Airport Landside Mobility –APM Implementation Issues

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Abstract

No two airports are exactly alike. Similarly, the appropriate time or activity level to implement a specific transport technology varies by airport and can be influenced by a number of different factors. For Automated People Movers (APMs), which provide high level-of-service at a relatively high cost, there are certain thresholds that are typically exceeded before a system is implemented. This paper describes the different factors and thresholds typically considered with a landside APM implementation. In addition, the landside mobility analysis at Dublin International Airport will be presented.

There are different factors that potentially lead an airport into implementing a landside APM. Each factor has a potential threshold that once "exceeded", would lead to implementation. The importance of any single factor varies by airport. The typical factors include:

- Passenger/employee volumes and facility spacing
- Terminal access spacing
- Terminal roadway capacity
- Regional rail station proximity
- Indirect costs
- Airport land use
- Airport's desired transport level-of-service
- Political considerations
- Competitive position to rival airport

Not all of these factors applied to the landside mobility analysis performed at Dublin International Airport in 2003. The Dublin specific factors will be highlighted against a range of landside technologies considered including APMs, buses and moving walks.

INTRODUCTION

The landside 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. Airports compete both with other regional airports as well as with high-speed rail in some markets.

This paper describes the various technology options that airports use to convey passengers and employees around the landside (non-secure) of the airport. As an airport grows in size and activity, the most appropriate passenger conveyance technology can change. APMs best meet the passenger conveyance requirements of an airport in number circumstances, providing a high quality and high capacity level of service to the airport. This paper describes the different factors considered in the landside passenger conveyance technology equation.

PASSENGER CONVEYANCE TECHNOLOGY OPTIONS

For conveying passengers between the Main Terminal (ticketing and bag claim) and other landside facilities, there are three technologies typically employed: moving walkways, buses and APMs.

Moving Walkways

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

Typical walkway speeds range between 27 and 37 meters (90 and 120 feet) per minute or approximately one-half normal walking speed. Moving walkway segments range in length between 10 and 150 meters (30 and 500 feet) with pallet width ranges between 0.6 and 1.4 meters (24 inches and 55 inches). Passenger conveyance capacities are a function of pallet width, passenger density, passenger passing ability, walking/standing ratio and the moving walkway's speed. For a landside airport application with baggage carts, moving walkway capacities range between 1,600 and 3,700 passengers per hour.

Buses

Rubber-tired buses are one of the most prevalent forms of transit at airports. At grade, bus operations type systems are favorable because they are able to reach a variety of passengers and destinations with few implementation obstacles and lower costs. Buses are also very flexible; routes and stations (stops) can be changed or added easily.

A. Standard Buses – Typically, these are driver operated, diesel-powered, 30- to 40-passenger buses. Bus lengths range from 10 to 12 meters (35 feet to 40 feet). System capacity can range from 400 to 500 passengers per hour assuming five-minute headways.

B. Articulated Buses - These driver operated, diesel-powered, 50- to 60-passenger buses are currently serving the long-term car park at Dublin. Bus lengths are typically 15 to 20 meters (50 feet to 65 feet). System capacity can range from 600 to 700 passengers per hour, per vehicle, assuming five-minute headways.

Automated People Movers

These technology categories are listed in ascending order of system line capacity (passengers per hour per direction) for landside airport applications. They are described in terms of general technical characteristics and by suppliers and their applications. 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.

A. 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 50 to 65 kilometers (30 to 40 miles) per hour can be achieved. The fixed-grip-technology is best suited for two- or three-station shuttle applications with relatively straight guideway alignments of one mile or less. Beyond this distance, the time between trains can exceed Airport's derived level-of-service. Detachable-grip is a new advance in the technology that allows for more than two trains to operate.

B. Self-Propelled - APMs are fully automated, driverless vehicles operating on fixed guideways along an exclusive right of way. Self-propelled vehicles or trains use a two-rail guideway system with rubber tires on concrete or steel guideway or steel wheels on steel rail.

