Procedure
SSI	Sensitive Security Information
TCP/IP	Transmission Control Protocol/Internet Protocol
TSA	Transportation Security Administration
XML	Extensible Markup Language

INTRODUCTION

Airports have been attractive targets for bad actors because of the opportunity to inflict mass casualties, attract widespread media coverage, and cause economic and psychological damage. Following the tragic events of 9/11, airport security efforts largely focused on minimizing the likelihood of a terror event onboard an airplane.

When authorities focus on securing areas at the checkpoint and beyond, opportunities are created for potential attackers to move their plans for destruction to the non-secure areas of the airport. The attacks at the Fort Lauderdale-Hollywood International Airport (FLL) in 2017 and Brussels Airport in 2016, and the Los Angeles International Airport (LAX) active shooter incident in 2013 highlight the need to reduce crowds in non-secure areas of airports.

Large groups of people assembling in a low security environment create an attractive target for an attacker looking to inflict maximum casualties. Additionally, non-secure areas are easily accessible and frequently provide multiple exit routes post-attack.

But crowds are a regular part of everyday operations at most airports. Lines form in ticketing halls, screening stations, and baggage claim areas. It is a daunting task for an airport operator to reduce crowds.

The objective of this Guidebook is to assist airports of various types and sizes to minimize traveler-related congestion that could be a viable target for acts of violence. The primary focus is crowd management during regular operations, though there is also guidance to minimize secondary targets created during incident response.

Each airport is unique in size, layout, and governance, so there is no "one size fits all solution" to protect soft targets. Airport operators must evaluate their airport's unique vulnerabilities and threats to identify the best choice of security measures to be deployed. Airports also must balance the competing priorities of security and customer service, while maintaining operational efficiency.

This Guidebook presents options that security experts in the aviation industry and other security-focused industries have shown to be effective at preventing and mitigating the impact of attacks on soft targets.[1] Every option discussed in this Guidebook will reduce crowds in the public spaces of an airport and, in turn, reduce the number of potential casualties in the event of an attack. In an ideal world, an airport would implement all of these options, but consideration must be given to that airport's particular layout, operations, and budget.

Diligent readers may notice that some information is repeated across multiple chapters. This is an intentional choice by the authors to ensure that readers looking for information on a specific topic do not miss good practices by only reading one chapter or section.

It is also important to note that many of the recommendations in this Guidebook serve more than public area security; these recommendations are also good operational practices that will enhance the airport's customer service in addition to strengthening the airport's security vulnerabilities.

[1] In 2016, TSA gathered industry experts, government officials, academia, international industry experts, and public officials to evaluate the current security environment and determine the best ways to move forward to protect the soft targets in public spaces, presenting several recommendations for the aviation industry.

1. FACILITY STRATEGIES AND PLANNING

One of the most effective ways to protect soft targets in the public area is to process travelers quickly through the non-secure areas and limit the density of people in the public spaces. Fast processing reduces the number of travelers vulnerable to attacks on the non-secure side by preventing them from dwelling in a single place for too long. This also provides reduced wait times, creating happier travelers that are more likely to spend money at concessions on the secure side of the airport and return for their next journey.

The terminal plan, space and processor requirements, and design of the spatial layout are the best ways to manage traveler flow through the non-secure side of the airport. The traveler's journey from the public to the secure side of the airport requires a network of discrete processing steps, supported by waiting areas and connected by entrances/exits, corridors, and vertical and horizontal circulation devices. All elements must be sized to serve the expected peak hour traveler demand as well as to create a balanced flow. Otherwise, the design of the facility may unintentionally lead to the creation of bottlenecks, or areas where travelers cannot move freely. Failing to regulate the flow of people in high throughput areas is the number one reason for injuries during most disasters related to crowd turbulence.

When new terminals are developed, or major renovations of existing terminals are underway, it may be a good time to examine the physical layout of the facility to see if it helps or hinders movements of large crowds. The airport should determine whether it has traveler processors with proper capacity, sufficiently sized passages and doorways, and adequate wayfinding that may avoid confusion and result in congestion.

The most common bottlenecks occur in the check-in lobby, security screening checkpoint, baggage claim and greeter halls, secure side exits, curbsides, and roadways. Existing terminals must continually benchmark people processing capacity against existing and projected peak-hour demand.

There are several terminal planning resources available that go into great detail about the most efficient designs and operation strategies for different types and sizes of airports. These documents offer tools for airports to identify operational bottlenecks in their processes and methods of reducing the congestion. The three most recognized industry standard documents are the ACRP Report 25: *Airport Terminal Planning and Design*, John J. Fruin's *Pedestrian Planning and Design*, and the International Air Transport Association (IATA) *Airport Development Reference Manual* (ADRM).

ACRP Report 25: *Airport Passenger Terminal Planning and Design*, Volume 1: This report provides comprehensive guidance to US airport owners, planning and design professionals, and air carriers for airport terminal development. The report includes guidance for developing a good forecast for peak-hour traveler demand within the planning horizon, as well as a spreadsheet tool to develop a facility program of traveler processing elements, e.g., the number of check-in desks and kiosks, security screening lanes, and baggage claim devices, as well as the size of the terminal areas required to house the processors. The included spreadsheet provides guidance on sizing the waiting and circulation areas, the corridors, restrooms, and all the areas required in a terminal.

John J. Fruin's *Pedestrian Planning and Design*: This reference provides more detailed planning and level of service (LOS) guidance for public circulation/waiting areas, queues, corridors, various types of doors, and horizontal and vertical transportation devices such as moving sidewalks, escalators, and elevators. Information is included regarding traveler walk speed and how it is impacted by congestion and two-way pedestrian flows. The author derives the area required for pedestrian walking speed and comfort, and his guidance is consistent with the information provided in the IATA ADRM.

International Air Transport Association *Airport Development Reference Manual:* This report is updated every 10 years to address the dynamic aspect of airport planning. Similar to ACRP Report 25, it provides guidance for airport terminal planning and design that is especially useful for airport terminals designed to serve international travelers. A unique value of the IATA ADRM is that it provides a set of metrics useful to airports and design professionals—known as LOS criteria—so that plans and designs can be evaluated relative to their capacity to handle expected traveler demand. IATA offers two types of LOS metrics: area standards required to provide the traveler and their meeters/greeters with adequate space to wait and circulate without impedance created by congestion, and a time LOS metric that provides guidance on the number of processors required to keep travelers' transit times within acceptable limits. These two types of standards ensure that traveler congestion levels for the expected planning horizons are within acceptable limits.

IATA has developed a standard framework for different areas of the airport in terms of space (Figure 1) and time (Figure 2) per traveler. Comparing space per traveler with the standard, the airport can identify if an acceptable (optimum) LOS is provided to the travelers or not. Terminal facilities that are optimally designed will provide sufficient space to accommodate all the necessary functions of the processor area in a comfortable environment for the traveler, as well as provide stable traveler flows with acceptable queue waiting times and minimal crowds.

Figure 1. IATA Level-of Service Space Framework

PASSENGER TERMINAL PROCESSOR	NOTES	SPACE STANDARDS FOR WAITING AREAS		
UNITS ADRM 9th Edition ADRM 10th Edition		(ft²/pax)		
		A B **Over Design**	**C Optimum**	D **E Suboptimum**
Public Departure Hall		>24.8	24.8	<24.8
Check-In				
Self-Service Boarding	pass/tagging	>19.4	14.0-19.4	<14.0
Bag Drop Desk	queue width 1.4-1.6 m or 4.5-5.0 ft	>19.4	14.0-19.4	<14.0
Check-in Desk	queue width 1.4-1.6 m or 4.5-5.0 ft	>19.4	14.0-19.4	<14.0
	queue width 1.4-1.6 m or 4.5-5.0 ft	>19.4	14.0-19.4	<14.0
Security Checkpoint	queue width 1.2 m or 4 ft	>12.9	10.8-12.9	<10.8
Emigration	queue width 1.2 m or 4 ft	>12.9	10.8-12.9	<10.8
Boarding Gate Lounge				
Seating		>18.3	16.2-18.3	<16.2
Standing		>12.9	10.8-12.9	<10.8
Immigration				
Passport Control	queue width 1.2 m or 4 ft	>12.9	10.8-12.9	<10.8
Transfers	queue width 1.2 m or 4 ft	>12.9	10.8-12.9	<10.8
Baggage Claim Area				
Narrow Body	Priority bags to be delivered before Economy	>18.3	16.2-18.3	<16.2
Wide Body		>18.3	16.2-18.3	<16.2
Public Arrival Hall		>18.3	12.9-18.3	<12.9
CIP Lounge			43	

Source: IATA, 2014

Figure 2. IATA Level-of Service Time Framework

	WAITING TIME STANDARDS (Minutes)			WAITING TIME STANDARDS (Minutes)		
PASSENGER TERMINAL PROCESSOR	Economy Class			Business Class / First Class		
ADRM 9th Edition ADRM 10th Edition	A B Over Design	C Optimum	D E Suboptimum	A B Over Design	C Optimum	D E Suboptimum
Check-In						
Self-Service Boarding	0	0-2	>2	0	0-2	>2
Bag Drop Desk	0	0-5	>5	0	0-3	>3
Check-in Desk	<10	10-20	>20			
		BUSINESS CLASS CHECK-IN DESK		<3	3-5	>5
		FIRST CLASS CHECK-IN DESK		0	0-3	>3
Security Checkpoint	<5	5-10	>10	0	*FAST TRACK* 0-3	>3
Emigration	<5	5-10	>10	0	*FAST TRACK* 0-3	>3
Immigration					*FAST TRACK*	
Passport Control	<10	10	>10	<5	5	>5
Transfers	<5	5	>5	0	0-3	>3
Baggage Claim Area	*FIRST PASSENGER TO FIRST BAG*			*FIRST PASSENGER TO FIRST BAG*		
Narrow Body	<0	0-15	>15	0	0-15	>15
Wide Body	<0	0-25	>25			

Source: IATA, 2014

Large terminal development and renovation projects that require the effective integration of legacy and new facilities will benefit from computer simulation analysis of the new terminal plan. Computer simulation provides a validation of the traveler LOS expected from the base design and operating plan, and also facilitates sensitive—or "what if"—analyses for terminal performance under less than optimal conditions, including man-made or nature-made service disruptions. The simulation can forecast and quantify the expected size of crowds in public and queue areas during disruptions. This information can be used by the airport owner and designer to develop and evaluate strategies for mitigating the impact of crowds during disruptions. The details derived from such what-if analyses during the design phase can inform planners of the cost/benefits of incorporating design features that would mitigate congestion and the associated operational risks.

In addition to a standards comparison, an analysis of crowd risk management measures will identify solutions that will improve inefficient choice behaviors, crowd turbulence issues (e.g., stampedes), and bottlenecks during evacuations. The information gathered during these simulation analyses will provide airports with the data needed to make critical decisions in the layout of their facility.

The following sections will discuss planning considerations for crowd mitigation in specific terminal functional areas. First, the authors will discuss processor areas of the terminal. The second section will discuss public circulation and waiting areas, queues, exits/entrances, corridors, and horizontal and vertical circulation devices that connect the processing areas. The objective of these following sections is to provide guidance on the placement of resources to ensure fast and easy flow of travelers through each processor area and ensure there is a balanced capacity between processor functional areas so that bottlenecks do not occur.

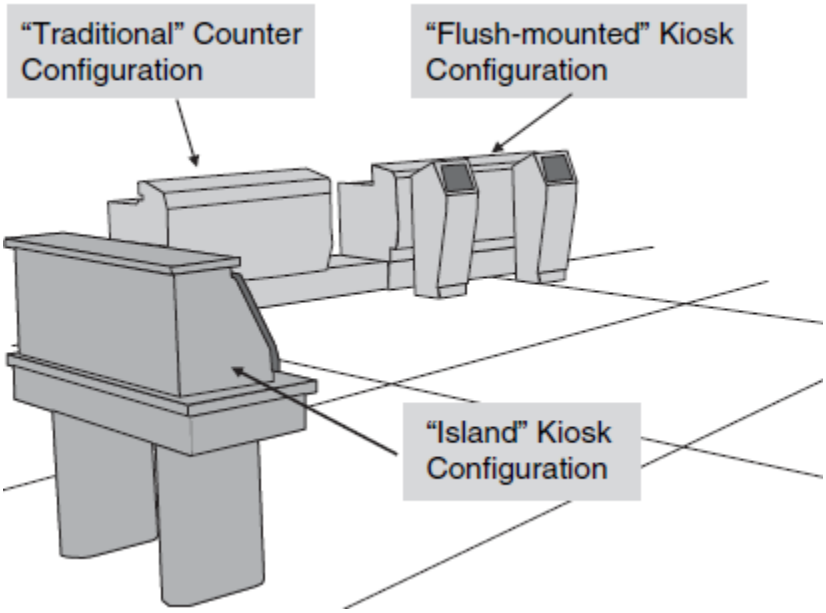
1.1 Processors

This report refers to a processor as a necessary step that a traveler must complete on their journey through the airport terminal that transforms their status in some way. For example, some travelers may need to visit a processor where they check-in for their flight, as signified by receiving a boarding pass, and/or they may need to check their baggage. Subsequent processors include the security screening checkpoint for outbound (departing) travelers and baggage claim for inbound (arriving) travelers. The following subsections discuss good planning aspects for processors that will help manage or mitigate large crowds on the public side of the airport.

1.1.1 Check-In Lobby

The traditional layout of the check-in lobby consists of the agent counter with a queue in front. Some airports have self-serve kiosks stationed either against the counter (flush-mounted) and/or as an island outside of the queue (see Figure 3). Sufficient space must be provided between devices to ensure that travelers interacting with the agent at the counter do not block the flush-mounted kiosks. If using island kiosks, the airport should ensure that the queue for one kiosk is not so close to the next kiosk that it interferes with another traveler's ability to interact with it. Crowding for both options could result in underutilized processing capacity and longer wait times in the check-in lobby.

Figure 3. Check-in Counter Layout



Source: ACRP Report 23

Some US air carriers have been experimenting with flow through check-in configurations similar to international airport terminals such as London Heathrow's Terminals 2 and 5. The flow through check-in processors eliminate traditional continual linear check-in counters and allow travelers to complete the check-in and bag drop process, then continue on a forward path between the counters to the security screening checkpoint. The process reduces congestion in the check-in area by eliminating the need for travelers to circulate back through the check-in queue area.

