Abstract

Personalized rapid transit pods (T-Pods), incorporating an intelligent wireless communications system, have the potential to allow the reinvention of large airports. A T-Pod system could transport passengers directly to their gates from remote parking areas. The system would dramatically decrease waiting and allow for downsizing or even elimination of ticketing and baggage handling functions. At the same time, concessions and security could be consolidated, allowing both to provide improved passenger service. Security is also improved by keeping people and bags apart and secured until they are screened. Savings from downsizing, eliminating, or consolidating existing facilities should offset implementation costs. However, retrofitting may be difficult and the system is likely to be first implemented for large expansion projects or for entirely new airports. T-Pod systems are currently in development in both the United States and the United Kingdom. Airports must start planning now in order to implement T-Pod systems when they come into general use in the next 10 to 15 years.

REINVENTING AIRPORTS USING PERSONALIZED RAPID TRANSPORT PODS (T-PODS)

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Background – Existing Airport Flaws

Airport landside (those areas inaccessible to aircraft) design has evolved incrementally since the middle of the twentieth century. Incremental improvements have included such developments as separate arrival and departure levels, passenger boarding bridges and remote concourses. These improvements have each had positive impacts on air travel, but have nonetheless resulted in a system fraught with numerous flaws.

Airport Capacity From the mid 1990s until September 11, 2001, airport capacity was a major problem in the air transportation industry. In April 2000 the U.S. President signed the AIR21 bill, which provided unparalleled levels of funding for airport improvements. Much of these funds were targeted towards alleviating airport capacity problems. Many of these problems were related to inadequate airside facilities such as runways and taxiways. However, inadequate landside facilities such as concourses, terminals, and surface transportation systems were contributing to capacity problems at many airports around the country.

Airport Security After September 11, 2001 airport security superseded capacity as the biggest concern at airports. However, many industry experts are predicting that, as air travel returns to pre-September 11 levels, capacity will once again become a significant issue.

The effectiveness of the security screening systems currently in place at major airports is questionable. Congress decreed that all checked bags be screened for explosives by the end of 2002. While many think this goal was achieved, it was not. What was accomplished was *explosive trace detection* of all checked bags. This is a much simpler, less expensive, and less effective method of screening than originally envisioned by Congress.

Even when all checked bags are fully screened for explosives, airport security will be marginal at best. Certainly we will have made it much more difficult for terrorists to take over an airliner or blow it up in mid air. Numerous terrorist opportunities still exist, such as air cargo and surface-to-air missiles. However, measures are being considered to address these vulnerabilities.

We need to remember that we are attempting to protect the public air transportation system from being disrupted and thrown into chaos by a terrorist act. Our attention has been focused on preventing aircraft-related incidents even though there are other ways of effectively attacking the system. Almost nothing is being done to protect against one or more terrorists exploding large suitcases full of high explosives while waiting in crowded lines to be screened. Such an event will certainly close the effected airport for an extended time and will undoubtedly also disrupt the air transportation system as we scramble to prevent recurrences at other airports.

Passenger Walking, Waiting and Processing Requirements Conventional airport design parameters simply accept that passengers will have to walk long distances, stand in long lines and undergo both airline and security processing on site.

Various techniques are employed to alleviate long walking distances. These include shuttle buses, automated people movers (APMs) and moving sidewalks.

No significant attempts are made by the design community to alleviate people having to stand in lines while waiting to be processed. This is probably because no suitable technologies have been available to alleviate this situation. The problem has been seen as one the airlines and security agencies need to address by reducing processing times.

Some attempts have been made to allow automated on-site passenger processing by the airlines. These include the implementation of self-service kiosks using touch-screen computers. Common use (available to multiple airlines) self-service kiosks will probably soon be commonplace.

Some airlines are allowing passengers to print their own boarding passes over the Internet. However this service has not been extended to the printing of luggage tags – probably because of the security issues involved.

