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Airports of Tomorrow

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AIRPORTS OF TOMORROW

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Transportation Research Board
National Research Council
2101 Constitution Avenue, N.W.
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FOREWORD

Three sessions at the Seventy-Third Annual Meeting of the Transportation Research Board in January 1994 were devoted to future airports. This Circular is a compendium of the presentations by speakers at these sessions. It consists of three parts. The first deals with the planning and development of four very large new international airports in the cities of Denver, Bangkok, Hong Kong, and Munich. The second part, entitled "What Does it Take to be an International Airport?", addresses terminal building design, surface access, customs and immigration inspection facilities, and passenger concessions. The third part examines the general question of environmental protection standards and mitigation measures that apply to all airports but which are particularly important at very large airports handling millions of passengers per year.

The underlying theme running throughout these presentations is that, as air travel grows, airports must keep pace not just in size but also in their complexity and level of technological sophistication. The new large airports now on the drawing boards are a quantum leap beyond those built as recently as two decades ago.

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THE NEW GLOBAL AIRPORT

F. Roy Madgwick, Session Moderator
HNTB Corporation

This session examined four new airports around the world, airports that are in various stages of planning, design, construction, or operation. It is clear that a cookie-cutter approach cannot be taken in creating a global airport. Each is a distinctive entity, with characteristics determined by its location in the world, the culture of the country in which it lies, the international and particularly the national aviation function that it is designed to serve, and the size of the market. The presentations by speakers at this session describe how these airports came about and how they have been configured in response to their setting and how the form and layout of the airports reflect the purposes for which they were built.

THE NEW DENVER AIRPORT

Ginger Evans
City and County of Denver

The City and County of Denver is building a new airport northeast of the existing metropolitan area in a location somewhat more removed from the existing central business district than the present Denver Stapleton International Airport. This a relatively undeveloped part of the metropolitan area that lies just outside what has been a military preserve for the last 40 years and provides a suitably large open tract of land for a new airport to accommodate air commerce on a global scale. (Figure 1)

The environmental approval for the project was obtained on September 29, 1989. Construction started on September 30, 1989. The new airport, designated Denver International Airport (DIA) is scheduled to open in 1994, after a construction period of about four and one-half years. Concurrently, the existing Stapleton International Airport will be closed forever for aeronautical purposes.

Historically, Denver's air travelers are roughly 55 percent hubbing passengers and 45 percent origin-destination passengers. There has been a strong market for international air service to Mexico for the last 20 years, a market that is expected to increase (along with service to Canada) as a result of the North American Free Trade Agreement. Denver is well positioned to service these markets.

Denver's first nonstop service to continental Europe was initiated in December 1993 by Martin Air Holland using B767-300ER (extended range) aircraft. In addition, both British Airways and Lufthansa consider Denver to be their number one unserved market in the United States. With the advent of new long-range aircraft such as the B777 in the next five years, the expansion of overseas service into Denver becomes even more likely. Hawaii and Japan can be served with the B777. Denver intends to compete for increased international air service, both by foreign carriers and by two domestic hub carriers, Continental and United Airlines, each with a significant presence in the international market.

It may very well be that Denver's primary function will be as a base for very large feeder operations to other existing gateways for these two domestic carriers. The existing gateways are expensive to operate and develop, and United and Continental will probably be reluctant to make that type of investment in multiple locations. The new Denver airport is positioned to be a very large feeder for existing gateways and to provide direct international service. The intent is to compete for both.

The new airport has also been designed as a major air cargo facility. Cargo has been the highest area of growth, a minimum of 10 percent per year for the last five years, generally closer to 15 percent per year.

Denver sold airport development bonds on the strength of the historical passenger and air cargo service markets. The airline agreement provides for preferential, rather than exclusive, gate use. This was a major breakthrough. There are no majority-of-interest provisions that require airline approval of construction of new facilities for market entrance. This is a key provision that was very carefully negotiated. It took about four years to get United Airlines to sign an agreement without the majority-of-interest clause.

AIRPORT DESIGN

DIA was designed with three main objectives:

- Ease of growth and expansion in all the service areas,
- Elimination of noise impacts on the metropolitan area, especially in the residential neighborhoods that surround the existing Stapleton airport, and
- Reduction (ideally virtual elimination) of aircraft delays by providing a highly efficient ramp and runway configuration.

The new DIA facility has a fairly high level of base finishes that will minimize the investment required of new market entrants. Denver wants to encourage new carriers to come to DIA.

AIRFIELD AND AIRSPACE CONFIGURATION

The new airport has a four-quadrant airfield configuration to provide capacity in all four cardinal directions. (Figure 2) In visual meteorological conditions (VMC) the major traffic flow is north-south. In instrument meteorological conditions (IMC), because of the prevailing winds that accompany low visibility, operations are exclusively to the north. For these

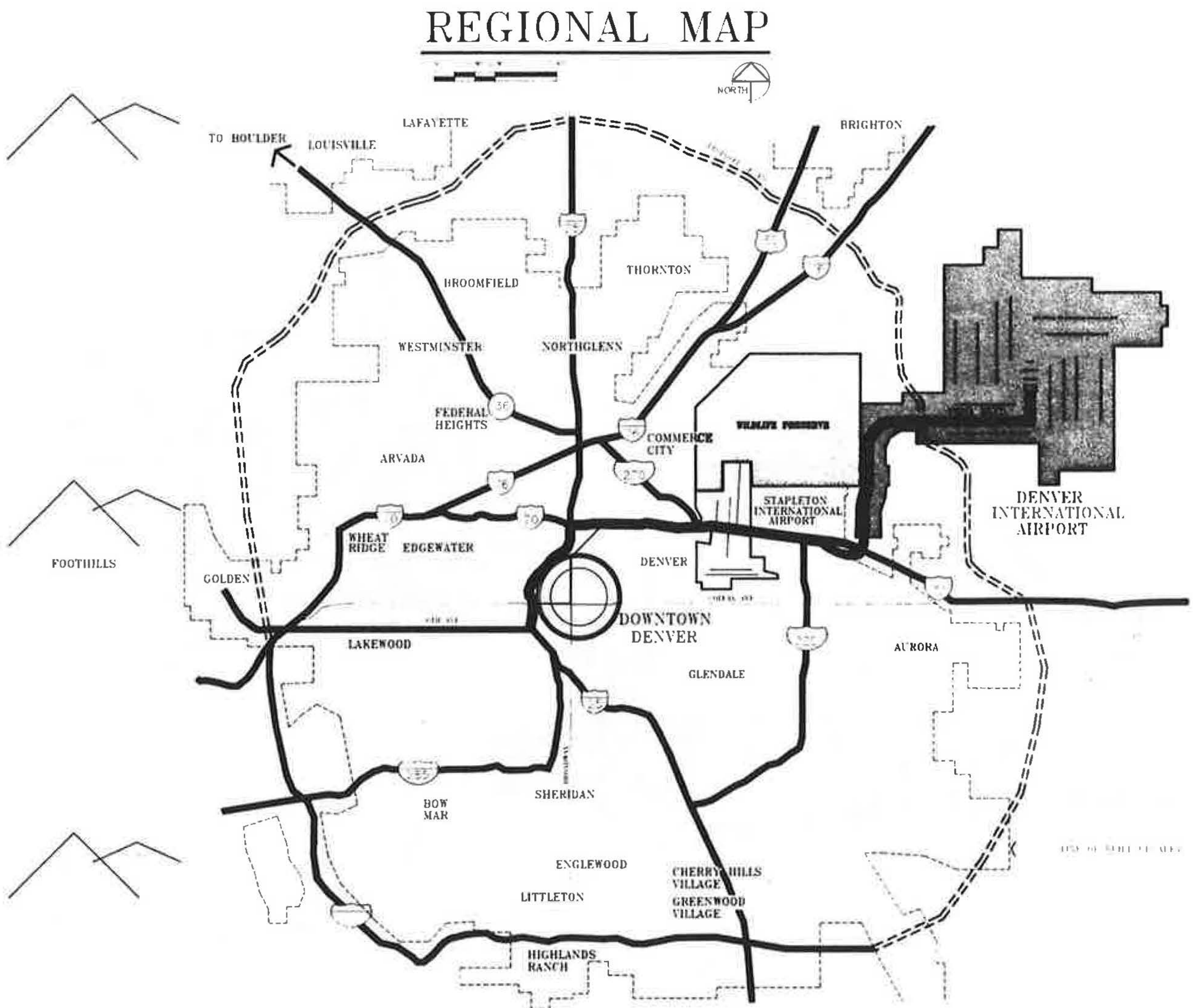


FIGURE 1 Denver regional map.

reasons the preponderance of the runways are north-south. However, there is a substantial crosswind (east-west) component at certain times. In the morning, because of Denver's location in the middle of the country there is an "east push", with a large number of aircraft inbound from New York and Chicago arriving from this direction The east-west set of runways allows these flights to make the transition from en route to a straight-in approach without changing direction and then to continue to landing, roll-out, and taxi to the ramp with maximum efficiency. Morning departures use the other side of the ramp and depart to the north and east.

This runway configuration also allows very efficient use of the 360 degrees of surrounding airspace. Oftentimes, designers rigidly apply the FAA advisory circulars, locating runway thresholds to avoid wake turbulence and to provide the required separation for independent IFR arrivals. All these criteria have to be met. However, if the airspace is viewed from the perspective of the air traffic controller in the tower, it is evident that many delays do not occur close in but at the 50-mile posts on the approach path. With all flights coming in from a single direction, traffic stacks up, and controllers must hold aircraft until they have spaces for them.

In planning DIA an attempt was made to sort out the traffic efficiently by minimizing what is called "flying the trombone", which involves getting approaching aircraft lined up for the runway in an orderly stream as early as possible. In a climate like Denver's where the winds are known to shift abruptly, controllers have to be able to redirect traffic flow very quickly.