Introducing self-serve resources (kiosks and bag drops) in non-traditional locations (e.g., in the parking garage and at curbside) has the advantage of reducing congestion and queues within the check-in lobby.

Remote traveler check-in and baggage check-in options (online and mobile) allow for even less congestion as the traveler moves directly from the entrance to the security checkpoint.

> Recently, many air carriers in several airports have introduced self-bag-tagging kiosks to the check-in lobby. The kiosks allow the travelers to check in and print their baggage tags without the need for ticketing agents to assist. Travelers spend less time in the check-in queue and make their way to the security checkpoint faster, while also freeing counter agents to serve travelers in the queue.

Common use devices (self-service kiosks, bag drops, and other check-in resources that function for multiple air carriers) allow air carriers to share the use of valuable airport infrastructure and space; have been proven to provide faster processing by consolidating services; and reduce the number of ticket counters needed. Ultimately, this leads to shorter queues, more efficient use of available lobby space, and lower operational costs for the airport.

The benefit to mitigating crowds by incorporating self-service and common-use devices is that the devices provide traveler processing capacity that is not dependent on air carrier staffing; they trade a capital investment for an operational cost. Traveler processing devices are planned for peak hour demand, ensuring optimal traveler flow during baseline high demand times. During non-peak times, self-service and common-use check-in devices reduce crowding to the minimum by leveraging excess processing capacity.

There is also the option of facial recognition or other biometric kiosks, which, when paired with self-service bag drops, will reduce the need for air carrier agents behind the main counter. The facial recognition technology uses a camera in the kiosk to compare the traveler's face to their passport photo. The self-service bag drops allow travelers to check in and tag their luggage without the need to interact with an agent. While there will always be a need for agents to assist some travelers, deployment of facial recognition and automated check-in technology will reduce the need for air carrier staff and allow remaining agents to roam the check-in lobby to assist kiosk users and survey the area for suspicious behaviors.

1.1.2 Security Screening Checkpoints

The security screening checkpoint is generally the biggest processing bottleneck at an airport because all travelers must pass through it. The process of screening individuals and their belongings is a time-intensive activity and too much expediting may lead to a compromise in security. This has always been a balancing act for the TSA and airports, but several technological advances in the screening equipment are designed to speed up the process without undermining the security of the airport.

Figure 4. Automated Security Lanes at ATL

Source: Star Tribune

The TSA is testing a new 3D carry-on baggage screening technology at Phoenix Sky Harbor International Airport and Boston Logan International Airport (BOS) that is expected to improve security effectiveness, although the primary Computed Tomography (CT) Three-Dimensional Bag Screening device is likely to take longer to process bags than current x-ray scans. By reducing the frequency of secondary bag screening, the overall throughput of the screening lanes may increase. When this new technology is deployed to a checkpoint, travelers may no longer have to remove liquids, laptops, or other large electronics[2] and rescreening of bags would happen less frequently.

Automated Screening Lanes (ASL), an example shown in Figure 4, provide several advantages to processing security throughput. Automatic diversion technology removes trays identified by the x-ray or CT screening system as suspicious. If the operator or the CT system cannot resolve the concern, the bag is diverted to a separate area for a secondary search. This allows the TSA officer and the bag owner to avoid bottlenecks by stepping out of the way of the screened-traveler re-composure area. Automated tray returns are also an option to recirculate the trays from the end of the screening lane back to the start of the lane, eliminating bottlenecks caused by a lack of trays and leaving staff free to focus on moving travelers through the screening process. Ultimately, it is expected that ASLs will enable remote, multiplexed reviews of carry-on bags. It is anticipated that remote, multiplexed views of bags will also increase traveler security screening lane throughput.

If investment in advanced security technology is not feasible, deploying more risk-based screening approaches and/or adding bomb-sniffing canines may be a viable solution to improve the throughput rates without sacrificing security effectiveness.

Another option for airports to reduce congestion at the security screening checkpoint is to work with their air carriers to incentivize travelers to check their baggage and reduce the number of carry-on bags.

[2] It is important that airports understand what technology is available and its capabilities. The federal government is constantly changing its risk assessment of the transportation industries and new rules and regulations will reflect those assessments. Airports must always comply with current regulations, but also plan for the eventuality that those regulations may become more restrictive.

However, while this option may reduce the lines at the security checkpoint, without proper facility planning it will likely increase the congestion at the check-in lobby as well as the baggage claim area.

1.1.3 Baggage Claim

Transportation security and law enforcement experts agree that the baggage claim area is one of the most vulnerable places in the airport. The baggage claim area is the typical meeting place of domestic travelers and their greeters, and the baggage claim devices are not in a secured area. Large crowds develop as travelers and greeters arrive in bag claim area prior the bags arriving on the baggage claim device. Fundamentally, good circulation in the baggage claim area is necessary to reduce congestion. Therefore, the impedance to flow created by columns, walls, bag cart racks, furniture, or other obstructions has traditionally been minimized. However, these obstacles may create temporary shelter during an active shooter event. Ultimately, additional baggage retrieval and circulation space may be required to minimize congestion and still provide temporary sheltering space.

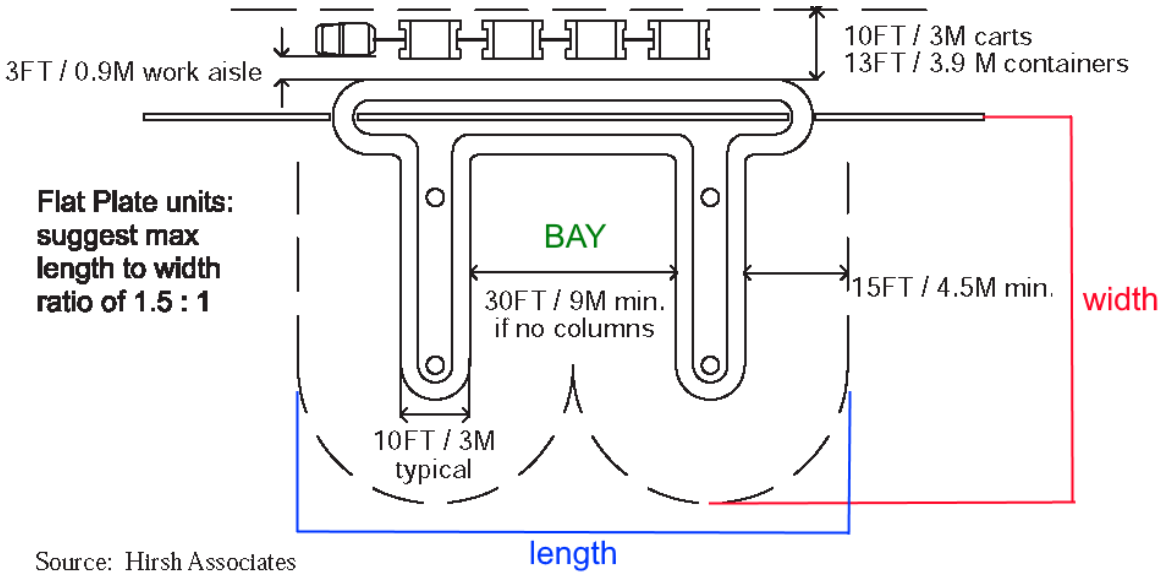
In addition to good design practice to minimize congestion, environmental design strategies (more specifically called Crime Prevention Through Environmental Design) are specifically applicable to protecting travelers and the public in the baggage claim. The goal is to eliminate long, unimpeded areas/site lines where travelers or the public can find no shelter or a quick escape to a safe location in the event of an attack. The design strategy is to provide walls or barriers in the baggage claim area so that travelers or the public may find temporary cover in the event of attack. Preferably, these barriers should be located along the egress routes. The provision of ballistic furniture—furniture designed to resist penetration by bullets and shrapnel and offer some cover from gunshots and explosions—may be considered; however, in the event of a secondary attack involving explosives, it is important that the ballistic furniture does not become flying objects, which also cause harm.

Another strategy some security experts suggest is to create a non-public, secure baggage claim area. This would create a lobby that would separate the recent travelers from their meeters/greeters (friends, family, drivers, etc.) while still allowing airports to maintain their secure exits from the sterile area. There are several non-US airports with domestic claim devices on the secure side, including Heathrow Airport (England), Frankfurt Airport (Germany), Václav Havel Airport Prague (Czech Republic), Brussels Airport (Belgium), and Tancredo Neves International Airport (Brazil).

In developing the layout of the baggage claim area, airports can consider two types of devices:

Flat Plate, most commonly in an L-, T-, or U-shape configuration: The bags are loaded onto the secure side (on the same level as the claim area) and pass through a set of fire/security shutters to be claimed on the non-secure side (see Figure 5). The typical waiting area around the device is 15 feet. The ideal ratio of the full length of the unit and the width of the unit is 1.5:1, which will limit deep, narrow bays and the congestion those bay types cause.

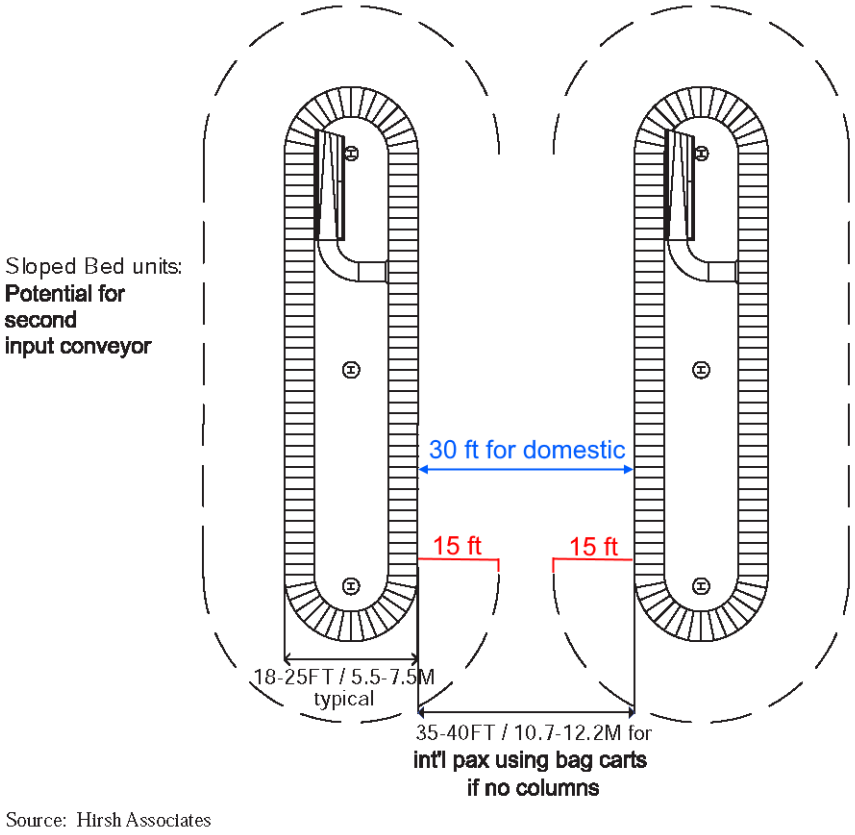
Figure 5. Flat Plate Baggage Claim Device



Source: ACRP Report 25

Sloped Bed or Carousel: These devices are fed from one or two conveyors, which may be located on a different floor level (above or below the device) and can be fed from some distance away, allowing for greater flexibility of placement (see Figure 6). Generally, these units are configured to allow travelers to circulate between them. A minimum of 15 feet from the edge of the unit is recommended for the retrieval and circulation area for all but the smallest of airports. This area could be shared by multiple units, so the minimum distance between two units needs to be 30 feet.

Figure 6. Sloped Bed Baggage Claim Device



Source: ACRP Report 25

Some airports have what is known as a positive claim. This is a baggage claim area that is enclosed in railing or a wall with security guards that check travelers' tickets for a positive bag match. If the baggage claim is separated from the terminal by a wall or gate, the designated meeter/greeter hall or lobby would need to be located immediately beyond the area to maintain high levels of customer service.

Airports can work with air carriers to implement operational or technological innovations to help minimize the time required to deliver a bag from a parked aircraft to the baggage claim device. This process, along with the flight schedule, determines how long and how many travelers and their meeters/greeters will wait at the baggage claim area, creating an inviting target for people with malicious intent.

1.2 Connectors and Waiting Areas

This section discusses the terminal areas that connect the various processors found in the terminal, as well as waiting areas. Connectors and waiting areas are paired with many of the processors and occur in several areas of the terminal; good planning practice is needed for all of the areas.

1.2.1 Curbsides

The airport terminal curbside roadway is the first opportunity for outbound (departing) travelers and well-wishers, and the last opportunity for inbound (arriving) travelers and greeters to create a crowd on the non-secure public side of the airport.

Vehicle-as-a-weapon attacks are a distinct possibility at airports, and they have the unfortunate ability to injure many people by breaching the airport facility, ramming and damaging infrastructure, and/or delivering a hostile actor to areas with unprotected crowds. The TSA has reported that 17 known vehicle ramming attacks worldwide between 2014 and 2017 resulted in 173 fatalities and 667 injuries.

> For more information on blast protection methods at the curbside, please review PARAS 0014: *Blast Mitigation Strategies for Non-Secure Areas at Airports*.

One of the hypothetical measures considered in recent discussions between the TSA and security experts was the possibility of turning the entire airport and/or the terminal into a secure area by requiring every person and vehicle to be screened before entering the airport space. This discussion presumably came from an examination of the processes in place at Israel's Ben Gurion International Airport, which has a reputation for being one of the most secure airports in the world. This would be achieved by disallowing any vehicles onto airport property without first being screened.

Unfortunately, such an approach is impractical and expensive for most US airports and their travelers. In addition, this solution creates another challenge, as it pushes the problem of public vulnerabilities farther back where the line of waiting people and/or vehicles would still create soft targets.

An alternate solution is to limit vehicle traffic passing through airports. Expanding the availability of public transportation such as trams and rail would limit the influx of travelers to smaller groups and potentially reduce the number of casualties in the event of a vehicular attack.

> Los Angeles World Airports is sponsoring a large airport development project that features an off-airport ground transportation transit center that accommodates public transit, rental car and other courtesy shuttles, with traveler connectivity to the airport terminals via an automated people-mover system. The long-term result will be a significant reduction in the number of vehicles permitted to approach the airport terminals.

More commonly, the security of US airport terminal roadways is achieved through good planning practice. The design features of curbside roadways, as well as the placement of ground transportation options along the roadway, can mitigate crowds and prevent congestion in adjacent terminal areas.