Methodology for Finding a Solution

In 2000 under the leadership of the author, the Airport Consultants Council undertook an initiative to find a solution to the problems and issues outlined above. This initiative consisted of a series of workshops entitled "*Reinventing Airports*". Workshop panelists included airport consultants from all disciplines, and representatives from airport-related industries including airlines, airports and aircraft and APM manufacturers.

While the incremental improvements of the past were recognized as having brought significant advantages, the premise of the workshops was that a whole new paradigm might be required to alleviate pressing capacity issues. Furthermore, there was concern that the short-term capacity solutions being implemented may not meet long-term needs. A vision was needed of what the future airport should look like and how it should function. The workshops attempted to develop this vision to reflect the desired airport of the future, not to try to predict the airport that would result from the continuation of present trends.

The workshops brainstormed various concepts with almost no consideration of feasibility. Little consideration was given to time frames either – the "future" was broadly described as twenty, or perhaps fifty years from now. The brainstorming sessions quickly revealed that the desired airport of the future would be vastly different from existing airports – an indication of the panelists' high level of dissatisfaction with existing airports. The conclusion was that airports of the future should provide *seamless door-to-door travel with no waiting.*

The workshops then set about the more serious business of considering methodologies and technologies that would allow the vision to be realized. Concepts as varied as "all bags should be checked bags" and "checked bags transported separately" were developed and considered. Numerous goals and objectives were developed. The vision was provided with a timeframe and adopted as the goal of the workshops – *airports will provide seamless door-to-door travel with no waiting by the year 2015.*

The final workshop was held in November 2001 shortly after the tragic events in September. While the goal appeared to have suffered a tremendous setback, the panel had developed numerous excellent ideas for the types of service airports of the future should provide. Many methodologies had been suggested for implementing these ideas but no clear solution was apparent.

In February 2002 the author unveiled a new airport paradigm that could allow many of the ideas of the workshops to be implemented. It could also allow new airports to mostly achieve the goal of seamless door-to-door travel with no waiting.

A New Airport Paradigm

People have envisioned using personal rapid transit (PRT) in airports since the nineteen eighties.[1] PRT involves using small self-guided transportation pods (T-Pods) to transport small groups of people directly to their destination. The trip is undertaken without stopping since all stations are off-line (i.e. a T-Pod pulls off the main guideway before stopping for passengers).

This new airport paradigm takes the PRT concept to a new level by incorporating wireless computer communications into the T-Pods. Each T-Pod is sized to accommodate a group of people typically traveling together and having the same destination. The T-Pods also accommodate all luggage, both carry-on and check-in.

The wireless computer communication system functions as a remote check-in kiosk, and all airline transactions can be accomplished from within the T-Pod. Since the vehicle carries all luggage, these transactions can include the issuing of luggage tags as well as boarding passes. This effectively eliminates the need for a ticketing and bag check-in area (the prime purpose for the terminal building) and passengers could proceed directly from their origin on the PRT system to their aircraft-boarding gate.

However, numerous benefits derive from having passengers wait in a consolidated concessions area until their aircraft is ready for them to board. Similarly, it is beneficial to undertake security screening as close to the airport perimeter as possible.

This new airport paradigm thus involves transporting passengers from remote parking or mode change facilities to their gates in small self-guided vehicles. Boarding passes and luggage tags are issued in the vehicle. Security screening is undertaken prior to entering any public building and almost all waiting is undertaken at a centralized concessions area.

Conventional concepts that could change under this paradigm include:

- Vehicles wait for people rather than people waiting for vehicles
- People are transported to aircraft rather than aircraft taxiing to people
- Ticketing and bag check-in is undertaken in vehicles rather than in buildings
- Security screening is undertaken prior to entering public buildings
- People and bags are transported on the same system
- All waiting is undertaken while seated
- Transportation is non-stop with almost no walking
- All concessions are consolidated in one facility.