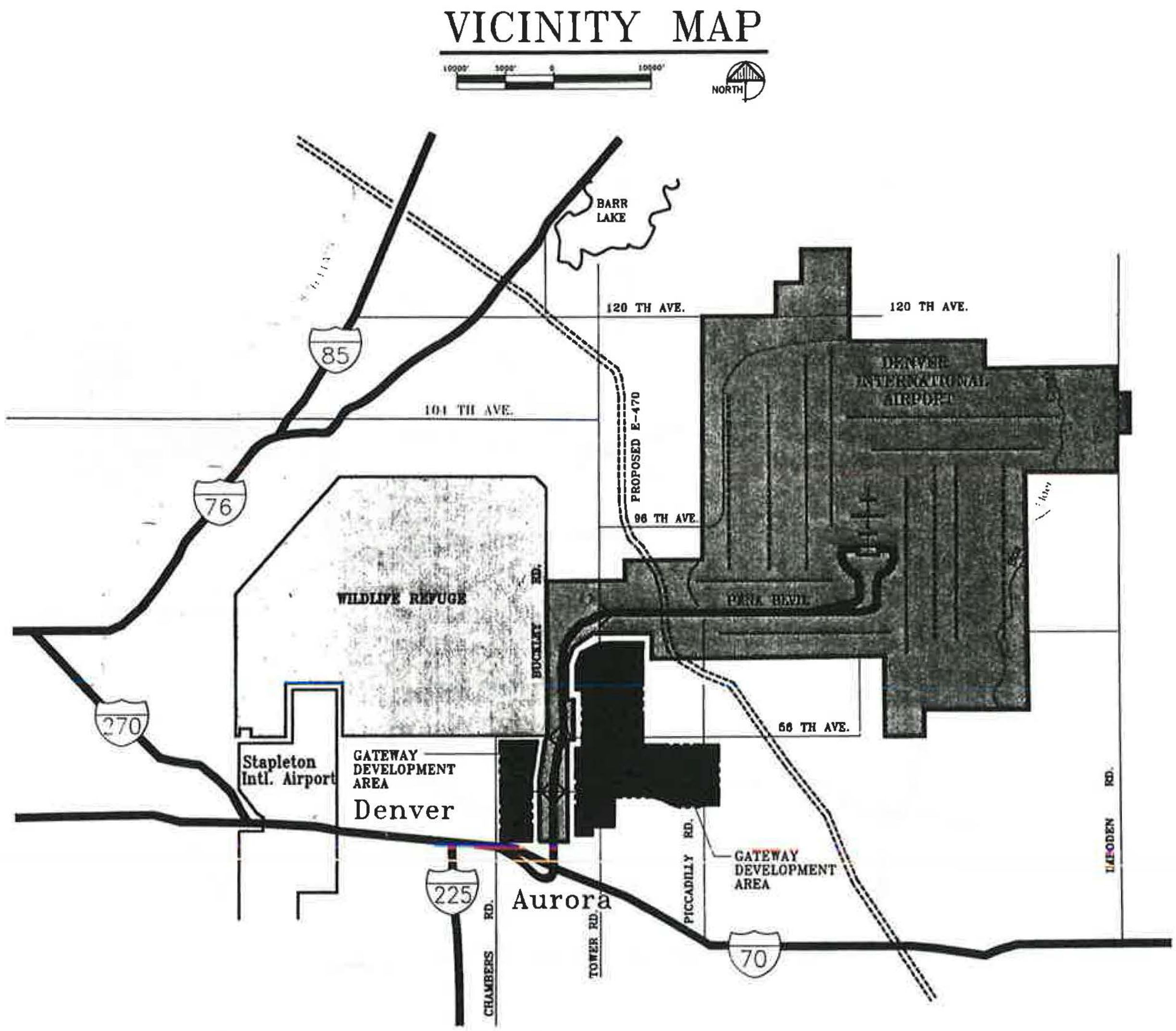


FIGURE 2 Vicinity map, Denver International Airport.

Today at Stapleton, which is basically a big L, it takes 90 minutes to change the direction of arrivals. DIA will be able to do it in less than 2 minutes. This will be accomplished by having four VORs instead of two. At any particular time two VORs will be in operation, permitting aircraft to arrive in two quadrants of the compass and to depart in the other two. How this works is shown in Figure 2.

In the afternoon, traffic flow reverses at Denver. The eastside VORs are turned off, and the two westside VORs are turned on. Aircraft coming in from San Francisco and Seattle land on the west side of the airport, and the departures to the east coast move out south and east on the other side of the airport.

This configuration facilitates departures as well. Air traffic controllers fan aircraft out from a particular takeoff path (or stick), and each of these sticks requires a cone of airspace. The cones of airspace are so widely separated at DIA that they are, in fact, independent, which lets controllers shoot flights out as quickly as individual aircraft performance will allow.

RAMP LAYOUT

The DIA terminal configuration was likewise planned to make aircraft movement efficient. The design is a modification of that used at Atlanta. The Atlanta arrangement is by far the most efficient airfield model in use, but it has some problems. One was that the concourses were too closely spaced to allow dual taxiways and independent push-backs from both

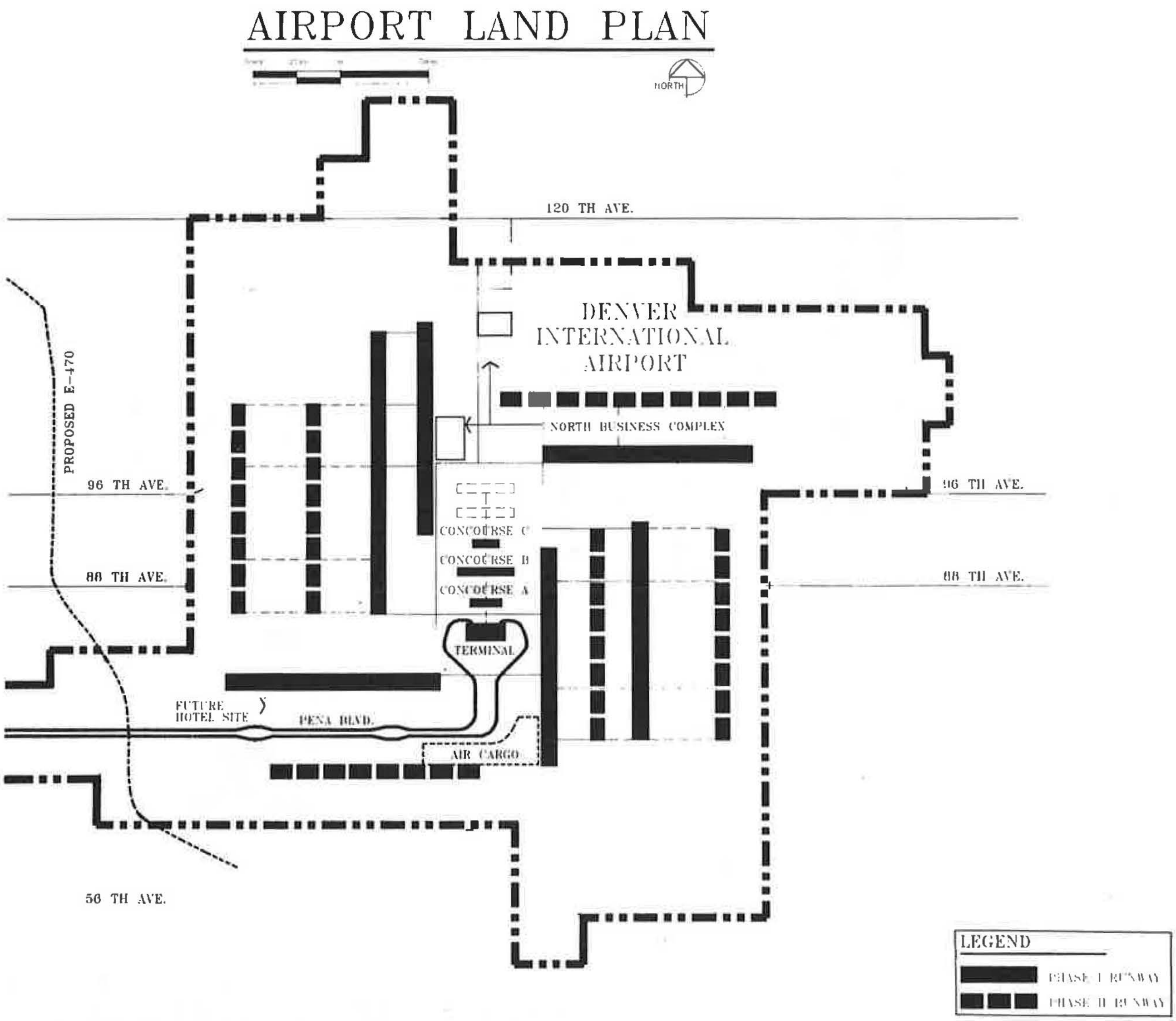


FIGURE 3 Denver International Airport land plan.

concourses at the same time. At DIA spacing was increased so that aircraft can push back, taxi out, and leave without coming into conflict with the ground movements of other aircraft.

DIA has three airside concourses, A, B, and C. The north side of concourse B is designed for Group 5 plus aircraft like the B777, which requires an additional 142 feet of ramp width beyond traditional Group 5 requirements. The north side of concourse A, where international flights will come in, is designed to Group 6 criteria. This is intended to achieve a smooth flow of aircraft through the ramp area. (I have a master's degree in hydraulics, so I call this the laminar flow theory of aircraft movement.)

The ramp is controlled by two towers on concourses A and B, staffed by airline personnel with a city observer, to make sure that parity of precedence is given to aircraft movements on the two concourses. At one time it was contemplated that FAA would control the ramp because it is so large, but the final decision was that it would be better to hand off to FAA at the ramp perimeter. DIA has the space to have a triple perimeter taxiway system around that ramp.

The deicing pads are on the west of the ramp, basically on the departure side, where aircraft take off during IFR conditions. The deicing pads are located immediately adjacent to the runway threshold, as close as FAR Part 77 criteria permit.

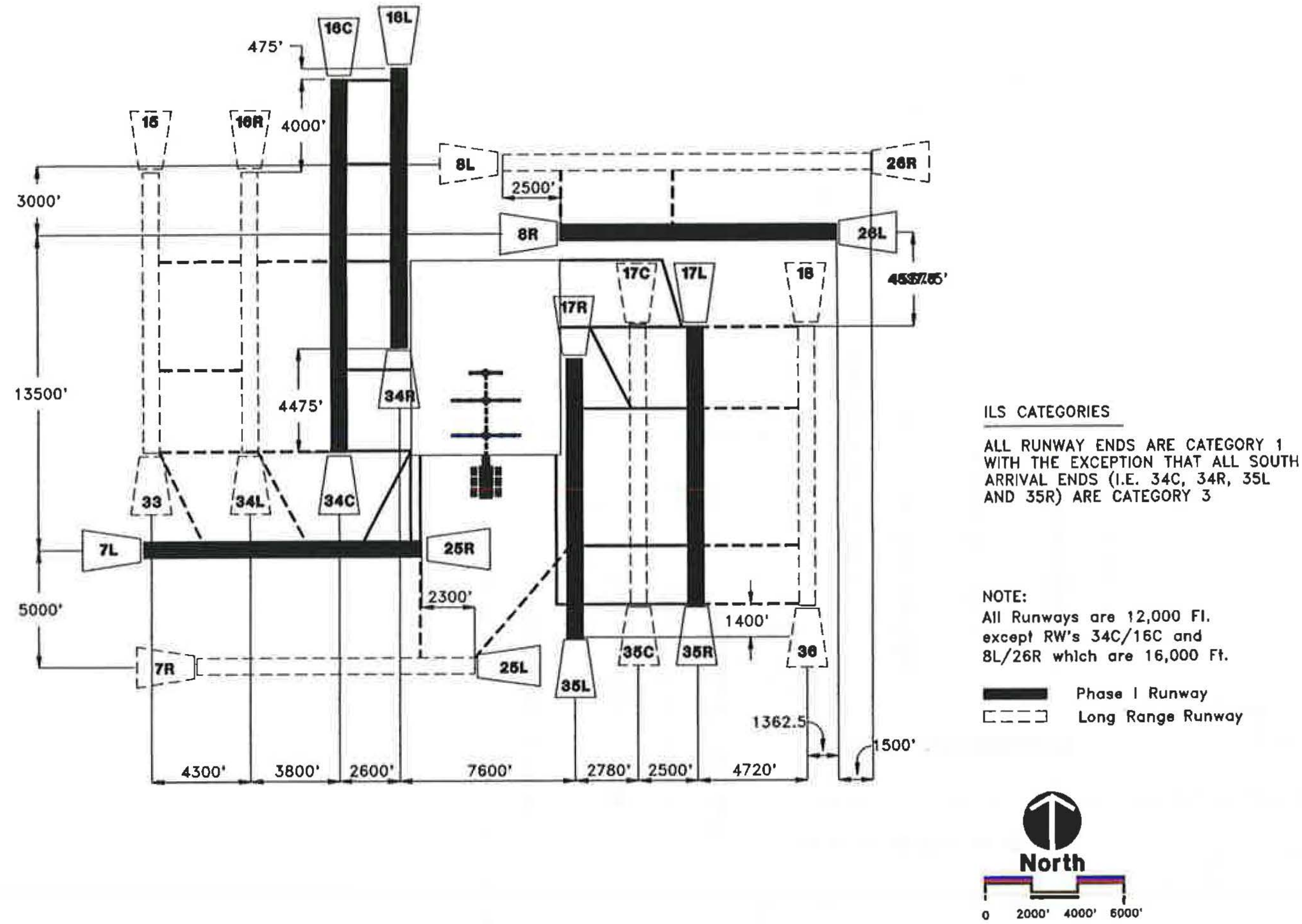


FIGURE 4 Denver International Airport runway layout plan.