The airport must consider providing adequate curbside lanes and standing spaces so that travelers (and their well-wishers/meeters/greeters) may complete their required business efficiently and depart the area as quickly as possible. These activities may include brief stops to load/unload travelers and baggage. If permitted by the airport, vehicles may be allowed to pause long enough so that travelers may check their baggage with curbside sky caps. The planner must always consider the best location for these activities so that large vehicle queues will not form and create delays or potential targets. Separating arriving and departing travelers—either vertically with multiple levels or horizontally with separate drop off/pick up zones—also relieves the curbside traffic.

The best locations for ground transportation options should be thoroughly analyzed to ensure that courtesy shuttles and buses do not create vehicle back-ups as they maneuver to reach traveler waiting areas. The planner must consider whether adequate curbside capacity exists to accommodate frequent pick-up service so that large traveler crowds do not build, creating congestion and the potential for attacks. If possible, separate bus/shuttle pickups from taxi and transportation network companies (e.g., Uber and Lyft) pickups to minimize the waiting crowds.

Pedestrian walkways are another potential solution for airports planning terminal upgrades. Installing pedestrian walkways or bridges that eliminate at-grade crossings at busy roadways increases pedestrian safety while alleviating traffic congestion in front of the airport entrances.

Pedestrians will not be as easily detoured by a bollard or concrete planter in their path, so if the airport needs to cordon off a large crowd, such as during a protest, interlocking barriers (such as bike racks with a branded banner to convey a welcoming attitude) can be temporarily erected. These will help define the area in which the crowd is permitted and minimize tension between the crowd and the crowd management team.

1.2.2 Entrances and Exits

Airport terminal entrances and exits are another area that may create a bottleneck. Aviation industry experts have suggested that properly sized and located entrances and exits paired with emerging technology may mitigate unfortunate consequences from large crowds developing on the public side of the airport.

It is important that terminal entrances and exits be adequate in number, width, and door operating speed so that a surged flow of travelers can pass through the portal without a large queue being formed. Not only must the entrance and exit be adequate to support the number of travelers entering and exiting, but there must also be adequate space on the sidewalk so that travelers passing by the entrance/exit are not impeded. Under no circumstance should queues overflow into the adjacent roadway.

Some security experts have discussed implementing a requirement to screen everyone entering the airport before they travel through the security checkpoint. One possible way to do this could be to install walk-through screening sensors at the entrances. These sensors are already a common sight at concerts and some schools.

The detection-at-range devices use sensors and sometimes cameras to detect anomalies concealed on the person walking through them. These systems monitor natural wave emissions from the human body and identify objects blocking or reflecting those waves.

Use of devices such as these would warn airport law enforcement officers (LEOs) if a person entering the facility carried a firearm or explosive without the need for a bag or personal search. In addition, it would alert travelers to forgotten firearms in their luggage, a common occurrence at airports, with the TSA reporting 3,957 firearms discovered in carry-on bags in 2017.

These devices have the potential to scan up to 800 people per hour, but airports considering installation of these devices should compare realistic capacities (considering travel party size and baggage volume), width, and available training. Proper deployment is essential to ensure that the new security measures do not cause bottlenecks at the entrance.

1.2.3 Circulation and Corridors

Circulation areas allow travelers and the public to move between functional areas of the terminal. Circulation areas have loosely defined limits, unlike corridors, which have a constrained width and length. Typically, circulation areas transition into corridors. The most important planning and design consideration is that circulation and corridors are sized to accommodate the peak occupancy of the areas (as determined by planning standards offered by IATA or Fruin) so that travelers and their well-wishers/meeters/greeters may stand and move comfortably, without impeding their ability to move to their destination.

When planning the width of corridors, it is important to consider that location of flight information display (FIDS) or other informational signs, seats, or any other piece of equipment will create physical or visual impediments to traveler or visitor flow. If these items must be located in the corridor, good planning requires that the corridor be widened so that as traveler crowds form in connection with these items, traveler flow through the corridor will remain unimpeded. All corridor widths must include an 18-inch stand-off distance from the wall (or equipment located next to the wall), since research indicates that travelers will maintain this distance to avoid collisions with the wall or equipment during their journey.

Most airport terminal designs require travelers to change levels within the terminal. Up to 90% of travelers choose to use escalators to move between floors as opposed to stairs or elevators, so it is vital for airports to ensure these devices are capable of handling peak surge loads without excessive queuing. It is essential to ensure adequate space at the landing zones to prevent backups and potential hazards. In general, a 40-inch step width is preferred as this allows enough space for one traveler to stand on one side and another to pass on the other side.

Elevators are generally used by travelers with limited mobility, including wheelchairs, scooters, strollers, and excess baggage. As a result, elevator usage is typically significantly less compared to escalators and stairs. However, the elevator car must be able to accommodate a wheelchair-user and their attendant, which requires a minimum of 5 feet 8 inches x 4 feet 3 inches x 7 feet. Audible cues inside and outside the elevator car will help travelers who are blind or with low vision identify when the elevator has stopped. If the elevator is located near a particularly noisy area, the volume of the external audio cue may need to be increased. Use of glass doors will help alleviate the number of signs needed in the area. It will also help orient the elevator riders as they travel between levels.

Additionally, good level-of-service standards require that traveler walk-distances in excess of 1,000 feet be assisted with moving sidewalks. A capacity of 4,800 travelers per hour (or approximately 60 feet/minute) is recommended but must not exceed 9,600 travelers per hour (approximately 120 feet/minute). Audible cues at the beginning and end of the moving walkway are recommended to alert travelers who are distracted or have vision loss.

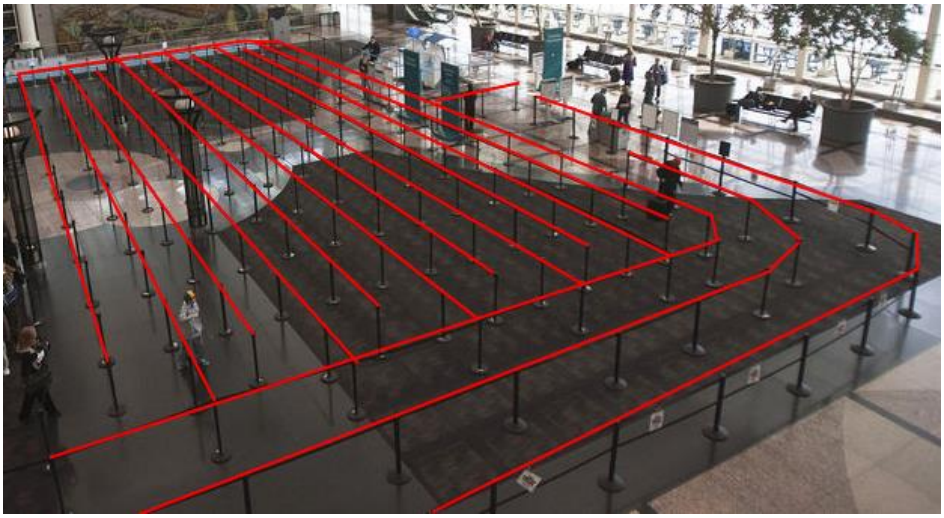
1.2.4 Queues

Queues serve an important function within a system of systems such as airports; they store traveler demand to balance the difference in processing rate between two successive operations.

Given the current technology and paradigm, queues are unavoidable at airports and often present the biggest bottlenecks associated with traveler processing functions. There are important design considerations for managing queues when they are unavoidable. From the traveler's perspective, wait times have a significant impact on the perceived and actual success of their journey; longer wait times result in an unpleasant traveler experience and increased stress level. Properly built and finely tuned queues ensure that travelers are quickly moving through areas and are not creating large, idle, and trapped crowds.

The most efficient queue type is the serpentine or switchback queue that feeds into multiple service counters (see Figure 7). Unlike a single queue or parallel queue that feeds into a dedicated service counter, customers in serpentine queues served by multiple counters are not held up by a single long transaction; the next available counter serves the next customer.

Figure 7. Switchback Queue at Denver International Airport (DEN)



Source: Reuters

All queues should be wide enough for a wheelchair to pass through easily, and wide enough for a wheelchair to easily turn at the switchback point (see Figure 8). This means that the straight portion of the queue should be at least 36 inches wide (48 inches according to IATA's optimum levels of service framework). The minimum space required for a wheelchair to make a 180-degree turn is a clear space of 60 inches in all directions (diameter), although 70 inches is preferred; electric chairs, scooters, and reclining wheelchairs require at least 94 inches. If possible, a separate line specifically designed for users of wheelchairs will allow for less space-constrained layouts, and these travelers may take their time passing through security without holding up the rest of the queue.

Figure 8. Minimum Turning Radius for Wheelchairs

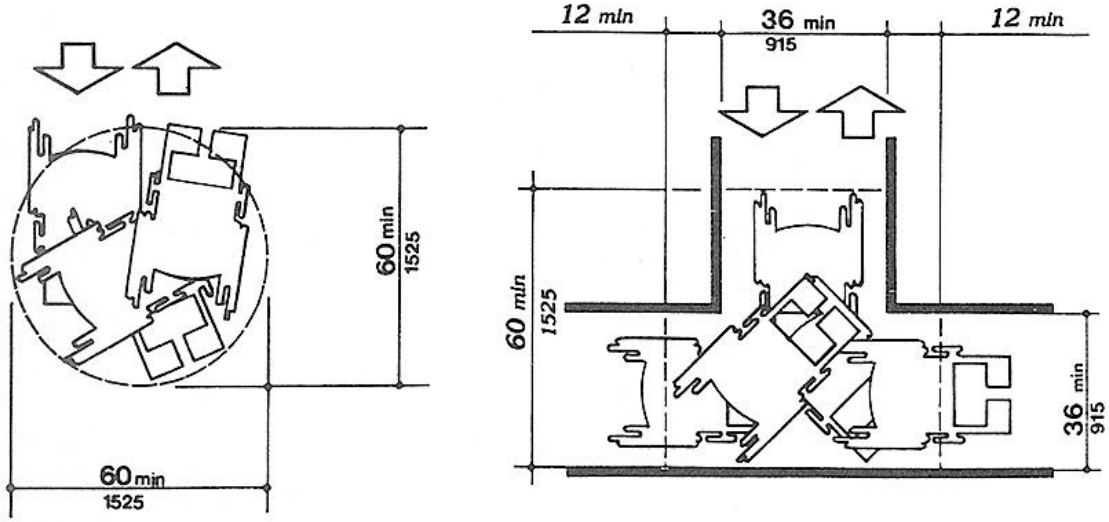


Fig. 3
Wheelchair Turning Space

Source: 29 CFR Part 36

Virtual queues are becoming common in other industries, most famously in Disney and other theme parks, and have shown positive results. The concept involves assigning a number or a sign-in list for an appointment time, which provides a first-come-first-serve order to the queue. In retail, this would allow the customers to browse the products while waiting, which in turn drives up sales. In general, virtual queues allow the crowd that would normally be constrained to a predefined queuing area to disperse throughout the adjacent area. The data collected from virtual queues would also provide managers with real-time information to help them analyze the service queues. However, application of virtual queues on the non-secure side of the airport may be limited and the authors have not identified any successful application at any US airport.

> A low-tech version of the virtual queue is Southwest Airlines' unique boarding queue in which travelers receive a number representing their place in queue. This enables them to leave the holdroom to use terminal amenities, confident they can return without losing their place in queue. Deployment of this innovative approach has decreased crowding and confusion surrounding the boarding process immensely.

Adding a display at the security checkpoint depicting cartoon-like illustrations performing the divesting process (emptying pockets, removing shoes, etc.) will not only eliminate some of the communication barriers—as even children can understand cartoons—but it also has the added benefit of speeding up the process.

> Seattle-Tacoma International Airport piloted a robot program, or avatar, at the security checkpoints. The robot reminded travelers to remove items such as scarves, jackets, and belts, and to empty their pockets before passing through the screening device. The robot was designed to augment the work of the TSA and airport workers, allowing them to spend more time on critical security tasks.

It is important to use sturdy and stable equipment when creating queues, but they should also be easy to move and adjusted by personnel to meet the current needs of the queue and waiting crowd.

> When Hartsfield-Jackson International Airport (ATL) redesigned the queuing area in front of the security checkpoint, they used magnetic stanchions to allow for flexibility in queue design and cleaning. This has also been recommended for checkpoint queues in the latest *TSA Checkpoint Design Guide (CDG) Innovation Supplement* document (06-2017, v.1.1).

Travelers have been shown to wait for congestion to decrease before joining a queue. To ensure that crowds do not form around the queuing area, airports should provide convenient distractions, such as concessions or spaces to work that have electrical outlets and Wi-Fi, in order to disperse potential crowds.

1.2.5 Arrivals Halls

Arrivals halls specially designed to serve visitors waiting or the arrival of domestic air travelers are not typically incorporated into US airport design. This means that domestic baggage claim areas usually serve the function of arrivals hall. During design, consideration for a comfortable waiting space for meeters/greeters in an area separate from the domestic baggage claim area may provide advantages in

crowd management by separating the two crowds. Otherwise, as described in the baggage claim section of this report, designers need to consider incorporating elements that will separate meeters/greeters from travelers actively claiming bags as well as amenities for the comfort of domestic travelers' meeters/greeters.

International traveler arrival halls are typically provided in US airports, and they tend to create large crowds. The best way to reduce these crowds is to provide reliable information about international traveler arrival time after customs screening, although this becomes an information systems strategy rather than a facility design strategy. Such information will enable travelers to utilize shopping, food, and beverage options as they monitor their "free" time, as well as better match meeter/greeter airport arrival time to when the traveler may actually exit the secure side of the airport.

Airports can consider arranging furniture such as planters and benches or columns and half walls to cue waiting travelers and their meeters/greeters on places to wait, sit, or avoid. Encouraging travelers' meeters/greeters to wait outside of the airport or in a specific meeter/greeter area will minimize the number of people gathered around the baggage claim devices. This can be done using low-cost monitoring systems and signage, as well as posting the information on the official airport website.

1.3 Wayfinding and Signage

Airports have several objectives for directing traveler flows in predictable ways using intuitive wayfinding and signage. Airports want to minimize the buildup of crowds and congestion, mitigate the safety risks that occur at pinch points, guide travelers to and from the gate, have well-wishers leave when their business is done, and accommodate operational changes during construction.