Preliminary Operational Details

This section describes how this new airport paradigm could operate if it were incorporated into a new green-field airport. The discussion is based on the ULTra PRT system being developed in the UK by Advanced Transport Systems (ATS). This system appears to be about three years ahead of competing systems and meets most of the requirements for this new airport paradigm. Advanced Transport Systems is contracted to London's Heathrow Airport for the second phase of a study to implement the ULTra system to provide surface transportation between the central terminal area and remote parking lots.

Vehicles (T-Pods) ULTra vehicles are electrically powered and follow magnets buried in the guideway surface. They run on rubber tires at speeds of 25mph. All stations are off-line and all switching is accomplished from within the vehicle.

Fig. 1. The ULTra Vehicle

For this new airport paradigm the vehicles would have to be fitted with wireless touch-screen computers or kiosks. This will allow in-vehicle communications with the airlines, airport operations and security.

Guideways Guideways are six feet wide and typically include twelve-inch high walls on either side. The walls provide secondary guidance and increase the perceived safety of travelers. Guideways are uni-directional and are typically laid out as a series of interconnecting loops. In this way multiple routes connect any chosen origin and destination providing a built-in redundancy as illustrated in Fig. 2.

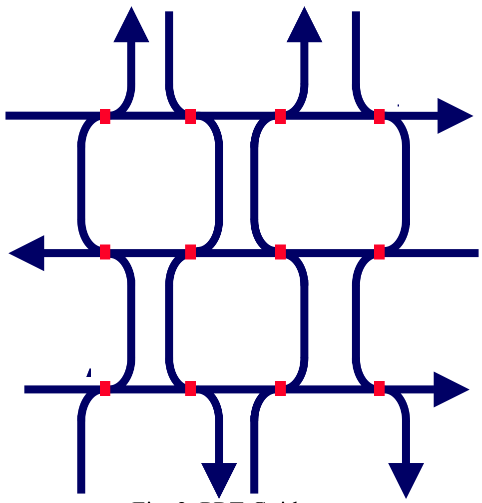

Fig. 2. PRT Guideways

Because the vehicles are light and will always travel with a small distance between them, the structural requirements for elevated guideways (and thus the cost) are actually less than for the equivalent footbridge. This is because a footbridge must be designed to withstand the loads caused by people crowding together.

Fig. 3. Elevated Guideway

Surface guideways are similar in construction requirements to a footpath or sidewalk. Underground guideways require a cross-sectional area less than a quarter of that required by an underground APM.

Wireless Computer Communications Each T-Pod will be equipped with a touch screen computer with CCTV, microphone and Speaker as shown in Fig. 4. The system will also have the ability to read a credit card and print boarding passes and luggage tags. Passengers will establish their identity upon entering the T-Pod by entering a number such as their airline confirmation number or swiping a credit card. They will then use the system to transact with the airlines and security.

The system will offer different language options. In the event a passenger is computer illiterate, the system will be capable of voice communications. A small conventional check-in station may be required for situations where computer communications are inadequate.

Fig. 4. Rendering of On-board Touch-Screen Computer with CCTV, Microphone and Speaker

Surface Travel Almost all on-airport surface travel would utilize the PRT system. The major exceptions would be for bulk transportation of goods and specialized equipment such as fire fighting vehicles. Remote parking lots and/or mode change facilities would be strategically located near the airport perimeter. These facilities will allow passengers, employees and others to conveniently transfer to the PRT system from whatever system they used to reach the airport.

While the PRT system is essentially a surface transportation system, it should be understood that it can effectively operate both above- and below-ground. Since the vehicles are very light (in the order of 2,000lbs loaded), they can also operate inside buildings where the floors are designed to conventional building code requirements.

People The vehicles can typically hold up to four people. The concept is that groups of people (such as a family) traveling together will share a T-Pod. This allows T-Pods to proceed to their common destination without stopping. Not having to share a ride will also provide an added level of security for single travelers. Larger groups traveling together will need to split up into two or more T-Pods. It is likely that during peak periods, some travelers will voluntarily opt to share rides. In this event intermediate stops will be unavoidable.