IMPLEMENTATION FACTORS

Just as no two airports are exactly alike, the appropriate time or activity level to implement a specific landside 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 is 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 landside APM implementations include:

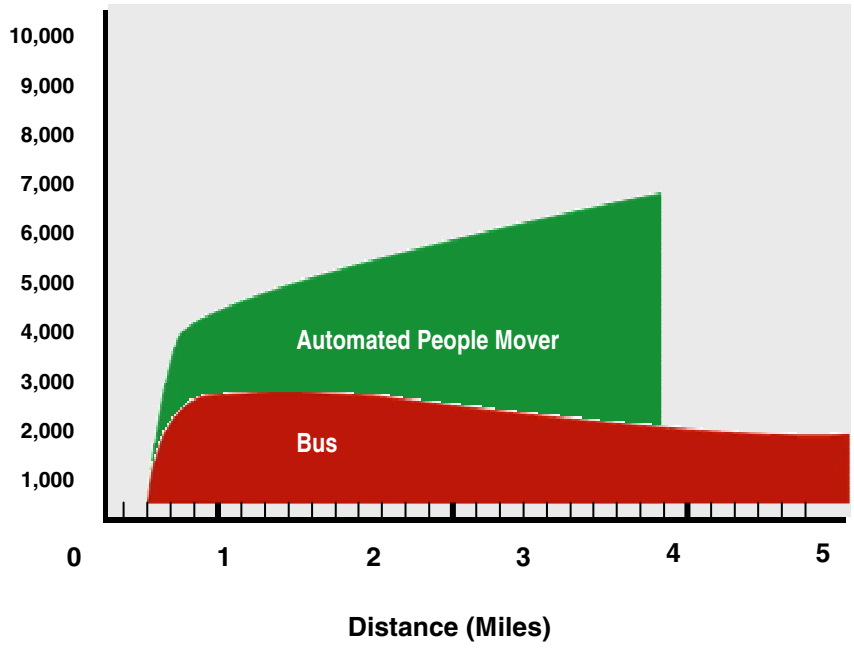
- Passenger/employee volumes and facility spacing
- Terminal access spacing
- Terminal roadway capacity
- Regional rail station proximity
- Costs and Revenues
- Airport land use
- Airport's desired transport level-of-service
- Competitive position to rival airport

Each of these factors is discussed below.

A. Passenger/Employee Volumes and Facility Spacing

In surveying airports that have implemented landside APMs, an overall measure such as million annual passenger (MAP) for origination/destination passengers does not provide a clear threshold for implementations. Airports range between 12 MAP and 30 MAP of origination/destination passengers at the time of implementation with a concentration around 22 MAP.

Exhibit A - APM and Bus Capacities (pax/hour) by Distance



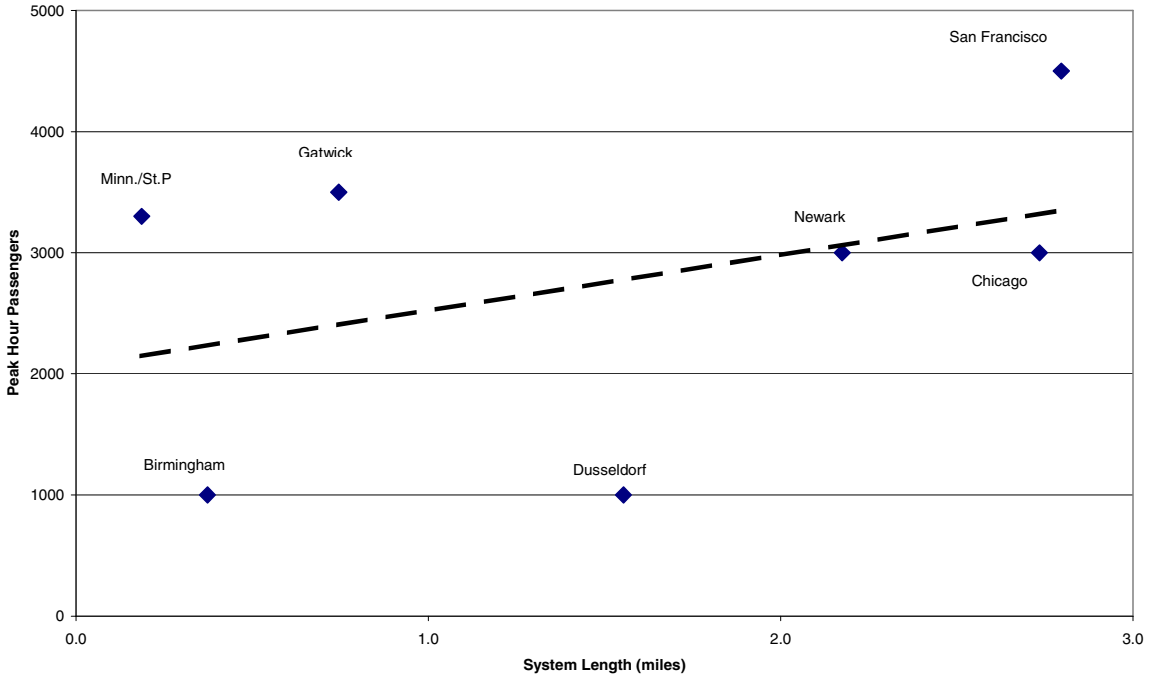
A better passenger metric is the design hour volume. APMs are designed to better accommodate high hourly volume with level boarding, multiple doors, and wide door widths. By comparison a bus operation is constrained by the number and location of bus berths and the technology requires steps in boarding and has a much lower door width to vehicle length ratio. As shown in the Exhibit A, landside APMs can potentially move over 6,000 pphpd while a bus system often has difficulty

