

Airport Airside Conveyance –Technology Assessments

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Abstract

The right time or passenger activity level to implement a specific transport technology for airside mobility varies by airport and can be influenced by a number of different factors. For the range of potential airside technologies, including Automated People Movers (APMs), there are certain level-of-service thresholds that indicate when a given technology is most appropriate for implementation. This paper describes the different factors and thresholds that should be considered in an airside technology assessment.

The different airside technology implementation factors will vary by airport and will vary over the lifetime of an airport. Each factor has a potential threshold that once “exceeded”, would lead to implementation of one type of technology versus another. The typical factors include:

- Terminal configuration and geometry
- Passenger level-of-service
 - Walk distance
 - Trip time
- Ridership volumes
- Costs and benefits

This is not intended to be an exhaustive or all-inclusive list. The specific factors will be highlighted against the range of typical airside technologies considered including APMs, apron buses and moving walks.

INTRODUCTION

The airside passenger conveyance needs of major airports vary widely. Providing a high level of service to passengers is critical to all airports as they compete to attract customers in this increasingly competitive transport environment. Larger hubbing airports compete with each other for connecting passengers and all airports compete with rail, bus and auto (and even other area airports) for regional traffic.

This paper describes the various technology options that airports use to convey passengers and employees around the airside (secure) of the airport. As an airport grows in size and activity, the most appropriate passenger conveyance technology can change. This paper describes the different factors that should be continually be considered in the airside passenger conveyance context.

AIRSIDE PASSENGER TECHNOLOGIES

For conveying origin/destination (O/D) airline passengers between aircraft gates and terminal functions (check-in, security and bag claim) as well as connecting transfer passengers between aircraft gates (both intra and inter-terminal); there are three conveyance technologies typically employed: moving walkways, apron buses and APMs. These technology categories are listed in ascending order of system line capacity (passengers per hour per direction) for airside airport applications. They are described in terms of technical characteristics and by suppliers and their applications.

Moving Walkways

Moving Walkways are a means of pedestrian transport that provides a flat or inclined, continuous moving surface of pallets or belts, which convey passengers (standing or walking) and their baggage over moderate distances. These devices are popularly known as moving sidewalks, moving walkways, movingwalks, and travelators.

Typical walkway speeds range between 27 and 37 meters (90 and 120 feet) per minute or approximately one-half normal walking speed. The resulting passenger speed ranges from 90 feet/minute (passenger standing) to 210 feet/minute when passengers walk on the movingwalk. Moving walkway segments range in length between 10 and 150 meters (30 and 500 feet) and widths between 0.6 and 1.4 meters (24 inches and 55 inches). Passenger conveyance capacities are a function of width, passenger density, passenger passing ability, walking/ standing ratio and the moving walkway's speed. For an airside airport application with baggage, movingwalk capacities range from 4,000 to 5,000 passengers per hour.

Figure 1 – Movingwalk Conveyance Technology



Apron Buses

Rubber-tired apron buses are a prevalent form of transit at many airports around the world. At-grade, bus operations are favorable because they are able to reach a variety of passengers and destinations with good flexibility and lower costs.

Buses are very flexible; routes and stations (stops) can be changed or added easily. These driver operated vehicles are typically diesel-powered. Maintenance can occur either on-airport or off-airport. Bus lengths are typically 14 meters (45 feet) and bus width is 2.6 meters (8.5 feet) for regular transit buses (with minimal seating) or up to 3.0 meters (10 feet) for specialized apron buses. These wider buses are consequently not “street legal” and require special operations to transport them to off-airport maintenance facilities.

Buses operating on the airport apron cross active taxiways (where aircraft have the right-of-way) can only achieve operating speeds well below their cruise speeds. Buses are typically and can carry 80 to 100 passengers in an airside application (carry-on baggage). A main terminal to remote concourse bus system with two routes at three-minute headways (each route) can achieve system capacities of 3,000 to 4,000 passengers per hour.