The vehicles are designed to meet the requirements of the Americans with Disabilities Act (ADA). As such they can accommodate wheelchairs as illustrated in Fig. 5.

Fig. 5. Wheelchair Accessible

One group of people not likely to be adequately accommodated by T-Pods is VIPs. These people typically travel in their own aircraft and can best be accommodated at general aviation terminals via road access.

Bags While the vehicles as presently designed can accommodate bags on the floor between the passengers, more sophisticated bag storage will probably be required for two reasons. First, the large bags typically accompanying a family on vacation will likely require a family of three or four to use more than one vehicle. Second, once screened, access to checked bags must be limited since checked bags can contain items not permitted to be carried onto the aircraft.

The most likely solution will involve a separate bag storage area in the T-Pod that would automatically restrict access during travel from security screening to the gate. At the gate, access to this area would only be granted to appropriately authorized bag handling personnel.

Another solution would have checked bags accommodated on the floor between passengers for all trips except from security screening to the gate. For this latter trip, screened checked bags will be transported in special T-Pods designed to carry bags.

Freight T-Pods specially designed to carry bags could also carry freight. However, it will be important not to lose sight of the enormous benefits derived from small vehicles. Any attempt to incorporate larger vehicles for increased freight carrying capabilities is likely to detract from the system's ability to meet passenger needs. A conventional roadway will still be required and will likely be the best form of transportation for bulk freight.

Airline Transactions Currently airline ticketing and bag-check transactions typically vary from a few minutes for the business traveler with no checked bags to half-an-hour or more for the international traveler with checked bags and scheduling problems. Completing airline transactions within the T-Pods will not always be possible in the short travel time from remote parking to security screening. However the system has the capability to combine and streamline four activities, airline queuing, check-in, security queuing and screening into two activities, airline check-in and security screening.

Upon entering a T-Pod, the passenger will swipe a credit card, enter an employee number, an airline ticket or confirmation number or some other means of being identified by the system. If the passenger is destined to travel on an airline, transactions with that airline will commence. The airline transaction process will continually keep the system informed of the estimated time necessary to complete the transaction. The system will then select the appropriate queue prior to security screening.

Security Screening Security screening will be accomplished in specialized screening buildings through which the T-Pod guideways will pass (see Fig. 7). These buildings will have no other function than passenger and bag screening. Only those passengers actually being screened will be allowed inside the building. Passengers waiting to be screened will remain seated in their T-Pods outside the building. Waiting T-Pods can be spaced sufficiently far apart to avoid being vulnerable to a bomb contained in unscreened luggage.

People People waiting to be screened will do so in seated comfort in a controlled environment. Fig. 6 graphically depicts the conventional ticketing and screening process while Fig. 7 depicts the same process under this new paradigm. Note the reduction in groups of unscreened passengers and luggage (solid dots) inside and outside a building in Fig. 7 as compared with Fig. 6. This represents a huge reduction in vulnerability to bombs.