TERMINAL LAYOUT

One special feature of the terminal is the way international arriving passengers are handled. Passengers come off the aircraft and stay high within Concourse A, moving through the central core portion of the building. The international passengers will use the upper level of the pedestrian bridge linking Concourse A with the terminal building and then go down two levels for processing through the FIS facility. That was a critical master planning decision, and there are some pros and cons. DIA is the only airport in the world where aircraft will pass under a pedestrian bridge. This was carefully negotiated with FAA. On opening day DIA will have the capacity for two widebody international flights on the north side of concourse A. This space can also be used for four domestic gates, if desired.

The terminal has three curbside levels. The upper level is for dropping off passengers. The next level is for commercial vehicles only. It includes a very wide roadway on the same level with baggage claim, so passengers can retrieve their bags, walk out the door, and catch a bus, van, or a taxi — an extremely efficient arrangement. On the lowest level is passenger pick-up. This segregates passenger vehicles from commercial vehicles, chiefly for reasons of air quality. With three curbside levels instead of two, DIA's curbside frontage has been increased by 50 percent, alleviating potential problems in what historically has been a highly congested area at airports.

Aircraft service areas and air cargo facilities have also been designed on a large scale. The United hangar at DIA is larger than the Phase I MOCII hangar in Indianapolis. It has the capacity to house two B747 and seven B737 aircraft under one roof simultaneously, with capacity for further expansion on the existing site.

The cargo area is located along the entrance boulevard to facilitate package delivery operation. Cargo operations need immediate access to make their stem times from their pickup points. The facilities were

FIGURE 5 Denver International Airport terminal.

FIGURE 6 Main concourse, Denver International Airport terminal.

carefully located to meet that requirement and assure that hubbing operations are not delayed.

DIA also has a very large area reserved for additional cargo operations or related development on the north side of the airport. The airport is built on 47 square miles of land, about 25 square miles of which are currently developed. Obviously there is real estate available for later airport-related activities and facilities. Key to this expansion are several large open tracts of land directly adjacent to the runways, which is the waterfront in airport terminology. The infrastructure — water, sewer, gas, electrical lines, and roadways — is all in place, which will make entrance by new carriers and new development very easy.

THE SECOND BANGKOK INTERNATIONAL AIRPORT

Joseph S. Revis and Cliff King
Louis Berger and Associates, Inc.

Aviation activity in Bangkok, Thailand, is projected to grow exponentially over the next 15 years. The major factors driving this growth are the increasing importance of Thailand as an economic center in Southeast Asia and its attractiveness for tourism and recreation. Table 1 shows historical and forecasted aviation activity in Bangkok.

The levels of passenger enplanement, air cargo tonnage, and aircraft movements anticipated by 2000 far exceed the capacity of Bangkok's present airport, Don Muang, and planning is now under way for a new major airport at a site in Nong Ngu Hao located southeast of Bangkok. (Figure 1) This facility, currently designated Second Bangkok International Airport (SBIA) will serve as the principal airport for the metropolitan area and as an international hub for Southeast Asia.

GENERAL AIRPORT CONFIGURATION

The land use plan for SBIA reserves areas for each airport activity and establishes the location of these areas relative to each other and the runway system. Representative activity levels for each area have been estimated based on projected peak hour measures. Level of service estimates have been derived from international guidelines and experience. The objective of these area reservations is to insure that all airport facilities will have capacities in balance with that of the runway system. Area reservations are shown in Table 2.

The airport land use plan systematically arranges the reserved activity areas across the site, with alternative land use options evaluated with respect to the following criteria:

- Relative facility locations,
- Extension possibilities,
- Aircraft ground operations,
- Airside ground operations,
- Landside transport,
- Planning flexibility, and
- Development phasing.

The preferred land uses for the first phase and ultimate phase of the SBIA airport development plan are shown in Figures 2 and 3. This plan features a single, centrally located, passenger terminal area that provides optimum efficiency of aircraft operations and flexibility for expansion. Air cargo facilities, and other operational and support facilities are located both north and south of passenger terminal areas. The plan also allows road access to the airport from both the north and south. A reserve area for potential airport-related development is identified. The plan calls for phased development, with the first phase concentrated mainly in the northern portion of the site to facilitate ground access from the

TABLE 1 BANGKOK AVIATION ACTIVITY FORECAST, 1980-2020

Aviation Activity	**Year**			
	1980	**1990**	**2000**	**2010**
Passengers (000)				
International	4,138	10,906	25,656	40,468
Domestic	452	3,423	9,360	15,481
Total Passengers	4,590	14,329	35,016	55,949
Air Cargo (000 tons)	111	447	1,353	2,463
Aircraft Movements (000)	54	109	203	279

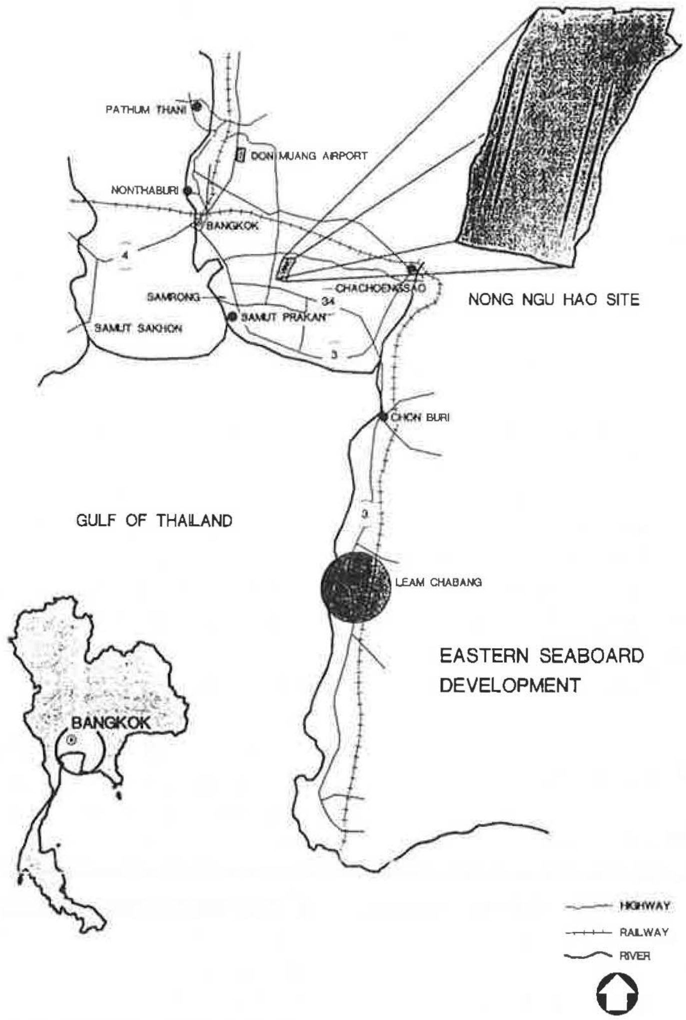


FIGURE 1 SBIA site location.

TABLE 2 SBIA AREA RESERVATIONS

AIRPORT FACILITY CATEGORY	AREA (hectares)	
	First Phase	Ultimate Phase
Passenger	190	380
Cargo	60	190
Maintenance	60	120
Express Freight	10	40
Support (Central Area)	40	85

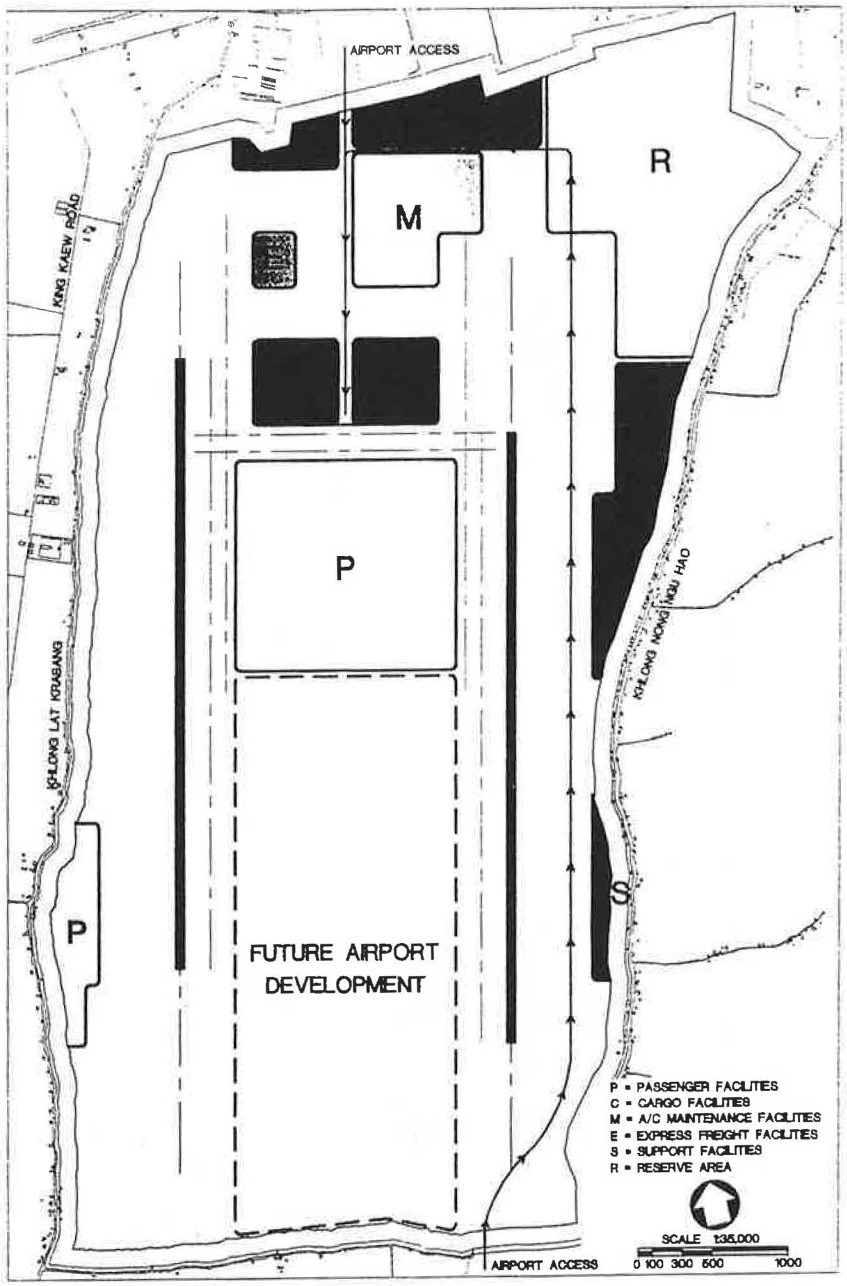


FIGURE 2 SBIA land use plan, first phase development.