Figure 2 – Apron Buses



Figure 3 – Apron Bus Conveyance Technology



Automated People Movers

APMs are fully automated, driverless vehicles operating on fixed guideways along an exclusive right-of-way. APMs are divided into two major groups: cable-propelled and self-propelled. Monorails, rubber tire and larger steel-wheel technologies are considered within the self-propelled group.

Cable-Propelled - This type of technology consists of medium- to large-capacity vehicles or trains using cable propulsion with various suspension systems. System line speeds of 45 kph (30 mph) can be achieved with longer station-to-station distances but the typical airside station-to-station speeds average 30 kilometers per hour. The fixed-grip-technology is best suited for two- or three-station shuttle applications with relatively straight guideway alignments of one kilometer or less. Beyond this distance, the time between trains can exceed Airport's desired level-of-service. Detachable-grip is a new advance in the technology that allows for more than two trains to operate.

Figure 4 – Cable APM



Self-Propelled - Self-propelled vehicles or trains use a two-rail guideway system with rubber tires on concrete or steel wheels on steel rail. System maximum speeds range between 50 and 70 kph (31 and 43 mph) depending on the supplier's technology with longer station-to-station distances but the typical airside station-to-station speeds are 45 kph (28 mph).

Figure 5 – Self-propelled APM



System capacity for both types of airside APMs can reach 9,000 pphpd assuming 75 passengers per vehicle (passengers with carry-on baggage), four-vehicle trains and two-minute headways.

AIRSIDE IMPLEMENTATION ISSUES

The appropriate passenger activity level to implement a specific airside transport technology varies by airport and can be influenced by a number of different factors. For APMs, that provide high capacity and level-of-service at a relatively high cost, there are certain thresholds within one or more of these implementation factors that are typically exceeded before a system are implemented.

With some factors, the thresholds are quantitative while with others they are more qualitative. The importance of any single factor can vary greatly by airport. The typical factors that influence airside APM implementations include:

- Terminal configuration and geometry
- Passenger level-of-service
- Ridership volumes
- Costs and benefits

All of these implementation issues are examined in detail below. This examination is based in large part on a survey of fourteen major U.S. airports with a wide range of airside conveyance needs and technologies.

A. Terminal Configuration and Geometry

An airport's terminal configuration and geometry have significant influence on the appropriate airside conveyance technology. A terminal configuration differentiator is whether the facility is contiguous, with a single structure housing the processing (check-in, security, bag claim) functions and all airline gates, or whether it has multiple terminals, one or more with processing functions and one or more being remote with airline gates only.

Airports with contiguous terminal configurations tend to have movingwalks for passenger conveyance. A limited number also employ APMs (but not buses) for passenger conveyance as when an airline hubbing operation is present. Contiguous configurations are often referred to as letter shaped such as "D", "E" or as a "spoke" configuration. Examples of the different contiguous terminal configurations are shown below and are typically a function of property constraints and roadway access.

Figure 6 - Different Contiguous Terminal Configurations

**"D"-shaped
Dallas/Ft. Worth**



**"E"-shaped
Washington-National**



**"Spoke"-shaped
Miami**



Airport terminal configurations with concourses that are remote from check-in, security and bag claim functions typically have APMs (elevated or underground), often in conjunction with moving walks. A limited number of “remote configuration” airports use apron buses to connect facilities. In all cases, passengers using these inter-facility conveyance systems include origin/destination (O/D) passengers and in some cases include transfer passengers. The distance between the facilities influences the choice of conveyance system with shorter distances accommodated by movingwalks, medium distances by APMs or apron buses, and the longer distances typically by APMs only.

Some airports have both contiguous terminals and remote terminals such as Seattle/Tacoma and Miami. Examples of remote configuration airports using APMs only include Tampa, Orlando and Denver. The airports with the shorter connections to remote terminals (Tampa and Orlando) have elevated APMs which cost less to construct than underground APMs. Airports with longer connections to multiple remote terminals (Cincinnati, Denver, and Atlanta) have underground APMs that go below aircraft taxilanes. Images of some of these airports are provided below in Figure 7.