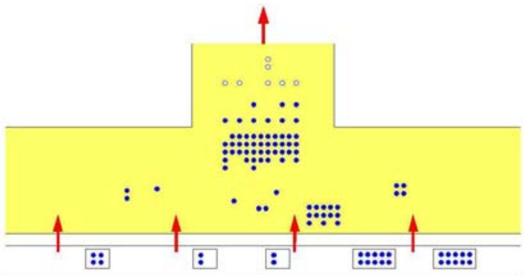

Fig. 6. Conventional Ticketing and Screening

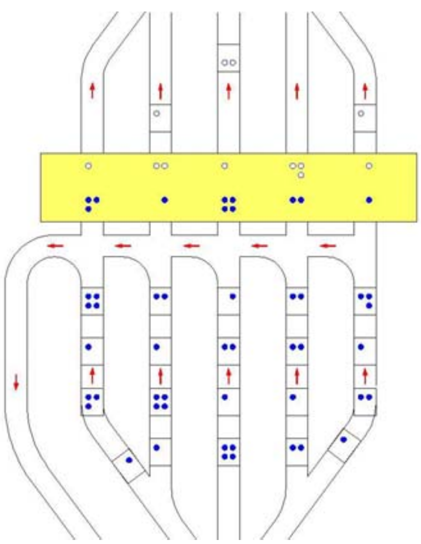

Fig. 7. New Paradigm Ticketing and Screening

It is likely that people will have to exit the T-Pods in order to be satisfactorily screened. Future technology that will allow in-vehicle screening will certainly make the experience more seamless.

There will be no need for a T-Pod to wait for its passengers who have exited to be screened. Rather, it will pick up passenger(s) that have just completed their screening process and take them to their destination. Even if the T-Pod were to wait for its original passenger(s) it would still be necessary to verify their identity before (say) taking a passenger to a boarding gate for which they did not have a boarding pass.

Bags Checked bags will be screened in the same area and at the same time as the passengers owning the bags. This will greatly facilitate resolving any issues that may arise such as the need to unlock suitcases.

Once the bags are screened their tags will be scanned, and they will be placed in a locked area of a T-Pod. This may not be the T-Pod carrying the bags' owners. The T-Pod will then typically first carry its passengers to their destination and then take its bags to their boarding gate.

At the gate, the bags will be unloaded from the T-Pod by authorized personnel and placed on a conveyor for loading onto the aircraft.

Security Enhancements The wireless computer communication system will enable security authorities to communicate with passengers for the purpose of obtaining pertinent information. This will allow the screening process to be tailored to the situation. For example an unknown traveler with a one-way ticket could receive more attention than an employee or an airline pilot who uses the airport daily.

On-board closed-circuit television (CCTV) cameras coupled to the wireless computer communication system will enable significant advances in security (and safety). CCTVs could be monitored by software capable of recognizing individuals and interpreting their actions (Northrop Grumman has developed such software). This software could alarm for such situations as:

- One passenger is assaulting another
- A passenger abandons a piece of luggage in a T-Pod
- The passenger boarding the aircraft is not the one to whom the boarding pass was issued.

Fitting the vehicles with global positioning systems (GPS) would allow security and/or operations personnel to monitor the position of individual T-Pods in real time. They could also view the video transmitted by the on-board CCTVs live or replayed to show an incident.

If the CCTV camera is mounted on the on-board touch-screen computer, it will obtain exceptionally good pictures of passengers who will have to look directly at the screen. This will facilitate the use of facial recognition software to identify known terrorists. The vehicles will hold their passengers captive and could thus deliver problem passengers to a secure area.

Queuing No more standing in line shuffling large bags – all queuing takes place inside T-Pods in a seated, climate-controlled environment. Queuing requirements are minimized by allowing airline and security transactions to take place while the T-Pod is moving. However, it will be desirable for most of these transactions to be completed prior to entering the screening building and the travel time may not be sufficient for this. In this event the T-Pod will wait outside the building to allow the transactions to be completed. The guideway layout will allow delayed T-Pods to circle to the back of the line if necessary as shown on Fig. 7.

Departing passengers will no longer have long waits at the concourse. If the airline is not ready for the particular passenger(s) on a T-Pod to board, they will be taken to a centralized concession building. They will be given a number of alternative destinations to choose from within this concessions facility such as entertainment, dining, lounge, casino, etc.

Upon dropping its passengers at the centralized concessions building, the T-Pod will offer to page them when it is time for them to proceed to their gate. The system will be able to page by cell phone or system-provided pager.

Concessions Eliminating waiting at the gate allows all concessions to be located in a centralized facility. This building will essentially replace the conventional terminal building. Since almost all departing passengers will spend some time in this facility, it should be feasible to provide significantly improved concessions in a shopping mall-like environment.