Travelers, on the other hand, have different needs to fulfill from wayfinding and signage:

- Orientation or "Where am I?"
- Route decision or "How do I get where I want to be?"
- Route monitoring or "Am I going the right way?"
- Destination recognition or "Have I arrived in the right place?"

Wayfinding in this document refers to spatial problem solving using architectural design; in other words, how can the physical layout assist a traveler in finding their way to their destination.

Effective wayfinding and signage will address the motivations of both the travelers and the airport.

"If you've seen one airport, you've seen one airport" is a popular saying in the aviation industry, and for good reason. Each airport has a unique layout and features within that layout; wayfinding that works in one airport may be impractical or impossible at another. However, the following discussion should provide recommendations and considerations that will work for airports of any size and layout.

Consider a given airport layout in terms of intuition zones:

Where are the decision points? Do travelers need to decide to change direction to travel to their destination? Do travelers need to decide whether to take the escalator or the elevator? Will travelers need to pass through security to grab something to eat? Decision points like these will help determine how travelers walk and congregate throughout the non-secure side of the airport.

Where are the confusion points? Is the men's restroom logically located and identified near the women's restroom? Are there family/disability restrooms? Are common-use check-in kiosks identified

clearly as common use? Are the entrances to queues easily found? Confused travelers may stop to orient themselves, potentially causing backups in the flow of traffic.

Where are the waiting points? The most obvious is the traveler waiting in a queue: a queue to check bags, a queue to buy concessions, or a queue to pass through security. But there are also meeters/greeters (family and friends) that wait in the public areas for their parties to exit the secure side of the airport. The baggage claim area and curbside also serve as waiting points, and crowds gather in predictable waves, which correspond to flight schedules.

Distinctiveness is a key requirement for effective wayfinding. This can be as simple as using finishes, light, colors, graphics, and other architectural and decorative elements to enhance areas and create distinctive landmarks. These landmarks can be picked up by virtually everyone, including persons with low vision.

The use of path markings will greatly enhance the wayfinding of the airport. These paths may be simple, such as using different textures or materials (e.g. carpeting versus tile) and ceiling or floor illumination. Both options will provide wayfinding assistance to persons with low vision; different floor materials provide tactile and aural cues to people walking or using a cane, and many persons with low vision retain some ability to perceive light levels. Rubberized compound with hatched markings is commonly used in rail stations to identify hazards and could be used in airports to alert travelers to a step or escalator up ahead. Using different textured floors will also discourage travelers from standing and waiting in heavily trafficked areas. Partitions or temporary blockades can provide clear directions to travelers, but planners should always provide a detour option.

When choosing and using colors, keep in mind that 9% of males and 2% of females are color blind, particularly with reds and greens.

Up to 50% of older adults have trouble distinguishing various hues of light and dark colors.

Signage in this section refers only to non-digital signage or "static" signage.

Several studies have proven that people do not read signs the way they might read a book, i.e., left to right, bottom to top, and each written word. In fact, many people read signs at a glance and signs that require someone to stop and read may result in a bottleneck or congestion. The most effective way to avoid this is to limit the amount of information that must be absorbed by grouping information in threes. An example of this is shown in Figure 9. Notice how the sign on the right is easier to comprehend at a glance.

Figure 9. List of locations vs locations grouped into threes

Administration Cafeteria Cashier Elevators Information Maintenance Pay phones Security Washrooms	Administration Cafeteria Cashier Elevators Information Maintenance Pay phones Security Washrooms

Source: Wayfinding: People, Signs, and Architecture, 2002

Rethink the design of signs with multiple destinations if they cannot be understood with a glance. Signage should treat information as a hierarchy: information that directs people to large destination zones, such as security checkpoints, should be given more prominence on signage than secondary or tertiary information, such as individual gates. As the traveler moves toward their destination, the information on the sign should become more granular and specific in nature.

Effective signposting will quickly orient visitors to the facilities and direct them exactly where they want to go. This clarity of information will keep bottlenecks to a minimum. In terms of communication, fewer signs make for better and more effective signage, especially in areas where there is already a lot of activity.

Applying a consistency in design—such as color, sign location, or graphics—will reduce the possibility of information overload and confusion. For example, painting the vertical circulation (stairs, escalators, and elevators) bright yellow and then having all signs associated with the vertical circulation the same color will clearly define the vertical circulation locations.

The legibility distance is one factor that determines the effectiveness of the sign's placement and will dictate the size the letters must be in order to be perceived and recognized. Under ideal conditions—no angular distortion, perfect lighting, no glare, and 20/20 vision—the legibility distance is 50 feet (15 m) per inch (25 mm) of the height of a capital letter. In other words, 4-inch letters can be seen at a distance of 200 feet.

When designing signage for persons with low vision, it is important to use strong colors and contrasts and, when possible, pair the visual signage with non-visual sensory information. Installing tactile signage that includes Braille or raised letters is beneficial but is only useful if the person who is blind or has low vision knows the signs are available and can read them.[3] However, these signs are virtually useless in the case of an emergency. Also, keep in mind that there is a social stigma surrounding tactile exploration; travelers who are blind or have low vision do not want to explore every wall and door to locate signage. A best practice is to pair visual signage with an audible message.

Persons with physical disabilities may also have difficulties with signage. Reflection and glare is often accentuated from wheelchair perspective and from the hunched-over perspective when using crutches.

Signage location will be heavily dependent on the layout of each individual airport, but the best practice is to have four signs per intersection—regardless of the configuration—to provide maximum visibility in all directions.

Signage on the floor may also be beneficial, but of all the possible locations for signage, the floor is the least recommended due to wear and the potential to be obscured in congested areas.

> There are several resources that describe details of wayfinding and signage development, including ACRP Report 52: *Wayfinding and Signing Guidelines for Airport Terminals and Landside*. For a more in-depth discussion, please review that document.
> For detailed information on providing services to travelers with disabilities, please review ACRP Report 177: *Enhancing Airport Wayfinding for Aging Travelers and Persons with Disabilities*.

It has become increasingly common for airports to install digital signage throughout the airport because digital signage messages can be customized. Digital signs have potential for distinctiveness, and therefore high impact, and have several benefits, such as improving safety, facility navigation, and operations, and enhancing travelers' experiences.

Improved safety: Unlike static signage, digital signage can be quickly updated or changed in real time, and several signs can be changed at once from a single location. This allows the signage to be quickly updated with emergency notifications.

Improved facility navigation: Touchscreens offer travelers an interactive way to navigate large facilities.

[3] The assumption that all persons who are blind can read Braille letters is false. Only 10% of the blind population can read some Braille. Raised letters can be read by a larger portion of the population.

Improved operations: According to a 2002 study in hospitals, 8,000 professional hours are lost per year to redirecting patients and visitors to their destinations. Using digital signage throughout the airport would quickly direct travelers to open counters and queues, warn of construction, and provide other important information while freeing airport employees for other duties.

Enhanced traveler experience: Many customers have come to expect technology as part of their daily lives, and their travel journey is no exception. By providing real-time updates on arrival/departure times and cancellations, news, weather, and entertainment, digital signage can reduce travelers' stress, alleviate perceived wait times, and even increase concession revenue because travelers do not fear missing their flight.

> In 2012, San Francisco International Airport installed several interactive wayfinding kiosks on the secure and non-secure sides of their terminals. The kiosks are location-smart and connect to a variety of systems and data sources to reflect the current environment of the facility, such as construction.

When adding digital signage to an airport, large screens are not necessarily more effective at delivering a message. Sometimes a series of medium-sized screens (22–32 inches) strategically placed around an environment and slightly above eye level is visually louder. Innovative display designs can quickly become iconic landmarks and potential meeting/rally points, such as The Flower structure at Toronto Pearson International Airport (YYZ), shown in Figure 10.

Figure 10. The Flower at Toronto Pearson International Airport

Source: Digital Signage Connection, 2017

Digital signage can be stationed along connecting roadways and curbsides to provide motorists with updated information. Notifying them where to detour will help keep the access ways clear for emergency vehicles and first responders.

2. OPERATIONS STRATEGIES – TECHNOLOGY, INFORMATION, AND COMMUNICATION

Innovative technology is becoming more common in the aviation industry. Futurists—scientists who study future possibilities and predictions—foresee a time when air travel will be a seamless journey through the airport; travelers will have a single ticket or token tied to their unique biometrics that serves as parking lot, air carrier, and baggage ticket. There will be mobile apps to tell travelers how long it will take to reach the airport from their house, how long they can expect to wait to travel through security, and allow travelers to track their bag as it travels through security and onto the plane. Checking bags, boarding planes, and accessing lounge areas will be completed via biometrics.

There are several examples of technology currently being used at US airports. The Houston Airport System released its turn-by-turn wayfinding technology that does not require an app. Digital and dynamic wait-time signage is used at several airports, including ATL. ATL and DEN are testing fingerprint scanners at TSA's PreCheck security lanes, and the CLEAR program claims to speed enrollees to the front of the security line with "a tap of the finger or blink of an eye" using fingerprint or iris scanning to verify a traveler's identity. The Société Internationale de Télécommunications Aéronautiques (SITA) and LG have both created robots designed to perform specific functions in an airport, including robotic self-bag checks, robotic kiosks, customer service robots, and cleaning robots.

Investing in new technologies has several benefits. It enables faster processing at the typical bottlenecks in the traveler's journey through the airport, reducing congestion. Technology provides travelers and employees with more information, minimizing confusion that could lead to crowds. It allows airports the ability to facilitate the improvements that are constantly required by the TSA and other regulatory agencies. Strategic deployment of some technologies may reduce the number of staff needed for a particular responsibility, freeing them to move to another area to assist travelers. Additionally, technology can be customized to improve daily and emergency operations strategies.

Innovative technologies can be leveraged to prevent or diffuse congestion in virtually all areas of the airport, for both processors and connectors. Astute use of technology even has the potential to mitigate potential threats from a secondary attack by providing airport operators and emergency personnel with up-to-date information.

Despite the innovative technologies that are currently available, not all airports will want to or be able to take advantage of the technology due to budgetary limitations, conflicts with currently installed technology, or physical layout restrictions. According to some experts, this situation is not necessarily a bad thing; some travelers prefer to talk to a person instead of using a mobile app or robot. All airports must use reliable, tested systems because in many cases, glitches cause huge complications.

When analyzing the need to add or update technology in the airport, it is important to keep in mind that older generations of technology, such as CCTV and FIDS, may not integrate well—or at all—with newer technology. An assessment should be made on how the existing systems will integrate and work with new technology.

In all situations, the technology should adapt to the workflows of the people using it, not the other way around. These workflows should be based on the airport's policies and procedures to ensure compliance and accuracy.

The following sections are divided into internal and external stakeholder systems; that is, systems designed to connect, inform, and interact with the people that work within the airport facility (internal

stakeholders) and the members of the public (external stakeholders). Generally, systems designed for internal stakeholders will not be used to communicate with external stakeholders. However, external stakeholder systems are often used to also communicate with internal stakeholders.

2.1 Internal Stakeholder Systems

Internal stakeholder systems are those devices that connect and inform internal stakeholders such as airport employees, air carrier employees, TSA officers, vendors, and first responders. In general, information gathered or disseminated using these systems are either sensitive in nature or may cause a panic if the public were to learn the details.

2.1.1 Radios

While radios may be considered legacy equipment, they are the most common technology used for airport communications. Radios include anything from commercial walkie-talkies to highly customized trunked systems. They are small and handheld/wearable, making them relatively portable devices. In addition, they do not rely on carrier signals to communicate, although there are always possible dead zones within the airport space. Some of the more advanced devices offer geolocation options.

Radios are often reliable, but many older systems can quickly become overwhelmed if too many users are accessing the system at the same time. Especially in time-sensitive situations, it is important that all transmissions are received and clearly communicated. When multiple people transmit on the same channel at the same time, the result is often that none of the transmissions are received clearly. Fortunately, more modern radio systems provide priority lock-out and related features to reduce or prevent this from happening.

> During the active shooter incident at FLL in January 2017, the radio system became saturated and periodically overwhelmed due to the large number of users attempting to use the system at the same time.

One solution to prevent overwhelming the radio system is to have dispatchers create talk group channels for each responding agency and leave the main channel open for agency leaders to coordinate within. Airports can create a fleet map of all radio channels to keep track of which agencies are on each channel and ensure that commanders have unique call signs for quick identification.

2.1.2 Cellular Phones and Mobile Applications

Many airport and air carrier employees, and most workers at the airport, do not regularly carry a radio. Cell phones and mobile apps are one way to supplement radios and walkie-talkies but are restricted to areas with Wi-Fi and/or cellular data service. However, these applications may provide options for airport operations managers to contact airport and air carrier employees who do not carry radios.

> During Hurricane Harvey in August 2017, mobile communication applications were used by volunteers to coordinate rescue efforts.

Each application will have its own features but will often be able to support dozens to thousands of users simultaneously in the same conversation, have the option to support channels to divide smaller conversations, and support multiple languages.

Other applications support text communications between large groups. These are best used before a planned event (such as a demonstration) but could also be used by airport operators to communicate during normal operations.

> Before the Charlottesville protests on August 12, 2017, Charlottesville business owners used a mobile group messaging application to share information about the planned event.

It is important to note that the applications must not be used as a replacement for radios but are intended to supplement the existing technology. Mobile communication applications will not work if the Wi-Fi or cellular towers are overloaded or disrupted.

2.2 External Stakeholder Systems

External stakeholder systems are devices and systems that connect, inform, and interact with the public and internal stakeholders to reduce congestion and crowds.

2.2.1 Identification Technologies

While increasing the number of security lanes may improve processing, it is costly and many airports will not have the available space or resources. However, there are other ways to increase traveler throughput without having to remove walls.

Enhancements to travel document verification, such as automated ID control technology, may help expedite the process of moving travelers through the security checkpoint, reducing the number of officers and wait times.

Biometric technologies currently being tested at airports offer travelers the option to use fingerprints and/or iris scanning to verify their identity, instead of requiring a TSA officer to compare the traveler to an identification card and the name on their boarding pass. Surveys have also shown that 57% of travelers would rather use biometric tokens to pass through security than a passport or boarding pass. As of 2017, this biometric technology is still in the pilot phases with only a handful of participating airports, but the ultimate goal is to reduce travelers' time spent interacting with the TSA officer and the time spent waiting in queues.

> Dubai International Airport has developed a virtual aquarium tunnel to assist with the security screening process. The tunnel is equipped with 80 hidden cameras designed to scan the faces and irises of the travelers passing through and admiring the display. If the traveler is registered (similar to TSA's PreCheck) they will be permitted to continue through the security lane. Unregistered travelers will have their identity verified by a security agent before passing through the security lane.