Bangkok metropolitan area which lies to the north and east and to minimize the need for new roadway construction.

AIRPORT LAYOUT PLAN

Runway System

The SBIA runway system will consist of two pairs of close parallel runways set in a 01/19 orientation. No cross-wind runways are required.

Lateral separation between inner runways will be 2,200 meters to allow independent instrument operations and to maximize space for airfield facilities between runways. Separation between the inner and outer runways of each pair will be 400 meters. (Figure 4)

The length of all SBIA runways will be 3,700 meters. Flexibility for extension to 4,000 meters is provided in the master plan. During the first phase two runways will be built. These will eventually become the inner runways of the independent pairs in the ultimate phase of development. They will be offset (staggered) with the threshold of the west runway 800 meters north of the

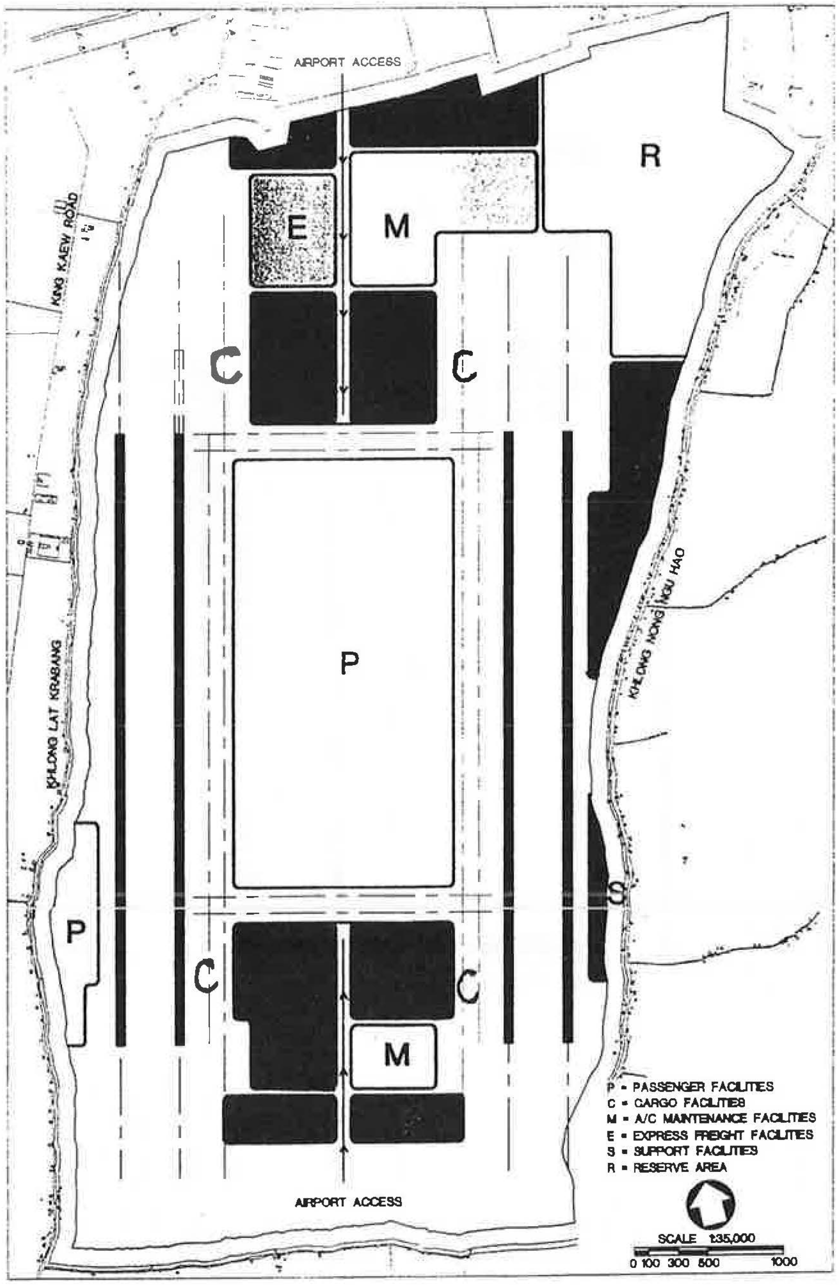


FIGURE 3 SBIA land use plan, ultimate phase development.

east runway threshold to optimize the efficiency of aircraft ground operations.

The capacity of the full four-runway system will be 112 aircraft movement per hour. This volume is equivalent to an annual figure of 100 million passengers and 6.4 million metric tonnes of cargo.

Taxiway System

A hierarchical system of taxiways has been selected to assure both optimum use of runway capacity and efficient aircraft ground circulation. Dual parallel taxiways will be situated along the inner runways of each pair and between the runway and the apron area. A single parallel taxiway will be provided between each runway pair. These taxiways will facilitate use of the outer runways for takeoffs and landings. Rapid exit taxiways will be located along each runway. Double entrance taxiways are provided for each runway. Located at each runway end, they will allow alternative paths for bypass of holding aircraft. Circulation taxiways and taxi lanes in the passenger terminal area will afford access to aircraft gates and parking stands.

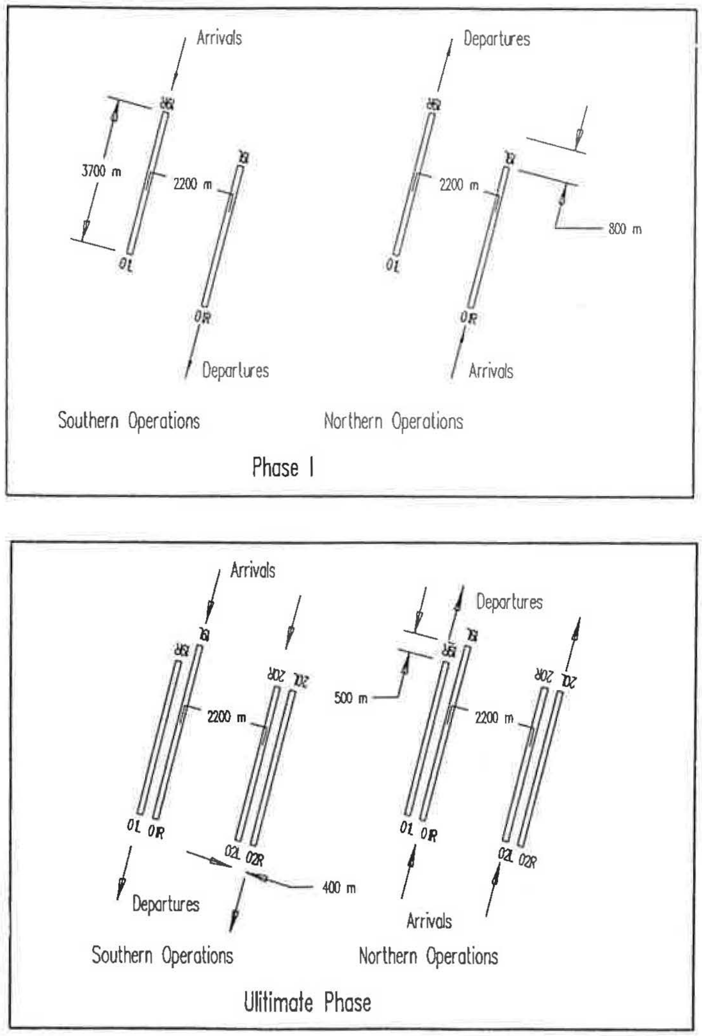


FIGURE 4 SBIA runway configuration and primary use.

Access taxiways will be provided at facilities such as air cargo and express freight terminals and aircraft maintenance facilities.

Pavement dimensions and lateral separation between elements of the runway-taxiway system are based on ICAO standards. A design aircraft with a 90-meter wingspan has been adopted for setting separation requirements. Lateral separation for runways and taxiways is shown in Table 3.

Safety areas and clear zones will be provided at each runway end, in accordance with ICAO standards. Space will be allocated for runway instrumentation, including ILS and MLS.

Passenger Terminal

The ultimate passenger terminal layout will consist of two independent terminal buildings with landside access and two mid- field satellites that will have airside people mover connections to each landside terminal but no landside access. (Figure 5)

To allow flexible development, the layout plan reserves space at both the north and south terminals to accommodate processing of up to 60 million annual passengers. Decisions concerning the appropriate size of each terminal will be made later.

The two landside terminals will each contain a landside interface, passenger processing areas, gate concourses, concessions, and office areas. The satellite buildings will consist of gate concourses, concessions, and processing facilities for transfer passengers. Domestic and international passenger processing facilities will be integrated into both landside terminals

Aircraft gates and certain other facilities have been designed for use by either domestic or international passengers during respective peak hours, leading to economical use of terminal gate space. The airside

TABLE 3 RUNWAY AND TAXIWAY SEPARATION

SYSTEM	SEPARATION (meters)
Runway-Taxiway	200
Taxiway-Taxiway	106
Taxiway-Apron Taxiway	106
Taxiway-Object	67

TABLE 4 AIRCRAFT PARKING POSITIONS

AIRCRAFT CLASS	PARKING POSITIONS	
	Phase 1	Ultimate
New Generation	2	26
B747	29	60
MD11/A300	38	86
B737/A320	6	20
TOTAL	75	192

portion of terminal has been sized according to the number of aircraft parking positions. The numbers of parking positions for each aircraft size are shown in Table 4.

In its ultimate configuration the terminal complex will handle 27,000 passengers per hour, excluding transit passengers. This equivalent to a capacity of 100 million annual passengers.

The terminal layout gives special attention to the hub role of the airport and handling of transfer passengers. The first-phase terminal facilities will include a portion of the ultimate north terminal sized to accommodate 9,550 peak-hour passengers or 30 million annual passengers. The terminal concourses will have seven piers, with 51 contact gates and 26 remote parking positions.

Subsequent terminal development could include either construction of the south terminal with its landslide access or of mid-field satellites. The terminal complex will be designed so that extension of facilities does not conflict with ongoing operations at the terminals.

Air Cargo Terminal

For planning purposes it was assumed that 30 percent of air cargo would be carried by freighter and 70 percent by passenger aircraft. Airside ground transport links between cargo and passenger terminals is thus a key consideration. In the future, anticipated high cargo volumes may require new ground transport systems between the terminals.

The SBIA land use plan includes air cargo terminals both north and south of the passenger terminal area. First-phase cargo facilities will be located in the north area only. Each of the reserved areas for cargo will be able to handle a minimum of 2.2 million metric tonnes of cargo annually. The ultimate combined capacity of the two areas is 6.4 million metric tonnes.