In-bound (arriving) passengers will no longer stand around waiting to collect their checked bags. Rather, they will wait in seated, climate-controlled comfort on board the aircraft until their bags are ready to be picked up. The proposed methodology will scan the bags as they are loaded from the airplane onto the conveyor leading up to the boarding gate. Passengers with checked bags will remain seated until notified that their bags are waiting for them. They will then deplane, pick up their bags and place them in a T-Pod.

Concourses Since there will no longer be any significant waiting at the gate, concourses can be designed strictly to serve the boarding process. There should be little need for seating and no need for concessions in concourses. Restroom facilities can be reduced to a minimum. Besides the T-Pod station and boarding gates, the major feature in the concourses will be facilities to load and unload baggage.

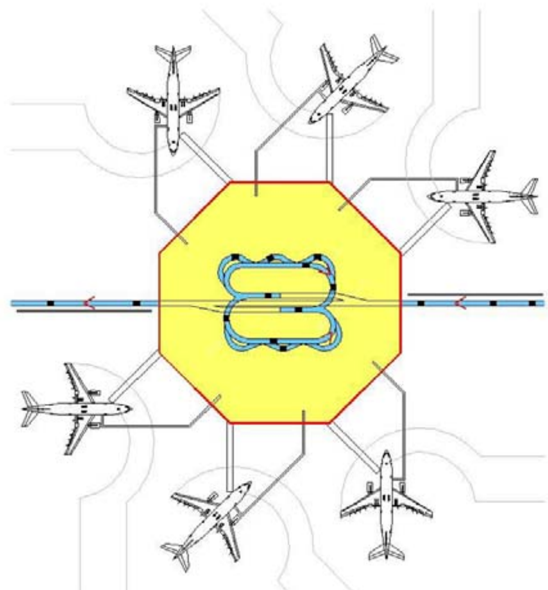

Fig. 8. Concourse Layout

Since PRT systems are so well suited to numerous stations, long concourses will no longer be appropriate. It is likely that each concourse will only serve four to eight aircraft boarding gates. A potential concourse layout is shown in Fig. 8. Note that this configuration allows aircraft to power away from the gate, saving the time and expenses associated with pushback tugs.

Arriving Passengers As stated above, arriving passengers will proceed directly from the aircraft to a T-Pod. Upon entering their access code into the on-board computer the T-Pod will remember where returning passengers originated and offer to take them directly back there. Transient passengers will be asked for their desired destination. If they are renting a car they will be able to transact with the rental car company by means of the on-board computer. The T-Pod will then take them to the rental car lot of their choice.

Connecting Passengers Connecting passengers will simply proceed to the nearest T-Pod. Once they have entered their identification number, the T-Pod will take them to their connecting gate. They will have no need to find their way or run to make a connection. In addition, as with all passengers, the system will always know where they are.

Connecting bags will likely be loaded into a T-Pod for delivery to the connecting gate. It is possible that passengers may be required to collect their bags and take them with them on the T-Pod. It is also possible that conventional means could be used for connecting bags.

Meeters and Greeters Airports will have complete flexibility in dealing with people visiting an airport for purposes other than air travel. Since all who travel the system will be screened prior to entering any public building, it should be possible to allow non-travelers freedom to visit the central concessions area and the concourses. However, should the need arise, the system could easily preclude non-travelers from visiting the concourses or even the central concessions facility. Meeters and greeters can drop off and pick up passengers at the remote parking lots if necessary.

Operating Statistics

ATS provided the operating statistics quoted here for the ULTra system. While they are not based on actual production and operation of a system in service and are thus estimates, ATS has calibrated these estimates by the actual construction of prototype track and vehicles.