accommodating flows over 2,000 pphpd at a single location with any fewer than four bus berths.

For current APM systems connecting a Main Terminal with (1) other terminals, (2) rental car, (3) long-term parking, and (4) regional rail, system demands are in the hourly range of 2500 to 3500 pphpd. APM systems serving all these groups tend to be longer systems of between 3 and 5 kilometers (2 to 3 miles). Systems serving fewer than the four groups listed above have proportionately lower demands and are typically shorter in length. Systems serving only rental car, long-term parking may have hourly demands from 1000 to 2500 pphpd and range from one-half to three kilometers (1,500 feet to 2 miles). As shown on Exhibit B, APM systems currently operate at Airports with peak hour passenger flows of 1,000 pphpd or more and alignment lengths from 1 kilometer to 4.7 kilometers (1,000 feet to 3 miles). For remote facilities located more than three miles from the Main Terminal, buses are the more typical transport technology.

It should be noted that for the purposes of this paper, the recently opened 14-kilometer (9-mile) Airtrain at New York's JFK International is considered a regional rail system extension rather than an airport landside APM.

Exhibit B - Existing Landside APM Systems



For existing landside systems the hourly passengers per kilometer (mile) of dual-lane guideway is another threshold to apply. The longer 3 to 5 kilometers (1.9- to 3-mile)-systems tend to have design hour flows of 500 to 700 passengers per kilometer (mile). Shorter systems of one-half to three kilometers (1,500 feet to 2

miles), though serving fewer rider groups, typically have higher flows of 700 to 1200 passengers per mile.

B. Terminal Access Spacing

Longer landside APM systems (length of guideway) typically serve multiple landside terminals, each having their own ticketing and bag claim functions. One of the APM's main functions is to connect these terminals. Connecting a terminal with international service to one or more domestic terminals occurs at a number of landside applications, including Chicago O'Hare, Newark, Frankfurt, San Francisco and a planned system at Paris (CDG). For those gate-to-gate connections, passengers must go out of and then back through security screening. As an implementation criterion, when terminal access locations are spaced 300 meters (1,000 feet) or more apart, APMs or buses are typically used to provide connections between the terminals as opposed to walkway connections.

C. Terminal Roadway Capacity

Terminal roadways can quickly become the landside "bottleneck," resulting in long delays for buses and autos. Lengthening or widening terminal roadways eventually becomes physically impossible if not cost prohibitive. At airports such as Newark, Chicago O'Hare, Düsseldorf and Birmingham (England), landside APMs provide an efficient means of supplementing the terminal roadways in providing access to and from the terminal buildings. These landside APMs allow the airport to increase passenger volumes without having to increase roadway capacity.

With this factor there is probably not a universal roadway capacity threshold. At individual airports a high demand/capacity ratio over a sustained period is probably a better metric.

D. Regional Rail Station Proximity

Most major airports desire to have a regional rail station located within its terminal complex allowing an easy connection between the rail station and ticketing/bag-claim functions. However, many major airport terminal functions are not served well by a single rail station location and regional rail's (rapid/light/commuter-rail) geometric constrains (curves and grades) do not easily allow it to place multiple station locations. Finally, the cost and constructability impacts of such a station location(s) have led some airports to locate a regional rail station remote from the terminal complex.