2.2.2 Trained Canine Units

Bomb-sniffing and vapor wake dogs have the ability to increase the processing times at security screening checkpoints because they do not need to inspect each traveler. Instead, the dogs are trained to sniff out specific chemical scent signatures that could indicate explosives in the area, including gunpowder. Travelers who submit to a canine screening are allowed to pass through expedited screening without having to take off shoes or belts, thus shortening queues and reducing crowds.

2.2.3 Public Address Systems

Just as radios are the mainstay of internal communications systems, public address (PA) systems are the most common method for one-way communication with external stakeholders. They use proven technology and relatively simple components. Most airport systems allow messages to be targeted to specific areas or broadcast widely throughout the airport.

The speech intelligibility of a PA system relies on the architectural design (room acoustics, ambient noise, room shape, and room volume), the announcement quality (user training, user operation, and other human factors), and the overall PA system design. Reducing the ambient noise will increase the intelligibility of the PA system.

Airports with high ceilings (more than 24 feet high) should work with professional system designers, as the volume of the room and the resulting reverberations will make a high level of speech intelligibility difficult to achieve. Filling the space with structures and furniture will help lower the reverberations but may not increase the speech intelligibility.

Messages spoken over the PA system should be clearly stated and clearly spoken, using keywords or "hooks" at the beginning of the message to draw the attention of people in the area. The message should also be repeated immediately after the initial announcement to ensure listeners have heard the entire message and can process the information. The message should be consistent with any digital signage in the area. It should be clearly stated if the information presented is a change to previously given information.

The words should be enunciated and spoken at a measured pace (about 120–150 words per minute); recent human factors research has shown that females are typically more intelligible speakers, possibly because females tend to have better diction and timing. If possible, airports can prerecord messages; this will not only save time during an emergency, but a calm, clear voice will be reassuring to a panicked crowd.

> For more information on designing PA systems, please review ACRP Report 175: *Improving Intelligibility of Airport Terminal Public Address Systems.*

Code words are especially useful if using the PA systems or radios to communicate with airport staff without alarming the traveling public. However, overusing code words may allow travelers that visit the airport often to recognize and interpret them.

2.2.4 Telephones

Information telephones have the potential to provide persons with sight, hearing, and literacy disabilities with a robust amount of information by using prerecorded wayfinding information or staffing the information line with information specialists. Using staff who can speak multiple languages or prerecording the messages in multiple languages will also support the airport's foreign travelers' journeys. If the airport decides to install specialty telephones for this purpose, or plans to upgrade the existing telephones, the headset should contain a magnetic flux coil to be accessible to persons using hearing aids, it should have a volume control, and it should not be situated closer than 15 feet to a fluorescent light as it may interfere with reception.

If installing new or upgrading existing telephones is not feasible, airports can consider adding a Telecommunication Device for the Deaf (TDD)-enabled phone in the operations center so that persons with hearing or speech disabilities can call ahead of time to obtain important accessibility information.

2.2.5 Beacon Technology and Mobile Applications

Beacon devices are simple devices with many potential uses. The devices themselves are usually no bigger than a common light switch cover, but they transmit a Bluetooth signal to any Bluetooth-enabled device (such as a smartphone) that moves within range (about 230 feet). These signals can trigger a relevant message that directs travelers to specific areas of the airport or provide information on gate changes and flights. In addition, the devices are relatively low-cost—with one manufacturer offering three devices for US$99—and can be installed quickly with no damage to walls if using damage-free hanging strips.

There are multiple ways to utilize beacon/Bluetooth technology within a terminal. One option is to simply push information based on the user's location, such as discounts at nearby stores and waiting time at restaurants. More complex options would provide turn-by-turn guidance through the terminal, similar to Google Maps. These beacons could also provide airports with information on how travelers navigate through the airport.

Mobile applications can be specifically designed for your airport. These can include wayfinding options that provide a map of the terminal with gates and stores marked on the map, coupons and discounts for vendors in the area, or a combination of options. When developing these applications, ensure that information on amenities available to persons with disabilities is easy to find in the application and locate in the terminal. Information on processes as well as geographical information will help persons with disabilities and travelers who are new to the airport or to traveling.

> YYZ has partnered with MagnusCards to offer a mobile application that provides digital how-to guides to people with autism and other cognitive disabilities. These guides provide step-by-step instructions on how to navigate different parts of YYZ and includes tips on how to check in to an air carrier, get help or ask questions, go through US Customs and Border Protection (CBP), and other helpful tips. The guides are offered in English and French and feature pictures, text, and audio.

An airport should consider whether its mobile application will require Wi-Fi or data to function correctly. An application that does not require real-time data to function can be considered if the airport does not offer free Wi-Fi.

2.2.6 Digital Displays

Some digital displays have the option of embedding a beacon or Wi-Fi hotspot. The benefit to this option is that it eliminates the need to place additional beacons and hotspot devices around the facility.

Passive radio-frequency identification (RFID) technologies, when embedded in strategic locations throughout the airport, and struck with a compatible walking cane or activated with an RFID chip attached to a guide dog, would provide wayfinding information to a person who is visually impaired.

Displays owned by the airport and connected to the airport's network should be incorporated into the airport's integrated communication platforms (ICP) or web-based emergency management collaboration tools (WBEMCT) to allow for quick deployment. If the airport does not have an ICP or WBEMCT, the

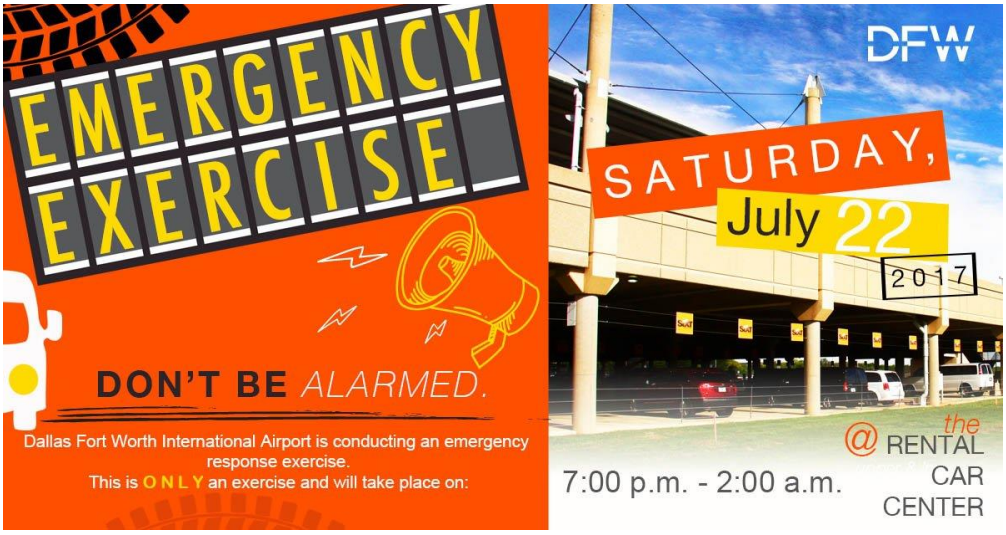
tool that allows the airport to change the display message should be quick and easy to access. This means that passwords should be stored in a place accessible to employees who need them.

2.2.7 Social Media and Websites

Social media platforms allow airports to connect with travelers by providing opportunities for two-way communication in real time. This allows for immediate interaction between the travelers and airport operators in ways that press releases and announcements do not allow. Travelers often reach out to the airport on social media to ask about facilities and services, or to provide feedback. Airport operators can leverage these interactions and the social media platform to advertise new concessionaires, offer discounts, and promote special events and contests. In addition, social media can be used to update followers on the status of ongoing projects, communicate ground traffic delays, and provide updates during crises.

Some travel experts believe that social media is replacing older traveler communication models such as PA systems and digital screens. Social media is undeniably becoming more widely used in the aviation industry—nearly a third of airports worldwide maintain at least one social media account—so it is important for airports to understand how to leverage these platforms during emergencies as well as during normal operations. An example of a tweet about Dallas Fort Worth International Airport's (DFW) emergency exercise is shown in Figure 11.

Figure 11. Notification of DFW's Emergency Exercise via Twitter



Source: @DFWAirport

There are several social media management tools to help airport operators manage and maintain their social media accounts. The features of these tools vary, but most offer the ability to schedule and publish posts, messages, and announcements; monitor public conversations that contain key words; and provide analytical and tracking capabilities. Some ICPs and WBEMCTs also offer these capabilities.

Some social media platforms have a character limit for posts; most notable is Twitter's 280 character[4] restriction, excluding account handles and external links. This can prove troublesome for airports that need to provide more information than the character limit allows. One way around this restriction is to

[4] For reference, this entire paragraph is 508 characters.

turn the information into an image file and upload to the site. The site's users will be able to open the image and view the entire message.

Your airport's website(s) should provide information to help travelers with disabilities determine how best to journey through the airport and the required processes. It is vitally important to include information on accessibility on the official airport website. This should be easy to find or search, not hidden under a dropdown menu or as a link on a separate page. The information presented should be specific when identifying all the amenities available to the public, including wheelchair access, service animal relief areas, quiet and sensory rooms, technology available for rent, tactile or audible signage, transportation systems, and any other facilities or services. Airports will need to be cautious about using the term "fully-accessible"; many organizations claim to be fully-accessible, but are only wheelchair accessible. It is also important to note any information about inaccessibility, as it allows travelers with disabilities to plan accordingly.

2.2.8 Bullhorns and Messengers

Sometimes, solutions that rely heavily on technology—or simply electricity—are rendered less useful by circumstances, such as power outages. In these cases, solutions that do not require any infrastructure may be invaluable.

Bullhorns and similar devices (e.g., megaphones) are useful backups for more advanced communication technologies. They are light, portable, and can project the user's voice across large spaces. However, their usefulness may be dampened if the user is having to compete with other loud noises such as alarms and sirens.

Using personnel fluent in sign language as messengers may allow the message to reach a wider audience.

2.2.9 Notification Systems

Notification systems allow airports to quickly send information to a large group of people, generally in the form of a text message or a push notification. The target audience can be a clearly defined group, such as internal airport stakeholders, or a large and undefined group, such as everyone inside the airport terminal. Notification systems are often linked to the airport's social media pages, allowing airports to inform an even larger audience about events happening at the airport.

When determining the content of the message, it is important that the information is timely, accurate, relevant, and accessible to the target audience.

Timely: When possible, the use of pre-recorded or pre-approved messages will allow airport operators to send information quickly. It is particularly important that the airport be the first to notify the public about an on-site emergency; this practice allows the airport to become the authority on the situation rather than the news media or affected travelers.

Accurate: The best notification systems have the ability to send photos and maps to the target audience. In addition to text, these graphics give information for the audience to act on more readily, especially during an emergency. Airports should always review the content of the notification before sending it to avoid spreading misinformation and misunderstanding. This is especially true when sending information to first responders and LEOs.

Relevant: Messages should be directed and specific to the target audience. The messages should be directed to impacted locations, but airports should also consider the possibility that push notifications to an entire area may give attacker(s) information that could help them with their plan. Airports should consider how much to tell the general public about the situation, as sharing too much or not enough information can possibly create additional panic or negatively impact an unaffected population.

Accessible: The message must be clear and concise with specific actions or instructions. Every message should be comprehensible to anyone at a 6th grade reading level or lower, which means there should be no uncommon words, phrases, acronyms, or long sentences. The only exception to this rule is if the messages are being directed to an audience that would understand industry-specific jargon. Airports should always proofread all messages before hitting Send.

When using multiple methods to notify affected stakeholders (text messages, PA system, digital signage, social media, etc.), airports should make sure that the message is consistent; assuming that the target audience is receiving notifications from several methods, inconsistent information will not only confuse them but possibly put them in harm's way.

The airport can consider how to use the notification system during non-emergencies. The benefit to this is two-fold: using the system outside of an emergency is an excellent way to train employees to both send and receive messages, and it ensures that planners have up-to-date contact information for airport employees.

FEMA's Integrated Public Alert and Warning System (IPAWS) allows for the distribution of Wireless Emergency Alerts (WEA) to smartphones in a designated area, such as the airport. Cities and counties are able to send these alerts on the behalf of the airport, but there is usually a significant delay because the city/county must approve the message before sending. One option to reduce this delay is for airports to apply for permission from FEMA to send public alerts (see Figure 12). For more information on applying for access, please visit www.fema.gov/how-sign-ipaws.

Figure 12. How to Sign Up for IPAWS Access

Source: FEMA

For more information on notifications systems, please review ACRP Report 170: *Guidebook for Preparing Public Notification Programs at Airports.*

2.3 Data Mining

Data mining is a powerful tool to help organizations focus on the important information that has been gathered about their customers' behaviors.

Data mining tools predict behaviors and future trends of a large group of people using large stores of data. Using data mining techniques will allow airports to make informed decisions about potential

security implementations and how each one may affect operations and customer service. Models are used to organize the data and turn it into useful and actionable information.

The key to accurate data mining and scraping information is to start with good data. This can be done using high tech analytics software, or simply stationing a person to count travelers passing through processors. As long as good data goes in, useful data will be returned.

2.3.1 Time and Space Data Collection

As computing capabilities increase and costs decrease, airports are finding more ways to use real-time or near-real-time data to make operational decisions. Of course, data cannot be used unless it is collected and processed to develop useful information.

Collecting time and space data at the airport does not require specialized software and top-of-the-line cameras. If the airport does not have the infrastructure or the budget to update existing systems or acquire new technology, there are low-tech and non-tech ways of collecting valuable information about how travelers move through the facility.

Several airports utilize the TSA's traveler throughput data, which is collected throughout the day. This data is typically gathered using hand counters, but some airports are using video analytics. While this data is useful for airports to get a general idea of the number of travelers in their airport during certain periods, it does not account for other people in the airport, such as meeters/greeters and other airport visitors. Airports will gain more benefit from conducting their own throughput data studies using data collectors or analytic software tied to their CCTV system.

> Disney has some of the most advanced methods of monitoring and tracking guests to their parks, but even Disney validates their wait time measurements using low-tech RFID readers. Customer service representatives hand an RFID-embedded card to the last guest in a queue, which is scanned once when it is given out and again when that guest reaches the front of the line. Disney does this several times a year to improve their processes.