Figure 7 - Different Contiguous and Remote Terminal Configurations

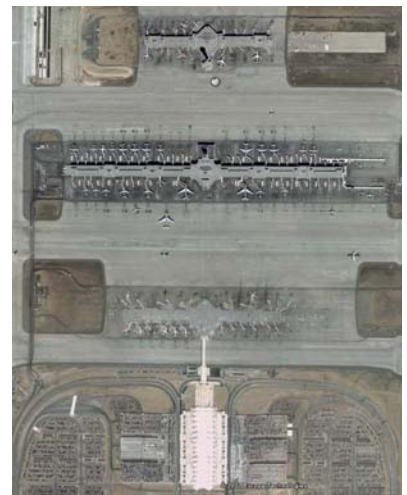
**Contiguous with Remote
Seattle/Tacoma**



**“Spoke” Remote
Orlando**



**“Parallel” Remote
Denver**



Airports employing the combination of APMs and moving walks include Atlanta and Cincinnati. Airports using apron bus systems to connect facilities include Washington-Dulles (with moving walks) and Cincinnati (with APM and moving walks). As Washington-Dulles plans to build future remote (parallel) concourses further from its Main Terminal, it is currently constructing an underground APM that will replace most of its current apron bus (Mobile Lounge) system.

The survey of fourteen major U.S. airports found a number of terminal configuration and geometric thresholds in terms of the airside passenger conveyance technology employed at an airport. Findings included;

Distance between Main Terminal and the furthest Concourse

- over 3,000 feet, APMs are the only conveyance technology employed
- 1,500 to 3,000 feet, apron buses and APMs are employed
- under 1,500 feet, moving walks are the dominant means of conveyance

Number of Connecting (Hubbing Airline) Gates

- over 60 gates, APMs and buses are employed to connect the gates
- 30 to 60 gates, a mix of all conveyance technologies are employed
- under 30 gates, predominately moving walks are employed

B. Passenger Level-of-Service

The passenger level-of-service, typically measured in terms of walk distance and trip time, influences the choice of passenger conveyance technology. For origin/destination (O/D) passengers, these distances and times are measured between security/bag claim and the average and maximum (furthest) aircraft gate. For transfer passengers, the distances and times are measured between the average and maximum connecting airline gates. Connect time between the two maximum spaced connecting gates is critical because the Official Airline Guide sets a minimum connect time between arriving and departing flights that an airline can ticket a passenger as a transfer.

The walk distance and trip time data from the airports surveyed did not present clear differentiation by conveyance technology. A maximum walk distance between security and the furthest gate of approximately 2,000 feet was found among all airports and thus appears to be a threshold of acceptable levels of service. When a given airport configuration reaches this threshold and still desires growth, the “solutions” have been the implementation of remote concourses served by either APMs or aprons, or extending the main terminal’s curb frontage to serve the additional gates.

For airports with remote concourse gates served primarily by APMs and secondarily by walkways with movingwalks, the walk distance savings for the trip between security and the furthest gate from using the APM versus the walkway is 50 percent or between 1,500 and 4,000 feet of walk savings.

Other differentiators among the airside conveyance technologies are level changes and exposure to the elements. Moving walks in concourse does not require a vertical level change while use of apron buses and underground movingwalks or APMs does require such a change. Elevated APMs (Tampa and Orlando) often do not require level changes. APMs and moving walks also have the advantage of not exposing passengers to the elements while boarding or alighting the system. Most

apron busing operations do however expose passengers to the elements with the exception of the current Mobile Lounge system at Dulles.

Figure 8 – Passengers Boarding APM



C. Ridership Volumes

As described earlier in the Airside Passenger Technologies section of this paper, the maximum passenger volume capacities that the different technologies can achieve on the airside of airports is as follows:

Apron Buses	3,200 to 4,000 pphpd
Moving Walkways	4,000 to 5,000 pphpd
Automated People Movers	8,500 to 9,000 pphpd

APMs are designed to better accommodate high hourly volume with level boarding, multiple doors, and wide door widths. By comparison a bus operation is constrained by the number and location of bus berths and the technology requires steps in boarding and has a much lower door-width to vehicle-length ratio. Moving walk systems are supplemented by connector or concourse walk corridors parallel to the moving walks. Moving walk capacity can be reduced by relatively slow passengers or passengers with baggage that block the “passing lane” on the movingwalk.