The areas reserved for air cargo include space for cargo buildings, vehicle parking, loading docks, offices, customs facilities, and equipment storage. A separate express freight area has also been reserved in the land use plan.

Aircraft Maintenance Area

In the future, heavy aircraft maintenance may be performed at SBIA. Aircraft maintenance areas have been reserved in both north and south portions of the site to accommodate hangars, aircraft parking, stores, workshops, engine test cells, and other related activities.

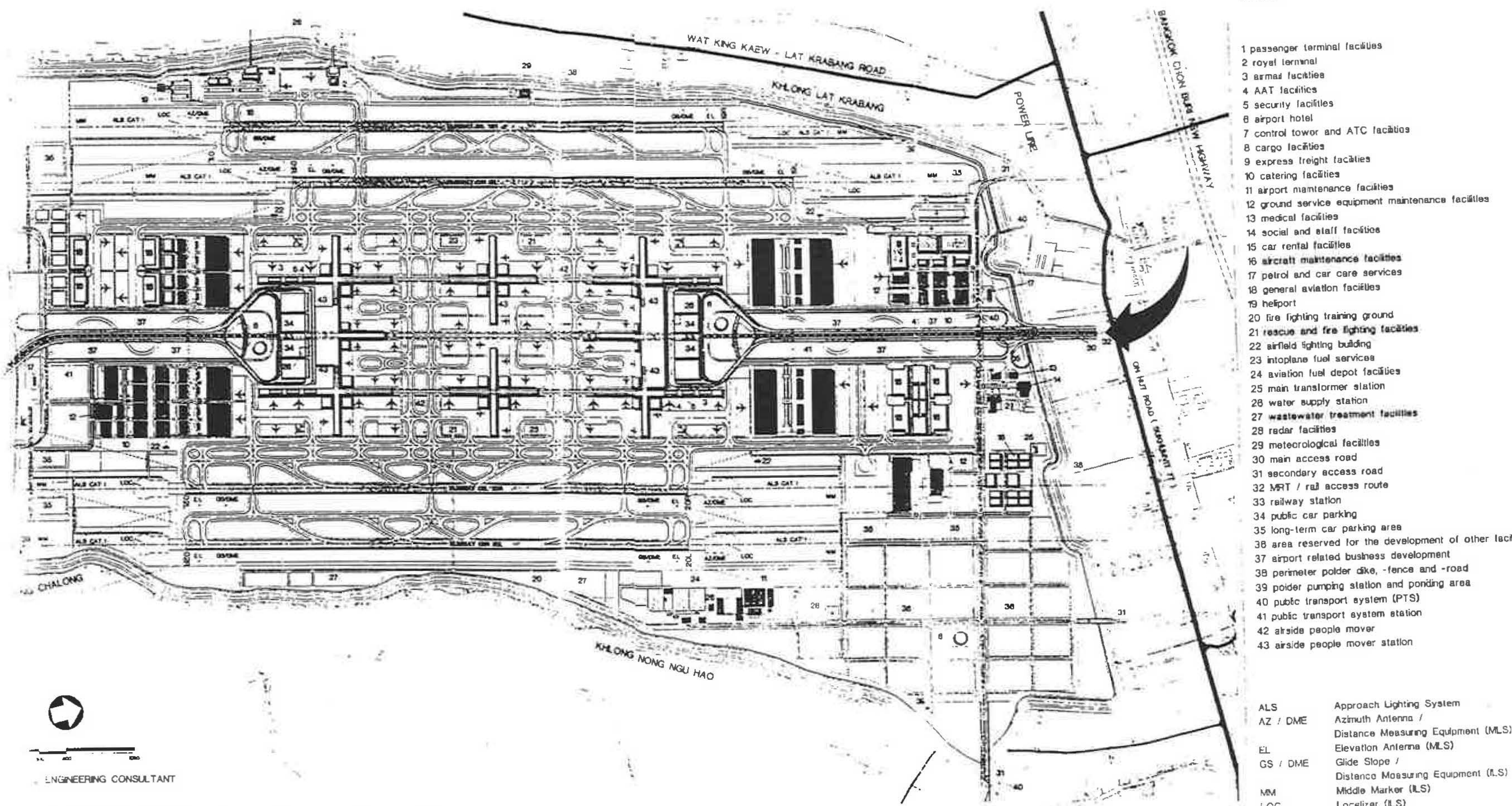


FIGURE 5 SBIA airport layout plan, ultimate development.

In the first phase maintenance facilities will be located in the north only.

Support Facilities

Support facilities (catering, utility services, ground service equipment maintenance, radar, airport administration, police stations etc.) will be located either between runways near main terminal facilities or in a remote location. In the first phase of development, support facilities will be located in the north and east, with later developments in the south.

Other Airside Facilities

The airport control tower will be located at the end of the middle pier of the north passenger terminal The height of the tower will place the eye level of controllers at about 90 meters above ground level. All other traffic control facilities will be located in the base of the tower. Whether the area radar control center is to be moved from Don Muang Airport to SBIA will be determined through further study.

Rescue and firefighting facilities will be designed to ICAO's highest category of protection. A system of three rescue and firefighting stations has been proposed. One main station will be located in each of the two passenger terminals. In addition two substations will be located near each of the satellite buildings.

An area for the royal terminal complex has been reserved in the southwest portion of the site. Activities at this complex will not be affected by commercial airport operations, and vice versa.

Airport Access

The master plan includes both road and rail access to the airport. Two classes of access roads will be provided: main terminal access roadways and service access roadways. The main access roadway will connect regional highways to the passenger terminal curbfront and parking areas. Service access roadways will provide access to all other facilities.

Rail access is to be provided by an intercity, high-speed rail system and an extension of the Bangkok municipal rapid transit system. The SBIA Master Plan includes provisions to accommodate either rail system, with direct access to the passenger terminals.

A third type of rail access, a light rail transit system, may be considered in the future. This system would provide circulation between the airport and the immediate environs and connect passenger terminals with airport service areas, remote parking for employees, and nearby business, commercial, and residential areas.

Airside Transport Facilities

For security reasons, ground service roads will be separated from the landside road system. The airside road system will be designed to enhance both operational efficiency and safety. Facility development concepts that minimize vehicular traffic will be incorporated in SBIA plan. Provision of satellite cargo, catering, and baggage facilities at the midfield satellite buildings will limit ground traffic between satellites and main passenger terminal, cargo and catering areas.

Airside transport of passengers will be required when development beyond the original north passenger terminal occurs. SBIA will provide airside passenger transport between the four buildings by people movers operating on fixed guideways. Initially the people movers will be simple shuttle systems, with provision for later expansion to a full double-loop system.

Reserve Areas

The SBIA land use plan includes some areas not yet allocated to specific airport purposes. This land is in excess of that needed for long-term airport operational and support areas. These tracts are being held in reserve for future airport-related uses that may result from unforeseen technological developments.

Revenue-producing development on the airport property could include airport-related activities (bonded storage, distribution centers, hotels, etc.) and non-airport related activities such as high-tech industries, office parks, and recreation areas.

Landscaping

The landscaping of SBIA will make a strong visual statement about Thai culture and the natural environment. The landscaping program will also recognize practical airport requirements such as the need for bird control, erosion prevention, soil conservation, cost control, and ease of maintenance.

Special attention will be given to the landscaping of the central spine, along the main passenger access road, because the spine will be the entry point for travelers to Thailand.

THE NEW HONG KONG AIRPORT

Norman D. Witteveen
Greiner, Inc.

INTRODUCTION

Hong Kong lies in the center of a region that has experienced, and is predicted to continue to experience, dynamic economic growth. This is manifested by double-digit annual growth in air transportation and development of six new international airports, not including the Peoples Republic of China (PRC) (Bangkok, Hong Kong, Kansai, Kuala Lumpur, Macau, and Seoul). The PRC has another 20 to 30 new airports on the drawing board or under construction in addition to the new Shenzhen Airport, located approximately 45 miles west of Hong Kong, which opened in late 1991. One half of the world's population live within this Asia-Pacific Region, all within only five hours flying time from Hong Kong.

Seven million tourists visit Hong Kong each year spending US$7 billion. Hong Kong is also a major center for export trade, 20 percent of which moves by air. It is essential that unconstrained and environmentally acceptable air transportation facilities continue to be provided beyond the July 1997 governmental transfer to the PRC to protect the long-term economic well being of Hong Kong..

The existing Kai Tak Airport, the world's fourth busiest international airport, has reached its design throughput capacity of 24 million annual passengers in late 1993. Because of its physical setting, Kai Tak cannot be expanded. Airline schedules are already constrained due to limited aircraft parking and a nighttime curfew.

These capacity and scheduling constraints, coupled with predictions of continued dynamic economic growth for the region, set the stage for the development of a new replacement airport at Chek Lap Kok. (Figure 1)

BACKGROUND

After a decade of airport site selection studies, a preferred site was selected in 1979 at Chek Lap Kok Island, directly north of Lantau Island and 17 miles (28 km) west of Kai Tak Airport. In 1982-83 a master plan was prepared, but its implementation was put on hold due to worldwide economic conditions. In the late 1980s detailed planning studies resumed and resulted in the Port and Airport Development Strategy (PADS).

The Provisional Airport Authority (PAA) was created by the Hong Kong government in 1990 to initiate the detailed planning, design, and construction of the New Hong Kong Airport at Chek Lap Kok. In 1991, a Memorandum of Understanding was signed by the United Kingdom and the PRC to confirm support of the PADS program by both governments.

Planning Objectives

The overall objective of the 1990-1992 New Airport Master Plan was to prepare a comprehensive and environmentally acceptable scheme for the planning and development of an operationally safe and efficient New Hong Kong Airport at Chek Lap Kok, with the first runway coming into operation in 1997 and with subsequent development into a two-runway airport operating 24 hours per day.

Planning Assumptions

During the course of the master plan study, several major assumptions influenced the planning of airport facilities: major assumptions were :

- The existing Kai Tak Airport will close when the new airport opens,
- All passengers will be international,
- High priority will be given to rail in a multimodal surface transportation system,
- Surface access by road, rail, and ferry will be provided on opening day, and
- Maximum opportunities will be given for privatization of airport facilities.

Planning Approach

The 17-month master planning study was conducted in three work streams: planning, civil engineering, and environmental.