With the more distant locations from the terminal, APMs and buses provide the connection to the terminal. Passenger arrival patterns at the station via the regional rail service depend on that service's train frequency and train size. Long trains arrive periodically and unload a large group of passengers in a very short time period. Such surged demand is better suited to the high capacity provided by APMs.

The majority of airports surveyed have their existing or planned (future) regional rail station between 60 and 300 meters (200 and 1000 feet) from their terminals. These are almost exclusively served by walkways. APMs serve a small number of airport rail stations with the distance ranging from 300 to 3,000 meters (1000 feet to two miles) between the station and the terminal. Bus served a larger number of airport rail stations with the distance between the station and the terminals ranging from one-half mile to three miles for most of these systems. The maximum distance served by frequent bus service was approximately 20 kilometers (12 miles).

E. Costs and Revenues

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 implementation of a landside APM can positively impact costs and revenues for an airport. The following are examples of indirect financial benefits:

- APMs can lower construction costs and shorten schedules of terminal roadway expansion or short-term parking expansion by allowing remote garages to temporarily serve "short-term parkers".

- APMs can reduce implementation costs of regional rail to an airport by allowing for a remote/at-grade airport station as opposed to a terminal/below-grade airport station.

- Given the high correlation between an airport's parking pricing and parking proximity (time/distance/ease access) to the terminal, the same remote garage could be "closer" and more convenient if served by APM as opposed to bus. Directness of route, lower headways, exclusive right-of-way, all contribute to the APM's quicker connect times. This faster service can translate into greater parking revenues for a given garage.

F. Airport Land Use and Revenues

Major international airports have a wide variety of land uses on their premises. With airport growth the expansion of terminals and roadways often force other facilities to relocate to more remote locations. Landside APMs have been used to facilitate such relocations at airports including Minneapolis/St. Paul, Düsseldorf and Chicago O'Hare. APMs are most efficient when such facility relocations have high densities such as consolidated rental car and/or multi-story long-term parking structures. The higher densities allow a single APM station to serve a large number of facility users.

Commercial development opportunities on airport and adjacent lands are a revenue generating land use that is under consideration for planned landside systems at Oakland, Paris and Phoenix. The ability of a landside APM to connect the airport

facilities and a regional rail station with a commercial development property can enhance that property's value to the tenant and, hence, revenues to the airport.

The relocation of check-in and security processing away from the aircraft gates and bag claim functions is a new land use issue under consideration at a number of major airports including Los Angeles and Baltimore. Again, APMs are in the planning for this type of high-capacity facility.

G. Airport's Desired Transport Level-of-Service

The level-of-service provided by a landside transport technology can be measured in many different ways. Level-of-service measures typically include trip time, wait time, walk distance, weather protection, mode changes, level changes and bag cart accommodation.

For example, weather protection was a major reason that Minneapolis/St. Paul implemented a relatively short 300 meters (1,000-foot) landside APM to car-hire and structured parking in its extremely cold climate. The ability to accommodate baggage carts has been a very positive factor for APMs in comparison to buses for south Florida airports that handle high volumes of baggage laden tourists (bound for cruise ships).

H. Competitive Position to Rival Airport

For multiple airports run by the same agency or for multiple airports served by a single regional rail system, there is often political pressure for the airports to be served "equally". There are examples of this in the U.S. in New York City and California Bay Area regions where the decision of one airport to implement a landside APM helped lead another airport to an implementation of its own.

For multiple airports in a single region run by separate agencies, often there is fierce competition to attract passengers. Again there are examples when one of these airports implements a landside APM, the competing airport soon follows. In the south Florida region where two major airports compete for tourist/cruise passengers, both airports are currently in the planning stages of landside APMs that would help connect the airport to the seaport.

DUBLIN INTERNATIONAL AIRPORT

In 2002, Aer Rianta, the Airport operator at Dublin Airport, commissioned a Public Transportation Study. The study was undertaken in coordination with a number of other studies that were examining other critical elements in the airport system: runways, terminals and piers and car parks. All of the studies were oriented towards long-term solutions that plan for the time when the Airport reaches 30 MAP at around 2020.