Another way to collect data is by "scraping" it from a variety of sources. For instance, traffic congestion on the airport roadway could be monitored using dedicated sensors, or the data may be readily available from an app being used by drivers (e.g., Waze or Google Maps). Several apps provide application programming interfaces that allow other programs to read the information that they have collected, and can function as virtual sensors that do not require additional infrastructure to be useful to the airport.

2.3.2 CCTV and Video Analytics

CCTV is a unique type of technology in that nearly all airports have some form of CCTV system already in place, usually as part of their security solution. While new technology may allow an airport to extend the useful service life of their existing CCTV system, many new technologies require the use of more advanced CCTV cameras to function effectively, and some airports must consider the cost of replacing their existing system to accommodate the new technology. When the system needs to be updated, whether to meet the standards of new technology or simply to replace outdated systems, there are a few things airports should consider:

Dashboard Interface: The camera and view control interface (sometimes called the dashboard) should be efficient. If installing a new system to meet the standards of another technology (such as active shooter

detection systems) this may not be as important because the additional technology may provide this dashboard. The camera feed should accurately reflect the date and time of the images being shown.

Monitors: The planned workload will determine which monitors to procure and the number needed. The monitor-to-operator ratio, size of each monitor, and viewing distance should be considered. Also, the ambient lighting, room temperature, and noise level may affect which monitor type and the number needed for the control room environment.

Cameras: The most obvious consideration is the number of cameras needed to cover the entirety of an area, but consideration should also be paid to the panning, tilting, and zooming capabilities of those cameras. Considerations include whether the camera can swivel 360° or if it is static; more static cameras may be necessary to cover a specific area. If the cameras will connect with another technology, planners should be aware of the quality of the screen capturing; some facial recognition software require high-resolution cameras to work effectively. Attention should be given to whether the recording process is utilizing image compression technology (which could result in lower quality images) or a live feed.

Once CCTVs are installed and running, they should be properly maintained. Airports should consider the optimal placement of lighting fixtures to be out of CCTV camera line-of-sight to avoid glare or lens flare, while providing adequate lighting of the area under surveillance.

Small or seasonably busy airports will gain more cost benefit from simple technologies such as infrared or thermal cameras that estimate waiting times and traveler throughput than more expensive technology that accurately counts queuing travelers. Heat maps created from infrared and thermal cameras can visualize the density of a given area, allowing operators to deploy crowd disbursement methods in a timely manner.

Video analytics sort, distill, and analyze data recorded by CCTV cameras and other sensors to help operators predict the best course of action. An effective video analytics software is optimized to detect things (e.g., luggage) and people. More sophisticated solutions are now calibrated to distinguish people who are sitting, walking, or running, and to ignore interferences such as shadows. Object detection analytics can alert airport operators about inadvertently left-behind or suspicious objects, or intrusions into restricted areas. These alerts can be calibrated to recognize the difference between a person who is making a phone call and one who is acting suspiciously, or identify areas that are becoming overcrowded.

Video-based people-tracking software enables airports to count travelers throughout their journey. These may help airports increase the efficiency of their queues and mitigate crowds while determining wait and processing times and resource utilization. The historical data accumulated from these people-tracking systems may provide evidence for planning and investment decisions.

> Dubai International Airport successfully reduced waiting times by 10 percent in 2017 using data analytics to optimize their queuing operation.

2.3.3 Social Media Monitoring and Listening

As discussed in Section 2.2.7, social media presents both opportunities and challenges to airports. Both should be considered when deciding how to integrate social media with operations.

Hashtags can be utilized to identify when travelers are discussing the airport, whether the user is giving feedback or is sending information about an incident. They can also be used by the airport to give updates on a situation.

Social monitoring addresses individual brand mentions on social media. *Social listening* collects data from all social media mentions and customer conversations for a broader discussion on the brand.

In 2016, wild fires in Fort McMurray, Alberta, Canada forced the largest wildfire evacuation in Alberta history. The nearby Edmonton International Airport (YEG) tweeted information about the wildfires using the hashtags #YMMFire[5] and #YEG to provide updates on the situation to users following those hashtags.

It is a best practice to tag other relevant users when discussing major incidents and to link to other websites that offer more information. User tagging (@username) is available on most social media platforms and will give followers another source of information (e.g., tagging your airport police during an incident). Add links to other sites using a URL shortening services such as https://goo.gl/ and https://bitly.com; this will be especially helpful if posts are character-limited.

A hashtag (#) allows social media users to apply custom tags to posts (messages, videos, and images) for other users to find content with a specific theme. Many airports use hashtags to gauge their impact on social media sites and to elicit feedback.

Airport management must evaluate the appropriateness of each platform for their airport as the popularity and use of each changes and new platforms enter the market. Airports just starting to use social media should master one platform before moving to another platform, but with one caveat: airports should create an account on every well-known platform using a consistent username (e.g. @DFWAirport) and the same profile image/logo for each. Even if the airport does not actively use the platform, this practice will help prevent unauthorized persons from misusing the airport's brand or posting under its name. By doing so, the airport will avoid trying to create an account at the time of an emergency. Log in information for each account should be stored in a place where authorized personnel can access it when needed.

In general, it is much more effective to use at least one person (preferably an airport employee and not an outside resource) to monitor the airport's social media presence during the airport's operating hours. This person is often the airport's Public Information Officer (PIO), but not always, and larger airports may have teams that are dedicated to social media channels.

Given that airports run outside of the traditional workweek, it is better to have at least two people assigned to monitor the sites, although one person may not be dedicated to the task. If this two-person operation is not possible, setting up a social media management tool will help alert social media resources outside of their work hours.

[5] YMMFire refers to the airport code for Fort McMurray International Airport (YMM).

2.4 System Connectivity and Compatibility

Airports should consider how their systems connect the different technologies within their facilities. The most common methods of connecting technologies throughout a facility is through an ICP or a WBEMCT. These tools are useful because they tend to overcome many of the shortfalls of simpler technology while making more complex technology accessible to almost anyone. They also allow notifications to be sent to multiple people via a variety of message methods, such as text, pre-recorded announcements, and social media posts.

It is important that these systems work together in an effective and coordinated manner, and that they are accessible to all departments and agencies involved in airport normal and emergency operations. Airports deploying these systems should ensure that the dashboards are customizable and configurable to work with their existing policies and procedures; rewriting SOPs is more difficult, time consuming, and costly than configuring the software to work within the existing constraints. Airports should work with their chosen service/software provider to customize the system and train the appropriate employees, especially the IT department and other system administrators.

> For a more in-depth discussion of ICPs and WBEMCTs, please review ACRP Report 112: Guidebook for Preparing Public Notification Programs at Airports and ACRP Report 94: Integrating Web-Based Emergency Management Collaboration Tools into Airport Operations – A Primer.

Critical system failures often create congestion and chaos. Additionally, the failures have quantifiable costs to the airport's reputation, of traveler disruption, and of resuming operations. This is true of all systems, including public area communications and electrical systems. Should one system fail, such as the radio system or primary power system, there should be other methods in place to communicate and activate security protocols.

> In May 2017, British Airways suffered a complete computer system failure when the power supply was disconnected from the air carrier's servers located in an offsite data center. This necessitated Heathrow International Airport to communicate to the public on the air carrier's behalf. Thankfully, this was a human error and not part of a nefarious plan by attackers, but the important lesson learned from the event is to have redundant notification systems in place to communicate with stakeholders.

When shopping for new technologies to support an airport's policies and procedures, there is an inclination to connect as many systems as possible to make deployment of emergency operations quicker. However, there are several reasons to be wary of this thinking. Airports should consider their backup plans if the primary network is hacked or fails. Technology should serve as a force multiplier and should not be the sole method of prevention and protection.

> During the active shooter incident at FLL, LEOs used hand signals, runners, and cell phones in addition to the radio system to communicate.

Small emergency kits stationed throughout the airport with items such as bullhorns, backup radios, and maps may aid airport employees and LEOs if the primary method should fail.

3. FINANCIAL AND LEGAL STRATEGIES

This section of the document is intended to offer general guidance regarding administrative concerns associated with investment in the need to manage crowds in public areas of the terminal, as well as legal considerations. Project finance requirements and airport governance at US airports are diverse; therefore, the guidance offered here is general.

3.1 Financial Tools

Security is an overarching priority at airports. However, justification of investment in prevention of consequences for emerging threats, given the competition for investments in operations and customer service for typically constrained budgets, can be challenging. A solid case for justification of the investment—based on brand appeal that results from a holistic approach to customer service, operations, and security—will keep airport customers happier and safer as they complete their journey. The recovery costs and the damage to an airport's reputation can be immense if it fails to prevent or respond adequately to disruptions resulting from attacks by bad actors, equipment or technology failures, or chaos created by nature.

As with any major investment, the capital and ongoing operational costs of security implementations must be based on a thorough planning and prioritization process that properly accounts for both the cost and benefits of the project. Investments in technology and upgraded equipment will almost always reduce associated resource and general operational costs. For instance, investing in common-use self-serve kiosks with biometric scanners in the check-in lobby will allow check-in agents to move around the lobby, assisting confused travelers while also maximizing the available kiosks for the airport's air carrier tenants.

Justification for projects that produce outright savings in operations costs is relatively straightforward. However, security projects designed to prevent circumstances that, fortunately, have an extremely low probability of occurrence but, unfortunately, have huge direct and indirect cost of consequence, will typically require project justification explicitly addressing risk of occurrence and resulting financial consequence, especially with a constrained annual budget.

The types of investments this guidebook recommends include both brick-and-mortar or facility changes as well as operational changes and investments in technology. Since airports in general are systems-of-systems, and public area security projects are also systems-of-systems that touch many stakeholder groups at the airport, it is important to consider the costs and value to each of these groups as part of the financial justification.

The most important tools to determine whether an improvement to technology, equipment, or training is cost effective are Process Analysis and Value Stream Mapping, ROI analysis, and the Effort-Impact Analysis. Performing these analyses for each security project under consideration will ensure that funding is appropriately allocated and justified to meet the short-term and long-term security and operational goals of the airport.

Using these justification tools will likely result in a proper evaluation of the holistic costs, benefits, and risks of these projects, making their timely implementation more likely. Expeditious approval of these projects will reduce the opportunity for dangerous actors to attack crowds within the public area of the airport.

For more information on informed financial planning tools, please review ACRP Report 120: *Airport Capital Improvements: A Business Planning and Decision-Making Approach.*

3.1.1 Process Analysis and Value Stream Mapping

This approach develops a detailed analysis of the current and proposed activities that take place as a result of a proposed new facility, technology, and operation by each stakeholder involved in that operation. The map is similar to a simple flow chart except the activities completed as part of the overall process by each stakeholder are represented by the stakeholder's own swim lane. This approach requires the detailed mapping of both the current and proposed processes. The process analysis is a step-by-step map of the flow of the materials/data, the flow of information, and the flow of people required in a process. The map is also a vehicle to attach total cost of operation information for each step in the process. Similarly, in the case of security projects, it is also a good vehicle to document risks associated with each step in the process. Therefore, as stakeholders collaborate in documenting the overall current process, the hand-offs between groups appropriately represent the complexity (and costs) of delivering results.

After the process is properly documented, a Value Stream Map (VSM) is created. Frequently, a VSM is constructed using butcher paper and Post-it notes (see Figure 13). The colors and shapes in the VSM are used to convey specific information about the process.

Figure 13. Example of a Value Stream Map

The VSM is populated with information such as number of people in each step, time to complete the step, number of errors made, total cost of operation, and the risks of completing or not completing the process. After the VSM is completed, each step in the process will be classified into three categories of value.

Value Added (VA): These are the things the customer wants, and the process step moves the material closer towards what the customer wants. Usually, less than 5% of the time in the process is actually doing something that is VA. In a world class process, VA steps can be reached almost 50% of the time.

Non-Value Added But Required (NVA-BR): These are steps in the process that are not important to the customer, but may be required by natural or human laws. For example, filling out a form might not be what the customer wants, but there is a law that requires the form to be completed. The best strategy for NVA-BR steps is to reduce the time in that step or try to make it a parallel step alongside a VA step.

Non-Value Added (NVA): These steps are waste in the process and they tend to be the majority of time spent in the process. One of the largest offending categories of waste is doing things faster than the next process can take them in. This leads to overburdening and variation, which multiples the wasteful effects, thus creating longer process times and poor quality. The strategy for handling these steps is to find ways to eliminate them.

After each step has been classified, the VSM is evaluated to identify ways to eliminate NVA steps and minimize NVA-BR.

The value analysis approach can also be used to quantify the impact to total security risk that will result from a project. Similar to the value classification of each step, each process is classified as reducing, maintaining, or increasing the security risk of each step. The risk-VSM is then reviewed to reduce that overall security risk by eliminating steps that increase risks or compensating by increasing the impact of steps that reduce risk so that, overall, the project achieves the reduction in risk required.

The VSM technique is a good way to comprehensively capture the total value, in strict terms of value as well as risk reduction, to all stakeholders in implementing projects designed to reduce crowding in public areas of the terminal, and to systematically identify and consistently quantify the specifics of potential risk.

3.1.2 Return on Investment Analysis

An ROI analysis is designed to evaluate a proposed project's holistic performance and justify investment based on assessment of the initial capital costs, as well as the total cost of ownership (e.g., ongoing labor and maintenance costs), as compared to the benefit—both direct and indirect—measured in dollars. An important aspect of the analysis is consideration of the project performance over time, as well as the rates of return on an investment. ROIs are versatile and simple gauges of the profitability and efficiency of an investment.

Qualitative ROI analyses take into account the benefits or profits that are hard to quantify in numbers or dollar amounts, such as increased safety and security. Because it is difficult to attach a quantitative number to a qualitative factor, high, medium, and low ROI are often the only way to characterize the factor's ROI.

The following generic questions can help an airport gauge a qualitative factor's ROI:

- Will this factor increase the public area safety and security?
- Will this factor increase the effectiveness of the terminal operations?
- Will this factor increase customer service and, by extension, increase customer satisfaction?
- Will this factor cut staffing hours or other operational costs?

If the answer is yes to all of these questions, the qualitative ROI for that factor is high. If yes is the answer to one or two, the qualitative ROI is low. Taking qualitative and quantitative factors into consideration when evaluating the value of projects will greatly reduce the ROI risk. Development of an ROI for a public area security project will be significantly easier if it is preceded by a process analysis and VSM.