Planning established the work program, parameters, and criteria for the project which resulted in a well defined physical configuration of all facilities. This

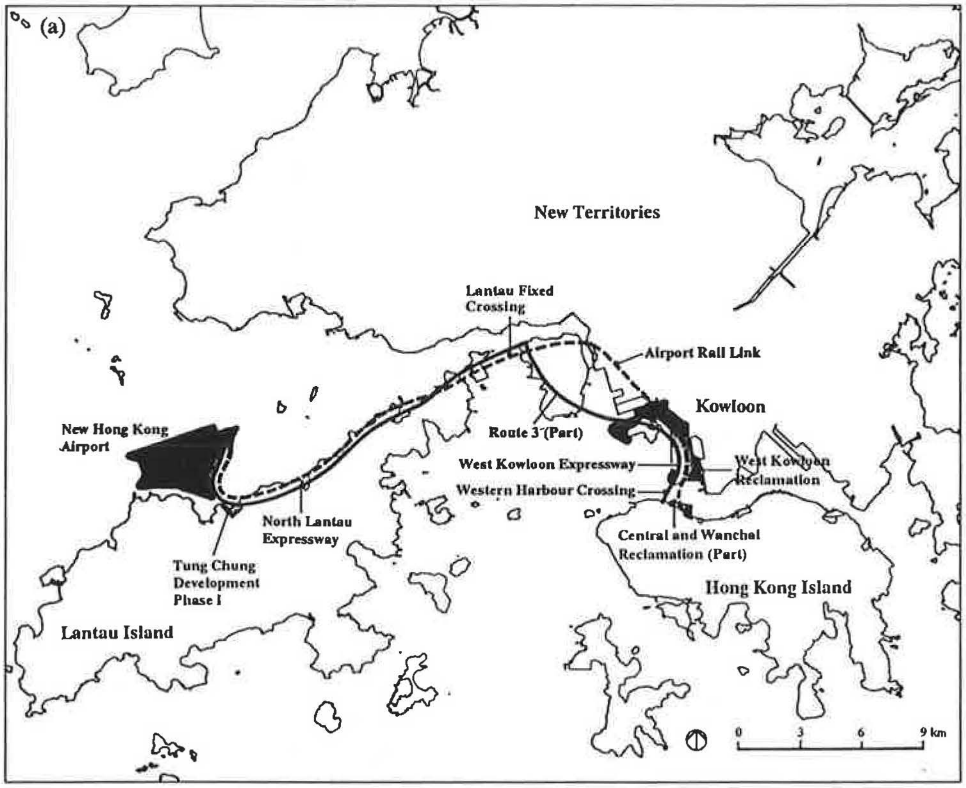


FIGURE 1A Hong Kong area airport site location and airport core program projects.

FIGURE 1B Hong Kong area regional airport locations.

provided the essential focus for the preliminary engineering and environmental studies to proceed concurrently in close coordination as the airfield, terminal complex, and surface access elements were further developed and refined.

Civil engineering developed the detailed design and construction documents for the site reclamation, as well as the preliminary design guidelines for all airport facilities and infrastructure.

The environmental work stream investigated impacts associated with construction activity and operation of the airport. The key considerations included noise, air and water quality, hydrodynamics, and marine and terrestrial ecology.

TABLE 1 SUMMARY OF ANNUAL FORECASTS (1000)

	Year		
Category	**1997**	**2010**	**2040**
Two-Way Passengers	28,500	44,700	87,300
Air Cargo (Tons)	1,130	2,300	8,900
Aircraft Movements (Two-Way)			
International			
Passenger	123	184	278
Cargo	12	22	66
Non-Revenue	4	6	11
Civil Local	7	7	7
Military	10	11	15
Total A/C Movements	**154**	**11**	**376**
Airport Employment	26	35	59

TABLE 2 SUMMARY OF BUSY HOUR FORECASTS (TWO-WAY)

Passengers	11,400	14,100	28,500
A/C Movements	44	53	82
Road Vehicles	2,900	3,750	7,300

The airport project interfaced with many other related PADS projects including the North Lantau development, rail service, roads and expressways, industrial and commercial relocations, utilities, business and financial planning, and other aviation- and infrastructure-related activities.

THE AIRPORT PLAN

The plan commenced with the development of aviation-related forecasts on which to base subsequent facilities requirements. Key issues that were addressed included the separation of runways, the terminal concept, and location of major support facilities such as air cargo, aircraft maintenance, and other support functions that optimized a sound business plan. Major elements of the Plan are summarized below.

Demand Forecasts

Aviation activity forecasts assumed continued resilience against periodic world economic recessions. They also assumed continued strong growth as the territory consolidates its financial, industrial, and commercial position within the region and its continued attraction as a tourist destination. New airports at Macau and Shenzhen were also considered in the forecasts, but due to the specific role played by each, they were not considered to have a major influence on the Hong Kong forecasts. (Tables 1 and 2)

Airport Description

Key components of the airport master plan are shown graphically and itemized on the airport layout plan. (Figure 2)

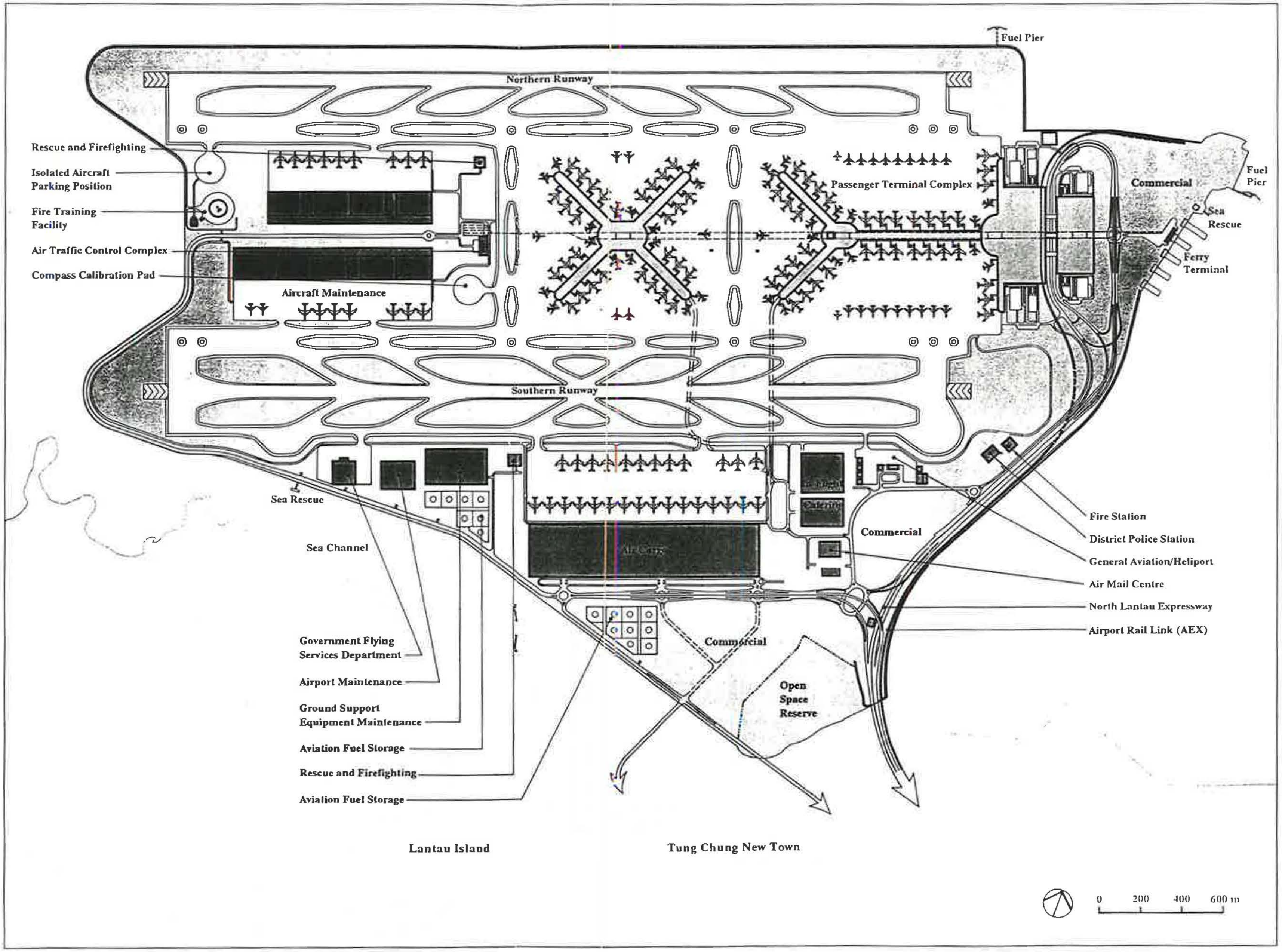


FIGURE 2 New Hong Kong airport layout plan.

Airport Description

Key components of the airport master plan are shown graphically and itemized on the Airport Layout Plan. (Figure 2)

Data included in the Master Plan:

- Airport site, 1,248 hectares;
  - one quarter existing islands,
  - three quarters reclaimed.
- Planned to satisfy forecast demand in 2040;
  - 87.3 million passengers,
  - 8.9 million tonnes of air cargo,
  - 375,500 aircraft movements.
- Two parallel runways;
  - 3,800m length,
  - 300m clearways,
  - 60m width,
  - 1,525m separation.
- Five parallel taxiways and four crossfield taxiways provided.
- Midfield passenger terminal complex.
- Centralized terminal processing buildings.
- One attached and one satellite terminal concourse.
- 120 aircraft parking positions.
- Road,rail, and ferry access along eastern site boundary.
- Three road bridges to the site.
- Midfield aircraft maintenance facility.
- A majority of support and ancillary facilities located south of the southern runway.

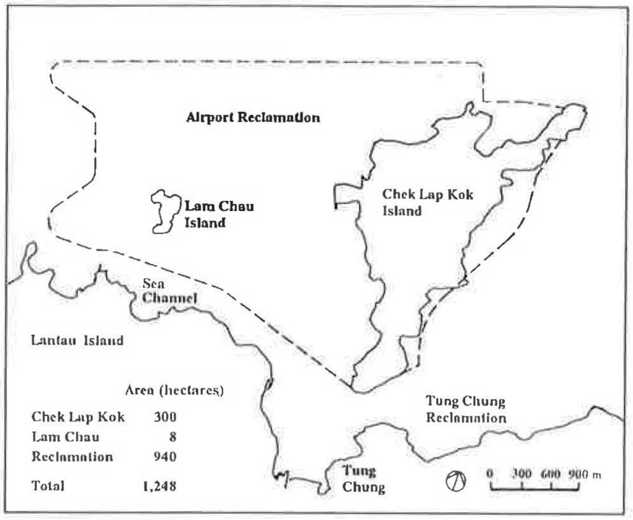


FIGURE 3 Airport land reclamation.

CIVIL ENGINEERING

The existing islands of Chek Lap Kok and Lam Chau are being blasted and cut to 18 feet (6 m) above sea level to form one quarter of the 3082-acre (1248-hectare) airport island area and yielding 160 million cubic yards (121 million cubic meters), or two thirds of the suitable fill material to form the airport reclamation. (Figure 3) However, this is only part of the total site reclamation picture. The removal of unsuitable mud from the airport site prior to placement of suitable fill material and similar dredging of unsuitable mud from marine borrow sites prior to dredging the suitable marine fill material make this the world's largest marine dredging project. Total dredging will account for about two thirds of the 480 million cubic yards (367 million cubic meters) of material moved for the entire reclamation project, all in a 41 month schedule. (Figure 4)

Nine miles of seawall will be constructed to resist severe storm wave forces and overtopping. Storm drainage of critical areas will have a capacity to discharge a 200-year storm. (Figure 5)

All runways, taxiways and aprons are designed to meet or exceed ICAO Code F (future) and/or FAA Airplane Design Group 6 standards. Infrastructure systems including roads, tunnels, railways, utilities, and support buildings and systems will meet the Hong Kong government and international design standards. (Figure 6)

TERMINAL COMPLEX

The terminal complex received much attention during the master planning process as it is the most visible aspect of the new airport. The series of planning objectives and performance criteria used as guidelines during its development are summarized below.