Transportation Study Objectives

One of the main objectives of the transportation study was to develop long-term strategies for increasing the level of service available to airport users including:

- Determination of the most appropriate transportation technology for 30 MAP to enable Dublin Airport to achieve its long-term landside transport requirements. Technologies evaluated included travelators, buses and APMs.

- Determination of alignments/routes compatible with 30 MAP land use.

- Cost benefit assessment for the different transport technologies considered.

Study Context/Background

The ultimate transportation system needed to connect the major activity areas of the airport. There were a number of outstanding issues at the Airport that would potentially impact the transportation system. These included the future development nature of the major activity areas, the public transport modal split and the location of a future regional rail station.

A. Major Activity Areas - The Dublin Airport landside environment consists of the following four distinct areas as shown in Exhibit C, each with its own future development options:

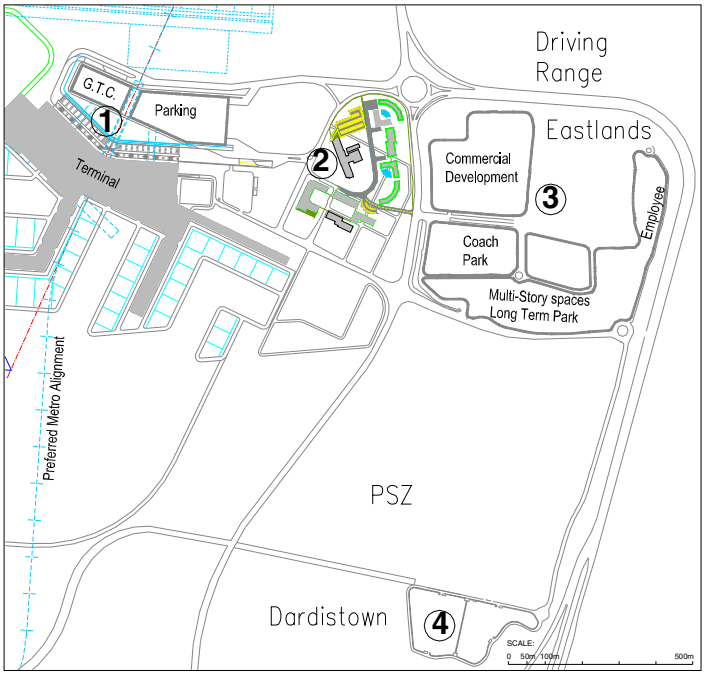
- **Terminal Area (1)**: Terminal Building, Airport Authority Offices and multi-storey car park (MSCP). Future plans are based around the development of a Ground Transport Centre (to include Bus Parks and underground metro station) and additional MSCPs.

- **Current Commercial Area (2)**: Existing facilities include two hotels and Airport Authority Offices. Future plans show further commercial developments including a hotel in this area.

- **Eastlands (3)**: Currently provides long-term surface car parking. Different combinations of commercial developments, coach park, long-term parking in multi-storey car parks, employee parking and a consolidated car hire facility are envisioned for this area in the future.

- **Dardistown (4)**: Currently provides long-term surface car parking and is separated from the Eastlands by the Public Safety Zones (PSZs) where development is currently prohibited. Future plans: employee parking or consolidated car-hire facility.

Exhibit C – Major Activity Centers at Dublin



B. Public Transport Mode Splits - In order to assess future transportation requirements for Dublin Airport it was necessary to estimate or make assumptions about the future mode split. The mode split on public transport would directly impact ridership on a landside APM. Aer Rianta in conjunction with the DTO (Dublin Transportation Office) undertook surveys and studies which resulted in the following range of target mode splits being adopted: High Public Transport Use (45%) and Low Public Transport Use (35%).

Exhibit D – Transport Mode Distribution

30 MAP - 2020		
Transport Mode	**High Public Transport Target %**	**Low Public Transport Target %**
Private Car	29.1	40.8
Car Hire	12.0	12.0
Taxis	13.5	11.8
Bus and Coach	23.0	16.3
Metro	22.0	18.7
Other Vehicles	0.4	0.4
Total	**100.0**	**100.0**

C. Location of Rail Station: There is currently no rail connection to Dublin Airport. A number of studies have been undertaken to look at the feasibility of providing a rail connection between Dublin City Center and the airport. These studies include proposals for conventional heavy rail systems as promoted by the Irish Rail and a new metro system as proposed by the DTO and as currently being developed by

the Rail Procurement Agency (RPA) pursuant to the Government's directive in January 2002. A number of feasible alignments and station locations were considered by the two agencies during 2002-2003 with the objective of ultimately providing a high quality efficient air-rail link and transportation interchange serving the Airport. The Airport expressed a desire to the RPA that a station be located as close to the existing airport terminal building as possible when the Metro system is completed.