When evaluating the value of projects intended to reduce congestion in the public areas of the airport terminal, it is important to consider the total cost of ownership by all the stakeholders, as well as costs in the event of adverse consequences of congestion in public areas. As described in the previous section,

airports may want to explicitly factor in risk calculations in the evaluations. With security projects, the cost of loss of reputation resulting from organizational failure to respond must also be accurately represented.

3.1.3 Effort-Impact Analysis

An Effort-Impact Analysis is a detailed examination of the potential risks and gains of a potential planning venture. These analyses are often used to make many types of business decisions, and can prove fruitful for airports considering new technology or construction that addresses public area security.

Each option under consideration is given a weight—determined before conducting the analysis—in both effort and impact, often on a numerical scale (e.g., 1–10) or rated low, medium, or high. Often, the options are mapped on an effort-impact matrix that visually shows which options should provide the greatest impact with the least amount of effort; in other words, which options provide the most value. The general template of an effort-impact matrix is shown in Figure14.

Figure 14. Effort-Impact Template

	Low Effort	**High Effort**
High Impac	**GREAT** (Quick Wins) Execute right away.	**GOOD** (Major Projects) Can the same impact be reached with less effort?
Low Impact	**WEAK** (Future Projects) Can the impact be increased?	**BAD** (Wasted Effort) Focus on other ideas.

The first step to conducting an effort-impact analysis is to list all the options that are under consideration. For each option, list all of the financial and resource costs that would be required, as well as the potential benefits. The more details that can be added to your analysis, the more quantitative (objective) and less qualititative (subjective) your list will become. This will provide the most accurate representation of the value of each option. Consider the example below:

	Effort (Cost)	**Effort Rating**	**Impact** (Benefits)	**Impact Rating**
Adding a social media monitoring service	• Finding a provider that meets our needs (time and resources) – requires someone to research • Costs of the service/software ($$) – monthly vs. one time • Working with provider to set up service (time) – one-time requirement • Assigning and training employee(s)	Most effort is upfront and a one-time effort **Low to Medium Effort**	• Quick communication with customers and public (time and increased security) – to and from customers • Better brand monitoring ($$) – find potentially harmful posts first	Most valuable impact is in the long term **Medium to High Impact**

	to monitor (time and $$) – new employee or existing?			
Adding walk-through screening devices at entrances	• Comparing providers (time and resources) – there are currently not that many providers • Cost of each device ($$ x number of entrances) – should all entrances be covered? • Training employees to use (time and $$) – providers claim easy to install and use • Train and inform public (time and resources) – use signage or employees to explain	Will depend on total number of devices needed, but mostly one-time upfront effort **Medium to High Effort**	• Could keep firearms and explosive devices out of the non-secure area (potential bottlenecks and increased security) • Could reduce time spent in security queue (reduced crowds and increased security)	Most valuable impact is to security of the non-secure side **High Impact**

For this particular example, a social media monitoring service would be placed in the upper left quadrant of the effort-impact matrix, and the walk-through screening device would be placed in the upper right quadrant. Between these two options, the social media monitoring service offers more value. This thought process should be performed for each possible option. The final analysis and matrix will be more effective if the effort and impact of each option is discussed with multiple affected parties, especially the managers and supervisors assigned to each crowd mitigation option.

Once each option has been mapped, projects can be created from the options, with the most valuable options given priority. In the above example, a social media monitoring service should be given priority over the walk-through screening device. Any potential projects that fall into the lower right quadrant (BAD) should be discarded.

3.2 Jurisdiction and Legal Concerns

US airport governance is diverse. Complexities in legal jurisdiction and the authority to act are a direct consequence of this diversity of governance. This section will discuss, in general terms, good practice in planning for and responding to management of crowds in the public areas of the airport. However, the best practice is to consult an airport's legal counsel during the planning stages of projects to address crowd management and ensure all tactics meet the requirements of local, state, and federal laws. It is always good policy to have legal counsel present or on-call throughout an incident.

3.2.1 Jurisdiction

Senior leaders at each individual airport are well informed regarding day-to-day federal, state, and local legal requirements governing operations of their airport. However, when developing new facilities or systems, operational procedures, policies, and response plans that require interaction with outside agencies, it is important to clearly understand what, if any, jurisdiction these agencies have over the

airport. These may include LEOs, TSA, FBI, and FAA. It is equally important—and in some cases poorly understood by these outside agencies—that they have constraints and limitations to their authority when acting at the airport. Additionally, should assistance be required by first responders and mutual aid providers, the complexities of authority must be thought out and communicated in advance to all parties.

As previously noted, it is important for airport counsel to be involved early and often when developing plans to address new projects, policies, and procedures to manage crowds in public areas of the airport. Typically, the engineers, IT professionals, and airport operations managers first involved in planning new facilities, equipment, and protocols are not attuned to the sensitivities of the public or the subtleties of legal consequences that may result from these new crowd management strategies. For expeditious project development and implementation, it is best that legal concerns are identified and addressed early.

Establishing a clear chain-of-command in the airport's SOPs, Airport Emergency Response Plan, and the Airport Security Plan will help minimize the confusion over who is in charge during an event. Proper planning and training on the chain-of-command will result in quicker response times, better coordination of resources, and more effective control over the situation. This is especially true for airports that fall under several jurisdictions (federal, state, city, county, tribal, and airport) and may have several responding LEOs and first responders on site during an event.

As projects are identified to better manage crowds in public areas of the airport, it is important to develop detailed concepts of operation to accompany the facility, equipment, or system plan applicable to normal operations, as well as during incident response and recovery, prior to finalizing the project requirements. Consideration needs to be given to the requirement to update the Airport Emergency Response Plan and in some cases possibly the Airport Security Plan. Complications may arise and are best addressed prior to finalizing any plan.

As will be addressed later in this document, it is critical that training—specifically addressing questions of jurisdiction by agencies, first responders, and mutual aid partners—be conducted frequently so that these matters do not have to be handled during an incident.

3.2.2 Other Legal Concerns

Much of an airport's success relies on its public image, and it takes very little to negatively change the public's trust in an airport and its operators.

Working with the public to ensure its rights are not infringed upon while also ensuring the airport is safe is a delicate balancing act. However, failing to do either of these things may result in a loss of reputation for the airport and a loss of trust from the public. Careful consideration of all possible options and a thorough discussion with the airport's legal counsel is highly recommended.

3.2.2.1 First Amendment Rights, Protests, and Demonstrations

Airports are often the chosen site for protests and demonstrations with the potential for creating both civil and criminal causes of action. For this reason, these events should be thoughtfully addressed in an airport's emergency operations plan and reviewed with airport counsel to guide the response. These plans and mutual aid agreements should identify key leadership roles and responsibilities of affected agencies and organizations. Plans should also outline the steps needed if the demonstration is more spontaneous (akin to a flash mob) and has not filed for a permit or has not identified a leader. Use of

news reports, internet postings, social media, and other open sources may help determine the expected number of attendees.

During a protest or demonstration, it is important to define the leadership roles and responsibilities among airport operators, elected officials (keeping in mind that some elected officials may be part of the demonstration), LEOs, and other agency officials. Airports should already have this information laid out in their emergency operations and in mutual aid agreements; failing to define these policies may result in a lack of consistent internal communication, an uncoordinated and chaotic response, and strained relationships. It is only through a collaborative and unified response that protests and demonstrations can be contained while still respecting the demonstrators' civil rights.

Airports should ensure that their plans regarding protests, especially spontaneous protests, balance free speech rights with the safe and efficient operations of the airport. The plan should also discuss procedures for protests that have no permit or no apparent leader. Airports should not wait until they have a protest or demonstration to create policies and procedures; lack of planning may result in injury to demonstrators and LEOs, legal liabilities, and brand damage.

Airports should consider how social media impacts a spontaneous demonstration; social media can bring together large numbers of people in a short amount of time. News reports, internet postings, social media, and other open sources can be used to determine how many people are expected to participate, which will help in planning a level of response.

Where possible, designating a free speech area where the crowd can convene may help minimize the impact the demonstration has on airport operations. Press releases should be distributed to the media to inform the public of the logistics of the demonstration, such as roadway closures, parking restrictions, and alternate reporting options for non-emergency calls. When possible, an attorney on site can prepare and advise the airport operators on legal and public policy issues that may arise spontaneously regarding the demonstration.

3.2.2.2 Second Amendment Rights and Open Carry Laws

The sight of someone openly carrying a firearm within the public spaces of an airport is enough to scare even the hardiest of travelers. There is no way to know if the person carrying the weapon has ill intent or is responsible enough to carry a weapon.

> In June 2015, a man legally carried a fully loaded AR-15 rifle into an ATL terminal. Several phone calls were made to the local police department regarding the loaded weapon and, though the man was questioned by the airport police, Georgia law permitted the weapon in the airport terminal.

As of 2018, it is legal to transport and ship firearms via airplane as long as the weapon is not readily accessible from the passenger compartment of the plane (18 USC § 926A). However, there is no federal regulation prohibiting the open carry of firearms on the public side of the airport.

Some states[6] have regulations prohibiting the open carrying of firearms within public spaces such as airport terminals. Airports in these states may post signs at the entrances to the terminals informing

[6] To determine if your state prohibits open carry firearms within the airport terminal, please work with your airport or city attorney.

anyone entering that open carry of firearms is not permitted for people other than law enforcement officers.

For many states, however, open carrying of firearms within the airport terminal is legal. Since airport police cannot ask firearm owners to leave the premises, the only option is to monitor the person in question as they travel the terminal.

4. CROWD BEHAVIOR STRATEGIES

Crowds are an accepted component of daily operations at most airports. As discussed earlier in the Guidebook, they tend to form at ingress/egress points and traveler processing areas, such as security checkpoints, ticketing kiosks, and baggage drop and claim areas.

Airports do not always clearly define who is responsible for managing crowd behavior at their facilities. Many airport security and police departments are trained in crowd control techniques, the purpose of which is to restrict or limit the behavior of the group with physical barriers and a security presence. But crowd control is often more appropriate for special events or emergencies. Planning for and supervising the orderly movement and assembly of people within a site or facility, which is known as crowd management, largely goes unaddressed.

4.1 Crowd Control

At times, airports experience crowds that have formed outside of daily operating procedures. Examples include crowds gathering as part of a labor protest or political movement, fans or detractors gathering to greet a high-profile figure arriving or departing, or crowds that form as a result of irregular operations or an emergency situation, such as an order to shelter-in-place, power failure, or travelers grounded at the airport due to inclement weather.

Traditionally, police and security forces have based their response on classic crowd psychology, which views crowds as potentially dangerous entities that should be contained. During a protest, for example, security officers make a strong show of force by wearing tactical gear and creating physical barriers with cars and bicycles. The intent is to demonstrate that the situation is under control and suppress any violence before it can occur.

However, recent research analyzing crowd behavior finds that open displays of force by the police during an event can have an unintended, negative impact on crowd dynamics and actually increase the risk that a crowd may turn violent. The rationale is this: when an initially non-violent crowd is treated with aggression, members of the crowd will become aggressive themselves.

While police need to maintain control and ensure that order is maintained, the militaristic show of force can be limited and/or replaced with a community-policing approach. In this model[7], the goal is to avoid the creation of an Us versus Them mentality by having security keep a lower-profile and intermingle with the crowd.

The model states that there are two types of crowds: aggravating and mitigating.

Aggravating crowds are created when otherwise peaceful groups are provoked (intentionally or unintentionally) into aggressive behaviors. As the crowd becomes more distressed, police perceive a disorganized crowd in need of crowd control measures. This begins a spiral of mutual distrust and escalating violence.

Mitigating crowds present a peaceful and positive atmosphere. By demonstrating a peaceful intent, police perceive a peaceful crowd and mutual trust is established. If aggressions do occur, they are handled on an individual level.

[7] This is formally referred to in social science research as the Elaborated Social Identity Model. An alternate model, the Aggravation and Mitigation model, is distinct but supports the same conclusions regarding crowd behavior.

According to this theory of crowd behavior, authorities acting peacefully and calmly will cultivate a mitigating crowd and a peaceful experience. If the authorities treat the crowd as a dangerous group, an aggravating crowd will develop and injuries may be incurred.

In this community-policing approach, security personnel at the airport should:

- Minimize their visual presence
  - Wear typical uniforms instead of riot gear
  - Disperse through the crowd in teams of two to three instead of creating a human barricade of officers
- Interact with the crowd
  - Smile and talk to individuals in the crowd to ease tensions
  - Operate within the crowd to gather intel and conduct ongoing risk assessment
- Utilize minimum force should trouble erupt
  - Address the individual causing the trouble rather than treating the entire crowd as a disturbance

4.2 Protests and Demonstrations

January 2017 tested crowd management techniques at airports across the United States as thousands of protesters gathered at dozens of airports to express their disapproval of Executive Order 13769 (*Protecting the Nation from Foreign Terrorist Entry into the United States*). The majority of the protests were peaceful with minimal arrests and injuries, though many airports were caught off guard by the size and spontaneity of the crowd, with some resulting in arrests and violence.

When preparing for a planned demonstration, the airport should review its demonstration/protest policies during roll call. In most cases, a planned demonstration will have a designated leader who applied for a permit to protest in a designated location. LEOs and airport personnel can communicate and coordinate with this leader to ensure a peaceful environment for all.

Airports should issue a press release beforehand to inform the public of the logistics of the demonstration, including road closures, parking restrictions, and alternate reporting options for non-emergency calls. Non-participants should be encouraged to avoid the area unless absolutely necessary. The press release should be published to the airport's website and social media accounts, and information should be provided to local news outlets (radio and television) with a map of any affected traffic patterns and road closures.

If possible, the airport's attorney should be onsite to provide legal advice while also protecting the protestors' First Amendment rights. A PIO should also be onsite to discuss the airport's involvement in the demonstration.

> The success of Orlando International Airport's travel ban protest was credited to the airport's organization in response to the protest. Though the airport had no formal policies or procedures to handle protests, they did have a standard policy protecting the protestors' First Amendment rights as long as they do not disrupt access to the airport for anyone. The organizers of the protest also reached out to the airport beforehand, allowing local police officers to be stationed prior to the meeting time to keep the protesters within their designated perimeter.

Unplanned demonstrations, in which social media messages direct crowds to gather at a given location, pose a more complicated scenario. These protests are unpermitted and have no designated leader, so the airport has less time to prepare.

Airports should consider how social media impacts a spontaneous demonstration; social media can bring together large numbers of people in a short amount of time. Airports can use news reports, internet postings, social media, and other open sources to determine how many people are expected to participate and plan a level of response.