Objectives

- Provide expansion and operating flexibility.
- Give high priority to rail access integral to terminal, separate platforms for arrivals and departures.
- Facilitate efficient and cost-effective movement of passengers and baggage.
- Provide facilities and services for the disabled.
- Maximize opportunities for concessionaires.
- Optimize energy conservation.
- Accommodate the next generation of large, high-capacity aircraft.

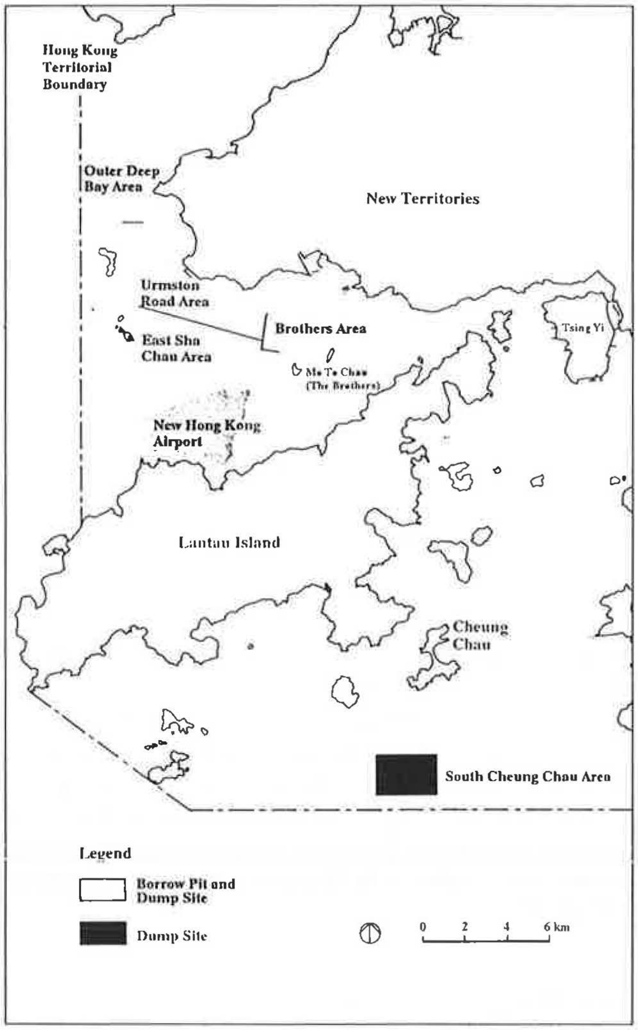


FIGURE 4 Marine borrow pits and dump sites.

Performance Criteria

• Departing passenger and baggage close-out time shall be 30 minutes.

• Arriving passenger and baggage processing time shall be 20 minutes.

• Space allocation for departure and arrival processing functions must be efficient, economical, and flexible to accommodate future processing procedures and systems.

• Passenger flow routes will be simple and direct with minimal level or directional changes and with provision for ramps and vertical assist systems.

• Walking distances (unassisted) shall be no more than 980 feet (300 m).

The optimal location for the terminal was determined to be between the two runway systems with surface access from the east. Many alternative terminal configurations were evaluated resulting in two final options, centralized versus decentralized. Consequences of the two options were measured and compared using detailed performance criteria, cost estimates,and operational factors. The preferred concept was a centralized passenger processing terminal.

The terminal concept selected will be organized into two pairs of centralized processing terminals, an attached concourse and a satellite concourse. Initial development will provide for Terminals 1 and 2 with their attached concourse. Ultimate development will include Terminals 3 and 4 and the satellite concourse. Fast and convenient connections between the processing terminals and the concourse will be provided by an underground people mover system located in the central spine. (Figure 7)

Aircraft parking positions will surround the concourses as well as located at remote parking positions. Surface transportation will access the terminal at two levels via road (expressway), rail and ferry connector in an integrated intermodal concept.

SUPPORT AND ANCILLARY FACILITIES

All the essential airport support and ancillary facilities are provided to allow the airport to function efficiently as a complete usable entity. These functions and facilities are shown on the Airport Layout Plan and include the following.

Terminal Facilities:

- Airline Passengers,
- Aviation Fuel Storage
- Air Cargo
- Aircraft Maintenance
- In-flight Catering
- Ground Support Equipment Maintenance
- Air Mail Center

Airport Operations and Maintenance Facilities:

- Air Traffic Control Complex
- District Police Station
- Airport Maintenance
- Fire Training
- Rescue, Firefighting, and Sea Rescue
- Isolated Aircraft Parking

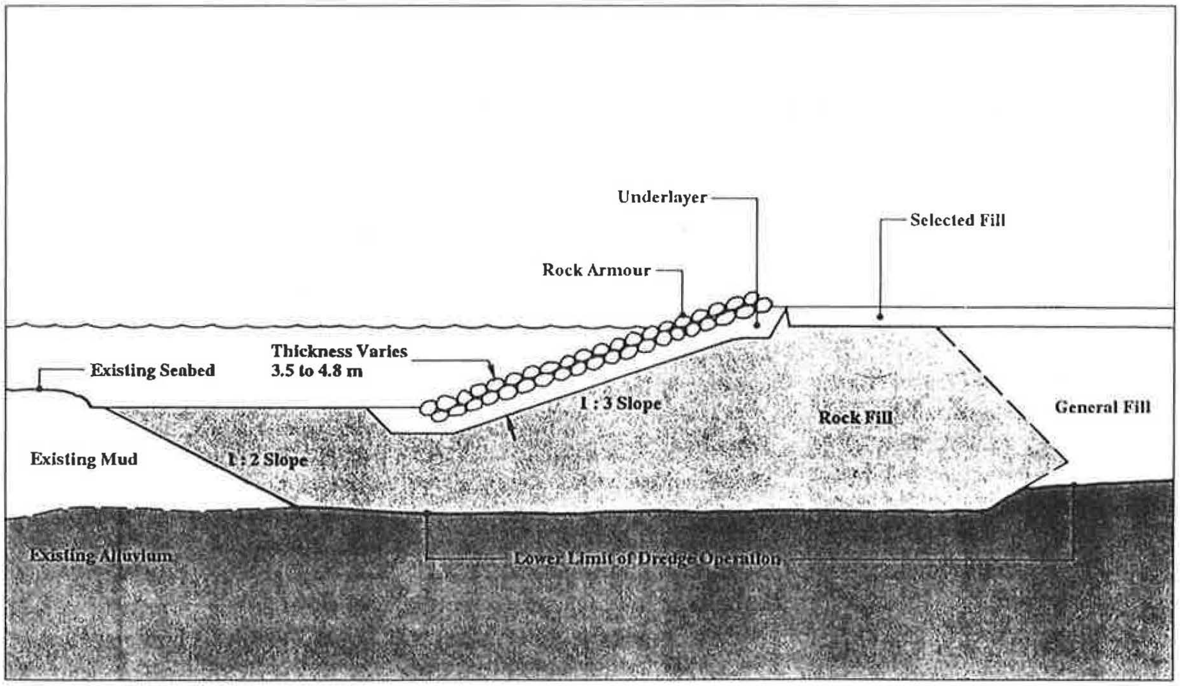


FIGURE 5 Typical seawall section.

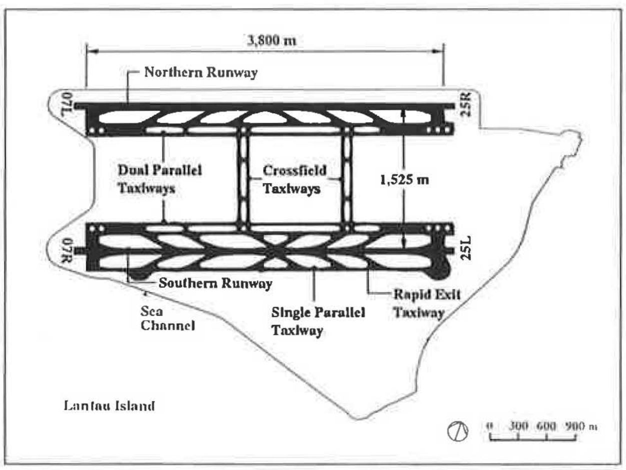


FIGURE 6 Runways and taxiways.

- Apron Control
- Meteorological

Commercial and Noncommercial Facilities:

- General Aviation
- Cargo Village
- Heliport
- Industrial Park
- Government Flying Service Department
- Business Park

AIRSPACE AND AIR TRAFFIC CONTROL

The new airport master plan provided for a complete airspace management and air traffic control plan. The plan included arrival and departure flight tracks conforming to ICAO and UK CAA criteria and supported by a land-based navigation system. Some airspace restrictions are required due to the mountainous terrain in and around the Hong Kong and on Lantau Island. The plan also provides for dual and simultaneous precision instrument arrivals and departures to and from the parallel runways 7R-25L and 7L-25R. (Figure 8) Terminal doppler weather radar facilities are planned to enhance operational safety.

ENVIRONMENTAL IMPACT ASSESSMENT

A complete comprehensive assessment of the environmental impacts of airport construction and

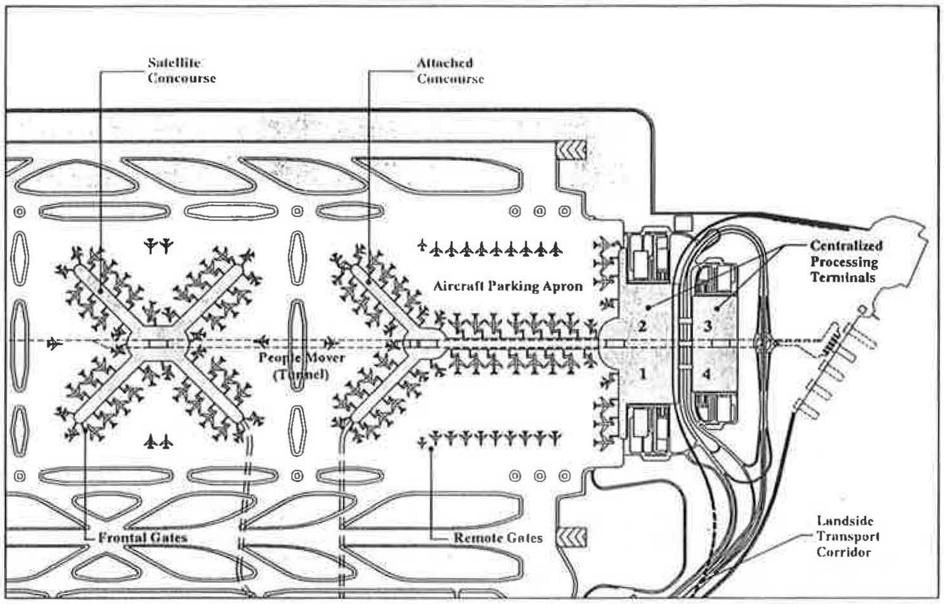


FIGURE 7 Passenger terminal complex, Year 2040.