Relevant Implementation Factors at Dublin

For Aer Rianta the most important factors in determining the relevant landside transport technology were peak hour passenger volumes, passenger level of service, and costs.

A. **Passenger Volumes:** The 30 MAP Dublin Airport peak-hour passenger/ staff flows on a shuttle system from the Terminal area to the Eastlands are expected to approach 3,000 passengers per hour per direction for the High Public Transport scenario. APM systems can typically accommodate higher volumes of passengers than buses since bus systems are constrained by either roadway or kerb front capacity at the terminals. In addition buses may not be able to maintain the headways sufficient to meet high demand.

B. **Passenger Level of Service:** Passengers using ground transport systems at the Airport are sensitive to two primary factors: journey times and quality of service. The journey time is the total time from a passenger's arrival at a parking spot or car-hire service counter until that passenger reaches their desired portal to the Terminal. Quality of service is a more subjective factor but is primarily influenced by: (1) The degree of protection from the weather; (2) the ease of boarding the transport vehicle; (3) the ease of transporting baggage and trolley carts; and (4) the comfort and "safety" of ride in terms of smooth acceleration/deceleration, seating, and potential for conflicts with other vehicles.

C. **Costs and Revenues**: Potentially, the higher initial cost for the APM can be offset by indirect costs savings, as compared to a bus system, through terminal area construction mitigation savings, remote location of Metro, and/or higher parking revenues.

Transport Technology Evaluation

From an early stage in the study it was apparent that bus or APM technology were the only two viable alternatives for providing a campus wide transportation system that would serve the airport as it approached 30 MAP.

Initially, an all inclusive range of APM transport alternatives were developed serving the different ridership groups traveling to the four major activity areas. A

total of twelve initial alignment/technology alternatives were developed for further development and consideration. Other guiding principles used in developing the initial twelve alternatives included:

- Metro station located in the preferred location within the terminal area.

- The priority passenger type served by the APM would be airline passengers, followed by commercial development users and employees.

- The APM system would be elevated in the majority of alternatives between the terminal area and the Eastlands. Subway alignment is significantly more expensive and a surface alignment becomes a virtual wall through a site.

A first level screening exercise was undertaken to reduce the twelve alternatives. Criteria used to perform first level screening included: cost, constructability, mobility, environmental, safety, flexibility and impact on PSZ. Three short-listed alternatives were carried forward as scenarios for a detailed analysis of operational, cost and level of service issues. These three APM alternatives/scenarios corresponded to three different APM lengths (short, medium and long). For each of these APM scenarios, an equivalent "all bus" transport mode scenario was developed and similarly analyzed. Following analysis of the three APM scenarios, it was decided that the Medium Length one-mile APM scenario provided the best balance between high level of service and affordable costs.

Transport Technology Evaluation Findings

The major findings of the Dublin Airport Public Transport Study are summarized as follows.

- By 30-MAP Dublin Airport peak-hour passenger/staff flows on a shuttle system from the Terminal area to the Eastlands will approach 3,000 passengers per hour per direction for the High Public Transport scenario.

- Both APM and buses can provide sufficient capacity to meet landside transport requirements and can accommodate the preferred land use arrangements under the High Public Transport and Metro assumptions used in this study. However, the APM system can meet the higher ridership demands of Low Public Transport Use levels if necessary.

- An APM system best meets the overall objectives of Dublin Airport in terms of overall long-term costs and passenger level of service. An APM would have higher initial costs (capital costs) but will cost the same in terms of Net Present Value (NPV) and less in terms of annual operating costs over the lifetime of the initial investment when compared to the bus system.

- Finally, in comparison with other existing landside APM implementations the refined APM alternative would compare favorably in terms of passengers carried over system length.

CONCLUSIONS

While this paper attempts to quantify some general implementation thresholds for different landside 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. 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 landside passenger conveyance analysis and fully integrating the Airport's goals and objectives, the best technology for that Airport will emerge.