Vehicle capacity:	4 seats
Vehicle speed:	25mph
Minimum headway:	1 second
Single guideway capacity:	14,000 seats/hr.
Capital cost/passenger (7% financing cost):	$0.75
Operating cost/passenger:	$0.50
Total cost/passenger:	$1.25

By way of comparison, according to presentations at the 2003 AAAE/ACC Airport Planning, Design and Construction Symposium in Denver, Colorado, the APMs being installed at Dallas Forth Worth and JFK Airports have capital costs of $3.47 and $5.00 and operating costs of $.35 and $2.00 respectively.

ATS has undertaken comparative time and cost studies at London Heathrow Airport relative to the existing shuttle bus system. They found that the ULTra system saves walk, wait and in-vehicle times. The overall average time saving relative to the existing bus system is 60%. It provides an operating cost saving of 40%.

Potential Benefits and Opportunities

To Air Travelers Air travelers will spend less total time and much less wasted time in airports. Almost all waiting time will be spent in the location of their choice away from annoying public address systems. The ability to work, make phone calls or just relax while they wait will be greatly enhanced.

Since the system will always know how to get passengers to their destinations, they should no longer get lost.

Walking distances will be greatly reduced and standing in line virtually eliminated. This will greatly facilitate air travel for handicapped and frail passengers.

Since bags utilize the same system and travel with their owners for more of the time, loss of baggage should be reduced. In addition, since bags are screened at the same time as passengers, there should be fewer incidents of theft and/or locks having to be cut off for screening.

Passenger safety and security will be improved since on-airport travel will be undertaken in a very secure environment.

To Airlines The airlines benefit by having a more automated check-in system. They have a reduced need to deal directly with checked luggage. They also benefit by having a much more streamlined boarding process. In addition, passenger IDs will automatically be verified upon gate check-in.

Airlines will also benefit from reduced aircraft taxi distances.

To Airports Airports benefit from a more flexible layout. Increased distances between runways will enhance instrument landing capabilities.

Flexibility in runway location will enhance the ability to direct noise away from sensitive areas.

Airports also benefit from reduced surface transportation costs relative to current APM and shuttle bus systems. In addition, they should see increased concession revenue. This is because passengers' waiting time will be consolidated along with the consolidation of concessions. This consolidation of both time and concessions should allow more people to have more time to shop from better concessions.

An additional airport benefit includes vastly improved security. The air transport system will become a truly hard target for terrorists who will probably turn their attentions elsewhere.

Another airport benefit relates to the flexibility of concourse design and location. Concourses will be much smaller and will no longer need to be located in close proximity to each other and the main airport terminal building. It should also be possible to design concourses in such a way as to allow aircraft to power away from gates, eliminating the need for pushback tugs.

In summary, all stakeholders should receive considerable benefits from operational improvements and savings in time, which should in turn result in operational cost savings.

This new airport paradigm should substantially reduce the need for airport roads, buildings and APMs. How this capital cost savings would compare to the increased cost of installing the PRT and wireless computer communications systems has yet to be investigated.

Another benefit that needs to be investigated is the impact on airport revenue generating opportunities. Since close-in parking will be eliminated, overall parking revenue may decrease. However parking charges at remote lots could be raised since they will provide the same or better convenience level.

In addition to improved concessions revenue, it should be possible to generate revenue from the new system. For example, the on-board computer could display paid commercials or provide Internet access when not being used for communication.

Conclusions

The new airport paradigm discussed here is enabled by two technologies that are rapidly becoming robust. No new technology needs to be invented to allow it to work. All that needs to be accomplished is to figure out how best to incorporate this system into new airports. While this is being studied, portions of this concept will be implemented at existing airports. For example, remote check-in kiosks are already coming into widespread use and London Heathrow is currently examining the merits of possible use of a PRT system.

It is not too soon to begin planning new airports using this new paradigm. In the time it takes for any new airport to complete the planning phase and commence detailed design, the various aspects of this system are likely to be functioning in the public domain and their operating characteristics will be well known.

Airports will be able to provide seamless door-to-door travel with no waiting by the year 2015.

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