> The Minneapolis-Saint Paul International Airport (MSP) experienced a spontaneous demonstration in 2015 that was brought together on social media. After a Black Lives Matter demonstration was turned away from the Mall of America, the demonstrators decided to move the demonstration to MSP and informed everyone on social media. MSP was monitoring social media and was able to prepare for the spontaneous demonstration and activate the Emergency Operations Center (EOC).

If a spontaneous protest is planned at an airport, one of the best things that airport can do is to set a calm tone. LEOs, airport employees, tenants, and mutual aid partners should be prepared for the possibility of a large crowd, but also be reminded that the protestors are exercising their First Amendment rights and need not be treated as a hostile assembly.

> Officers of the Charlottesville Police Department did not wear riot gear during the July 8, 2017 protests, hoping to cultivate calm crowd behaviors. Plain clothes detectives were scattered throughout the crowd to detect any hostile or violent behaviors.

While the protest or demonstration is occurring, there will likely be travelers trying to get to, or make their way through, the airport who will have been inconvenienced or perhaps intimidated by the crowds. Airport personnel can be deployed to usher travelers through crowds and/or show them to alternate routes.

> On January 28, 2017, thousands converged on LAX to protest the travel ban. Officials at LAX knew the travel ban protest was coming, but they were surprised by the size and ferocity of the crowd. Airport police activated unified command and stood up an incident command post. Officials did their best to guide the crowd to designated locations, but by day two of the protest, the crowd was blocking streets, snarling traffic, and negatively-impacting ticketed travelers trying to get to their flights.
>
> The spontaneous crowd had not applied for a permit and did not have a designated leader. Airport police sent officers into the crowd, both uniformed and plainclothes, to determine who could negotiate on behalf of the crowd. The ad hoc leaders were identified and together with the police they reached an agreement: every hour protesters could block traffic for 20 minutes and then they would clear the streets for 40 minutes. Once the arrangement was reached, the information was relayed back to the incident command post so that everyone at LAX knew what was going on. Despite the size of the crowd, there was no reported violence and only two arrests.

4.3 Crowd Management

The previous examples all highlight unexpected crowd events that the police and security would be responsible for controlling. However, managing and assisting the crowds that form as a part of daily operations at an airport requires a more proactive approach, often referred to as crowd management.

Travelers at an airport want, and expect, to be able to navigate unfamiliar terrain by following signage and prompts from helpful personnel strategically placed throughout the facility. Many crowd management solutions combine elements discussed earlier—stanchions, serpentine queues, and wait-time updates—to keep travelers informed about where they are going and how long it will take to get there, all to help maintain a sense of calm and order.

During regular daily operations at an airport, most crowds likely form at ingress/egress points including the check-in lobby, security checkpoints, traveler greeter halls at exits from the secure area, and entry and exit points for escalators and elevators. At times, a crowd will continue to press forward even if egress is blocked because there is a lack of communication between the front and back of the crowd. Attempting to control the crowd from the front, urging people not to push, is not effective unless the incoming flow of people is also restricted. Escalators can pose a particular threat in such situations because they continuously move people without regard for conditions, and if people cannot disembark, a pile up will occur. A more effective approach in such a scenario is to place airport personnel at the base of the escalator who can re-route travelers to the stairs or elevator, while communicating that there is a crowd at the top of the escalator.

5. TRAINING STRATEGIES

Traditionally, crowd control has been the domain of police and security forces, who receive specific training on methods and techniques. However, crowd management techniques can and should be taught to a variety of airport personnel.

5.1 Stakeholder Training

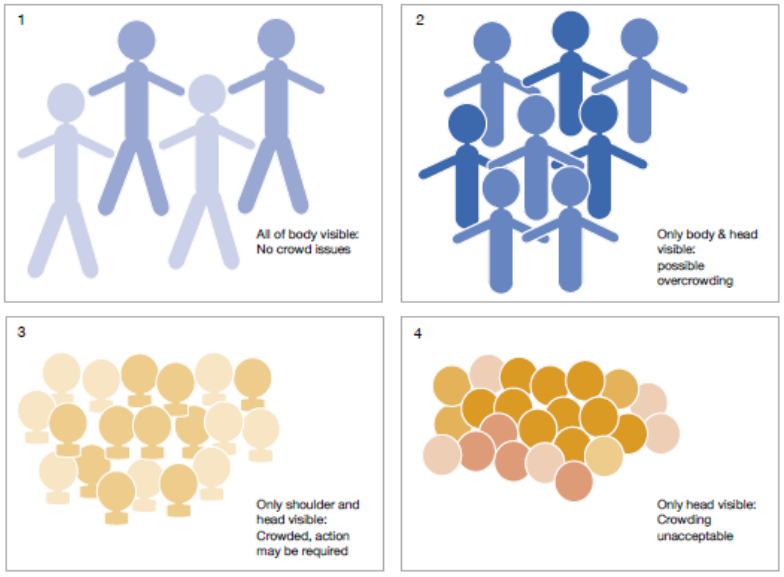
While crowd control will largely fall to those in security, all airport personnel should be familiar with some basic concepts of crowd management.

First, airport personnel should be trained in the importance of maintaining the flow of travelers in the non-secure areas of the airport to avoid creating soft targets for bad actors. While many people are aware of the recent terror attacks at airports, they might not have realized that at FLL and Brussels the attackers specifically targeted the crowded areas in the non-secure sections of the airport.

Second, airport personnel should be trained to recognize populated areas that are at risk of becoming overcrowded.

A quick way to determine if an area is becoming or has already become crowded is to compare the crowd to the following four cues (see Figure 15):

Figure 15. Visual Cues to Determine Crowd Build Up



Source: Managing Large Events and Perturbations at Stations

1. If the entire body of each person is visible, there is no crowding issue.
2. If only the body (not the legs) and head of each person is visible, there is possibly overcrowding in the area.
3. If only the head and shoulders of each person is visible, then there is definite overcrowding. Crowd management action should be taken.
4. If only the head of each person is visible, then the crowding has reached unacceptable levels and action must be taken immediately or injuries could occur.

Third, all airport employees should be trained to some extent on methods of providing wayfinding information to travelers, especially those who might need special assistance. For example, knowing how to guide those who are blind or have low vision; methods of providing wayfinding to the hard of hearing, including written messages, lip-reading, and sign language; and how to guide those with other access and functional needs to ensure they receive the information in the most appropriate and effective manner.

It is important that airport personnel are trained to treat persons with disabilities with compassion, respect, and patience. The best time to start this training is during the new employee orientation. Part of this training should include correcting assumptions about persons with disabilities; see the text box to the right.

54 million people in the United States have a disability

21.2 million people in the United States are blind or have low vision

1.5 million people in the United States use wheelchairs, but not all wheelchair users are unable to walk – some have impaired strength, endurance, balance, or coordination; some have heart conditions or other "invisible" conditions that reduce mobility

36 million adults in the United States have hearing loss; 1 million are completely deaf

Approximately 4.76 million people in the United States have intellectual and related developmental disabilities; 1 out of 6 people fall somewhere on the autism spectrum

Fourth, airport employees can be trained in the basics of crowd control and crowd management to support local law enforcement and to keep travelers calm during high-tension situations, such as evacuations. In the event of an evacuation, these crowd controllers can assist travelers by directing them to the nearest exit or rendezvous point. Crowd controller personnel should wear highly visible clothing that clearly identifies them as airport employees who are available to assist.

Studies have shown that pulling groups toward an exit in the event of an evacuation is much more effective than pushing. Crowd controllers should be trained in ways to pull or guide the crowds to exits and rendezvous points rather than point or tell them where to go. While they cannot restrain travelers against their will, crowd controllers should keep everyone together and discourage them from wandering off. This must be included in training as the high density of a crowd, paired with the noise and chaos of an emergency situation, creates a natural desire to leave the crowd to seek alternate routes.

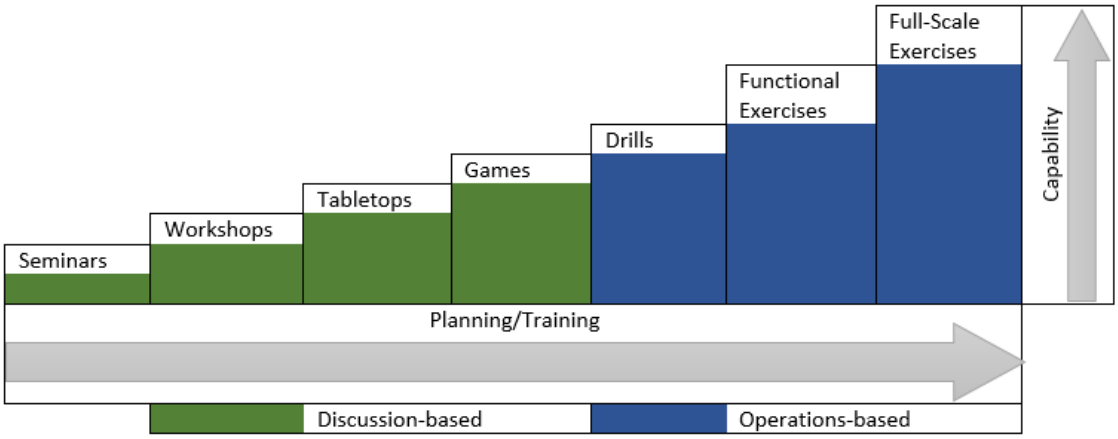
Crowd controllers should be trained to be particularly vigilant during evacuations. Disorderly movement, such as during an evacuation, increases the risk of slips, trips, and falls. This increases the risk of injury to the more vulnerable members of the public: children, older adults, and people with disabilities. They should also be trained in techniques for diffusing tense situations and ways to aid travelers with disabilities.

Also, anytime an airport adds crowd mitigation strategies, such as (1) updates to the policies and procedures, (2) completes any new construction or redesign of the physical layout, and (3) installs and activates any new technology, it is important to prepare and train personnel and stakeholders on all of the changes in their areas.

Research shows that personnel retain as little as 5% of information within the immediate 24-hour period of receiving it, which is why it is so important to train, practice, and reinforce key messages and instructions. In addition, employee turnover rates should be taken into consideration to ensure an airport is training all newly hired personnel properly. When working with a limited budget, it is important to invest in training personnel, especially if there is a limited number of personnel that work at the airport.

As part of stakeholder training, the airport may also want to use some simulated scenarios. The most effective training program is progressive, as shown in Figure 16. Airports can begin with seminars (the kind with PowerPoint presentations), and slowly add interactive trainings and exercises until they are at a level of a full-scale exercise.

Figure 16. Progressive Training Program Outline



Source: Thomas Crane, 2017

It is important to ensure that exercises and training are not biased to succeed. It is far more useful to create situations in which participants may fail, thus identifying the appropriate way to overcome the situation. For example, airports can consider prohibiting the use of one or more evacuation routes so that stakeholders become familiar with alternative routes, or add challenges such as full evacuations, full shutdown, traveler relocation, travelers with disabilities, and mass care, such as feeding, psychological care, and family reunification. Creating high stress situations will help simulate real-world scenarios, so airports should consider simulating system slowdowns and shutdowns that require alternative communication strategies and protocols.

5.2 Secondary Targets Created During Incident Response

When responding to an emergency situation, crowds are often created as a by-product of the response. For example, in response to a power outage or active shooter, travelers may be directed to evacuate or shelter in place. However, the crowding caused by these actions may create a vulnerable secondary target. Examples from recent terror attacks in the United States and abroad demonstrate the intent of violent actors to take advantage of some known emergency response protocols.

> On November 13, 2015, terrorists in Paris carried out multiple attacks, targeting the Stade de France, restaurants in the 10th and 11th arrondissements, and the Bataclan concert hall. After the first attacker detonated his suicide vest outside the stadium, traditional response protocols would have led authorities to evacuate the sports venue, which contained thousands of soccer fans. However, concerned that the attacker's intent was to create a stampede out of the stadium with other attackers lying in wait to ambush the exiting spectators, the stadium was quietly locked-down and play continued. Due to spotty cell reception inside the stadium, the public remained largely unaware of the events that were unfolding outside, and hundreds of lives were likely saved.

> On February 14, 2018, a gunman shot and killed 17 students and staff members at a high school in Parkland, Florida. The shooter reportedly pulled the school fire alarm so he could fire at unsuspecting students as they evacuated the building.

When reviewing Emergency Action Plan and/or other incident response plans, airports should think through whether the intended response directs a crowd to congregate in a non-secure area of the airport.

While every airport and its layout is unique, there are some best practices that can be followed to maximize the safety of staff, travelers, and first responders:

- The EOC should be located in a safe and secured area in or near the airport, but not marked on public maps. This building or room should have dedicated power and phone lines that are not tied to the main sources. This helps ensure that operations can continue even if the main sources go down.
- Two evacuation routes (in opposite directions) should be determined within each terminal building. These routes should be kept relatively secret to prevent potential attackers from exploiting them. All employees at the airport should be trained on the evacuation routes.
- Rendezvous and rally points should be scattered throughout the terminal building(s), but to be effective, they must be well protected, clearly lit, and unobstructed. Rally points should never be located inside parking garages/lots or near windows and doors.
- When designating and establishing Evacuation Areas, Family Assistance Centers, Reunification Centers, etc., airports should plan to keep the area covered and/or position fire trucks around the area.

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ACRONYMS

ADRM	Airport Development Reference Manual
ASL	Advanced Security Lane
ATL	Hartsfield-Jackson International Airport
BOS	Boston Logan International Airport
CBP	Customs and Border Protection
CDG	Checkpoint Design Guide
DEN	Denver International Airport
EOC	Emergency Operations Center
FIDS	Flight Information Display
FLL	Fort Lauderdale-Hollywood International Airport
IATA	International Air Transport Association
ICP	Integrated Communication Platform
IPAWS	Integrated Public Alert and Warning System
LAX	Los Angeles International Airport
LEO	Law Enforcement Officer
LOS	Level of Service
MSP	Minneapolis-Saint Paul International Airport
NVA	Non-Value Added
NVA-BR	Non-Value Added But Required
PA	Public Address
PIO	Public Information Officer
RFID	Radio-Frequency Identification
SITA	Société Internationale de Télécommunications Aéronautiques
VA	Value Added
VSM	Value Stream Map
WBEMCT	Web-Based Emergency Management Collaboration Tool
WEA	Wireless Emergency Alerts
YEG	Edmonton International Airport
YYZ	Toronto Pearson International Airport