The survey of fourteen major U.S. airports found a number of passenger volume thresholds in terms of the passenger conveyance technology employed at an airport. Findings included;

Million Annual Passengers (MAP) Connecting

- over 20 MAP connecting, APMs are predominately employed
- under 20 MAP connecting, moving walks are predominately used

Hourly Passenger Volumes

- over 3,000 pphpd, APMs are predominately employed
- exceptions include Chicago O’Hare (moving walk) and Dulles (buses)

D. Costs and Benefits

Every airport has its own unique set of geometric constraints to growth: from existing runway locations on the airside to existing roadways and other property owners on the landside. The relative “strength” of each of these constraints at a given airport, in conjunction with the passenger conveyance technology’s performance characteristics, determines the best option for an airport’s facility growth plan.

Figure 9 – Tunnel APM



The capital and operating costs of any transport system must be financially feasible to the airport. These costs need to be considered in the short and long term as the most affordable technology (bus versus APM) can change depending on the financial timeframe.

The capital and operating costs of airside conveyance technologies vary widely. Indirect costs can apply to the technologies as well. Dual-lane moving walks increase the width of a concourse by approximately 3.4 meters (11.0 feet) and some airports have installed four parallel moving walk lanes. Buses require a maintenance facility which may occupy valuable airport property. System equipment costs and annual operating costs range from relatively low for buses, to moderate/high for moving walks, to high for APMs. Facilities costs include the system’s elevated or tunnel structure (movingwalk or APM), maintenance facility (bus or APM) and stations (bus or APM). Facility costs typically exceed the system equipment costs and vary widely by region.

On the revenue side of the equation, aircraft gates translate into airport revenues. All three conveyance technologies help to connect distant gates with main terminal processing and/or other connecting gates by reducing the walk distance and travel time between the two locations. Thus the technologies allow for more gates to be utilized while still adhering to level-of-service thresholds for walk distance and trip time. The faster the technology conveys passengers, the more gates a technology allows an airport to utilize. For hubbing operations, a strong correlation was found between the number of connecting gates and the conveyance technology as summarized below:

Connecting Gates	Conveyance Technology	Terminal Configuration
20-40	Movingwalk	Contiguous
40-75	APM	Contiguous
40-65	Movingwalk & APM	Remote
65-85	Bus & APM	Remote
85-120	APM	Remote

Aircraft gates for a hubbing airline operation have higher gate utilization and therefore generate greater revenues for the airline and airport. Hubbing (connecting) passengers also do not require landside facilities as well. Hence, many airlines/airports have been able to justify remote terminals connected by underground APMs on a cost/benefit basis. The APMs have allowed an airport to turn otherwise nonperforming land into revenue-generating property, placing more terminals farther away and generating greater numbers of annual passengers.

APMs also allowed contiguous terminal configurations to be converted into major hubbing operations (Dallas/Ft. Worth and Miami). Chicago-O’Hare and Newark use landside APMs to connect international terminals with domestic ones and increase both their international and domestic traffic volumes.

CONCLUSIONS

This paper attempts to quantify some general implementation thresholds for different airside passenger conveyance technologies, the most appropriate technology at a given airport is always the technology that best meets the goals and objectives of that airport. The survey of fourteen major U.S. airports identified a number of thresholds in terms of facility spacing (distance) and passenger volumes that clearly show the preference of one airside technology over another. Given the many components of an airport’s environment, the framing of these goals and objectives in a technology assessment must be comprehensive and inclusive. By properly framing the airside passenger conveyance evaluation and completely integrating the Airport’s goals and objectives, the best technology for that Airport will emerge.

Figure 10 – Airside Conveyance Technologies