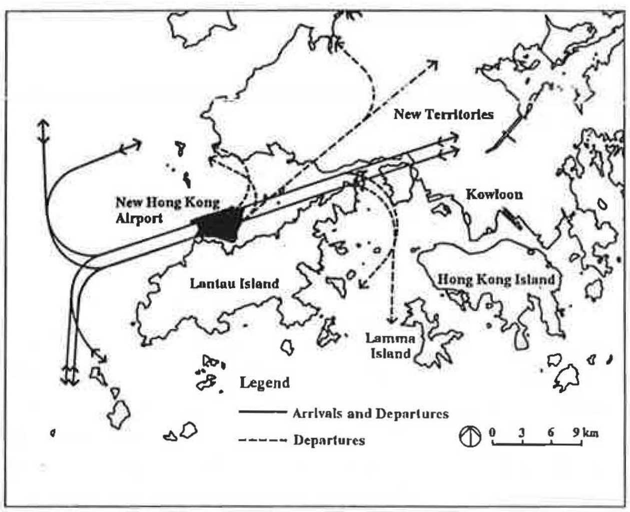


FIGURE 8 Arrivals and departures flight tracks.

airport operational impacts were conducted for the new airport master plan. Mitigation measures and monitoring programs have been planned and designed to ensure acceptable impact levels and are being implemented by the PAA and government's Environmental Protection Department. (Figure 9)

CURRENT DESIGN/CONSTRUCTION PROGRESS

Final design of all major facilities and systems are currently under contract and proposed franchise agreements for privatized facilities such as air cargo, aircraft maintenance, and others are being evaluated for award.

The site preparation (reclamation) construction contract, which started in early 1993, has completed over one third of the new land formation. This massive project (US$1.16 billion) is moving 520,000 cubic yards (400,000 cubic meters) each day with 100 tons of explosives and the world's largest dredging fleet (22) for a single project. Other facts regarding the site preparation which will form a land area 4.3 times larger than existing Kai Tak Airport, or roughly equivalent to the entire Kowloon peninsula, include:

• Construction equipment will consume US$128 million worth of fuel.

• 56,000 tons of explosives will be detonated to blast 90 million cubic yards (70 cubic meters) of rock.

• Dredges will move an equivalent volume of 320 Empire State Buildings.

By March, 1994, the terminal foundation contract is expected to begin. The target date for airport opening remains at 1997.

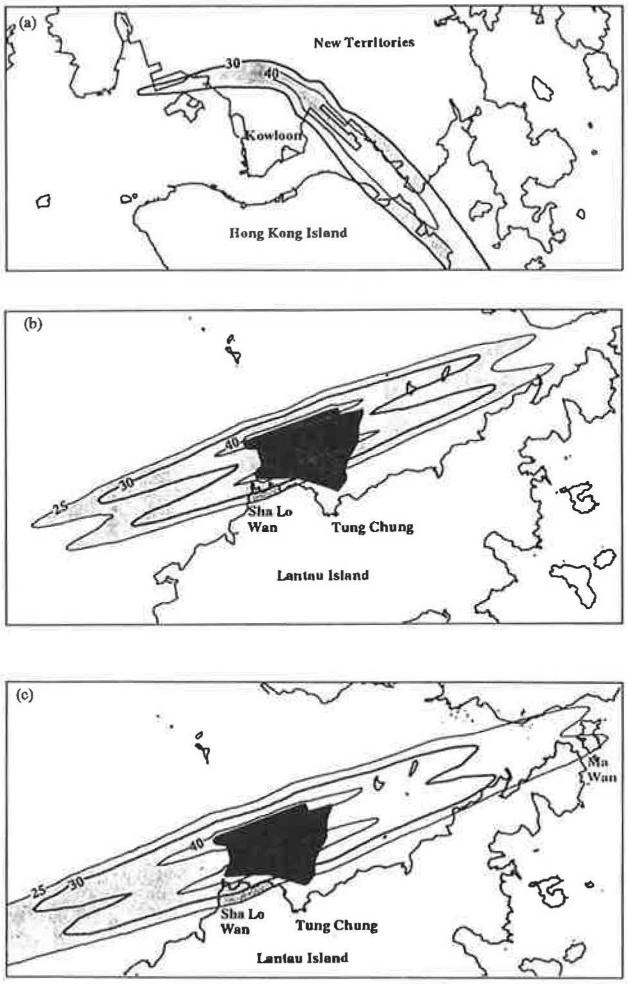


FIGURE 9 Airport noise contours.

PROGRAM BUDGET (ESTIMATED)

PAA Share	US$6.2 billion
Hong Kong Government Share	US$0.6 billion
Privatization Share	US$1.9 billion
Total Budget	US$8.7 billion

THE NEW MUNICH AIRPORT

Evan C. Futterman
HNTB Corporation

INTRODUCTION

If one word could describe the process of building the new Munich Airport, it would be persistence.

Capacity limits of the single-runway Munich-Rheim Airport, became a major problem the early 1960s. In addition to capacity problems, the airport was a major environmental concern for the surrounding communities. Munich-Rheim was encroached on three sides by urban development, and the main aircraft approaches were over densely populated areas, raising issues of safety and aircraft noise

In 1960 the West German government initiated the process of planning a new Munich airport. The basis of the planning was that the old Munich-Rheim Airport would be closed when the new airport opened. The new airport would replace, not supplement, the existing airport.

As the Germans like to say, West German airport law is the most citizen-friendly in the world. This project was a testament to that, in terms of how long it took to complete the studies, obtain public acceptance, and construct the airport. The law required an extensive environmental impact analysis by the City of Munich and the West German government. It took nine years of investigation and public hearings to select the final site — a process that involved extensive coordination and interaction with the many authorities, commissions, and citizen action groups with an interest in the airport.

In 1969, the Erding-North/Fresing site, 29 kilometers (18 miles) northeast of Munich, was selected as the site for the new Munich Airport. Years of litigation followed and numerous environmental studies were undertaken. In 1979, 10 years after the site was selected, the West German government gave the designation order to begin construction of the new Munich Airport. Construction began in 1980, but once again, legal and financial actions and environmental impact reviews delayed construction intermittently. The longest delay lasted four years while legal and environmental problems were worked out.

Finally, in 1986, construction was resumed with a goal of completion by 1992. In May, 1992, more than 30 years after the start of planning, the new Munich Airport, with its pair of parallel, staggered runways, was open for business; and the old Munich-Rheim Airport was closed. The airport has been operating quite successfully for about a year and a half.

AIRPORT OVERVIEW

The area of the new Munich Airport is 1,500 hectares (about 4,000 acres.) This is not a large site compared to U.S. airports like the new Denver Airport and Dallas-Ft. Worth. However, given the amount of land available in the Munich area and the fact that the site was surrounded by rural development, a balance had to be maintained.

The basic runway planning was done first. Two runways 4,000 meters (about 13,100 feet) in length were laid out. One of the reasons for runways of this length was to minimize use of reverse thrust in the interest of noise abatement. This was the first of many accommodations in the airport layout to minimize noise impacts to the surrounding towns.

Considerable effort was devoted to determining the best stagger and separation between the runways to minimize the ground noise impacts of aircraft operations on both runways simultaneously. The runways have a lateral separation of 2,300 meters (7,500 feet), and the thresholds are staggered by 1,500 meters (4,900 feet). The runways are actually "imbedded" in the terrain to minimize their impact on the surrounding areas. (Figure 1)

The basic concept in planning the site was to locate all airport facilities between the runways, creating a noise protection barrier between activities on the airport and the communities on both sides of the airport. The airport is designed so that each of the functional areas (airfield, terminal, cargo, etc.) can be expanded in very small increments adjacent to already constructed facilities. An area for a potential third runway is identified adjacent to the northeast portion of the site.

The terminal is located in the middle of the area between the two runways. It includes a central terminal facility, where the transit system links with the terminal area and where meeters and greeters are concentrated, and four unit terminals. The number of unit terminals can be increased on the east side of the terminal roadway, in a mirror fashion to the existing ones. Other facilities in the terminal area can also be expanded in small increments. As with other aspects of the airport plan, significant consideration was given to limiting the potential community and environmental impacts of airport expansion.

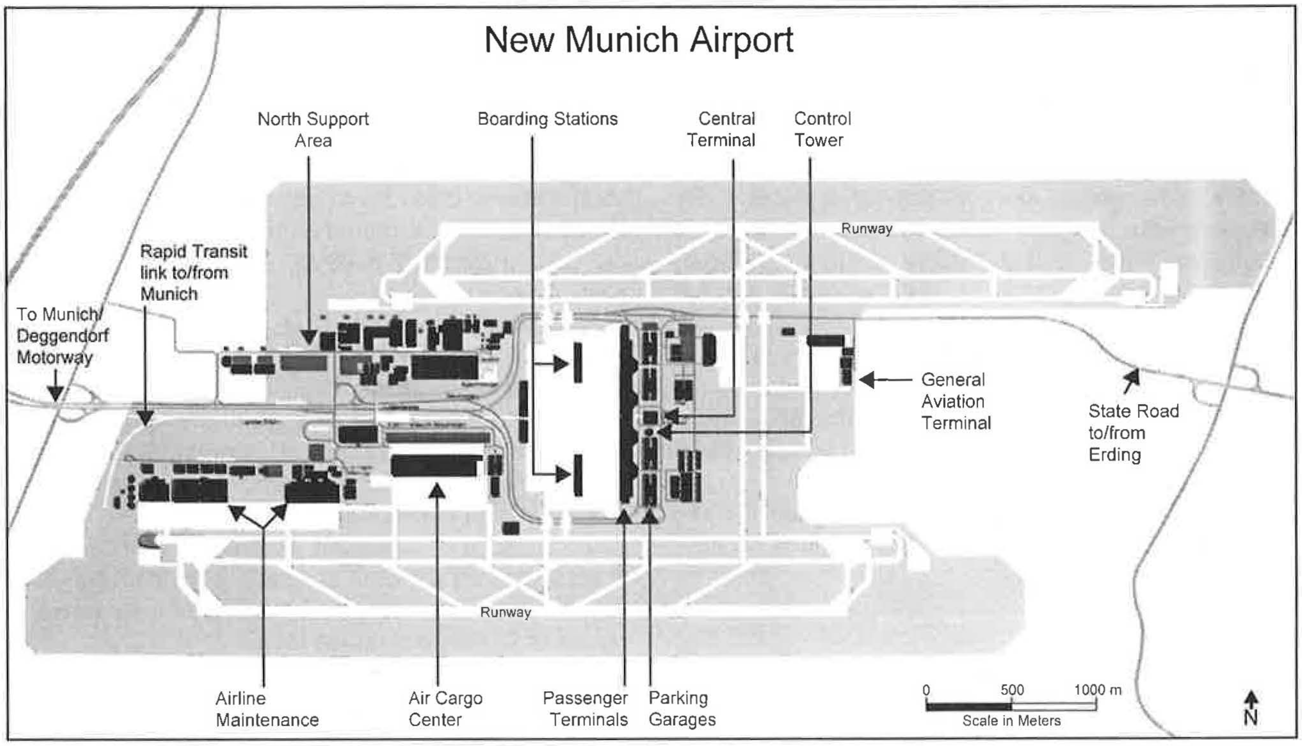


FIGURE 1 New Munich Airport layout plan.

The cargo area, known as the Munich Air Cargo Center, is also located between the runways. Aircraft maintenance facilities are located between the runways to the west of the terminal area. North of these facilities is the north support area, where flight kitchens, airport maintenance facilities, and the airport administration offices are located. Each of these functional areas can be expanded in small increments.

One of the goals in planning the airport was to bring together three modes of transport — aircraft, train, and automobile — at a central point. There are two major rail stations on the airport. One is in the central terminal area; the other provides access to the support area for airport employees and serves the cargo and maintenance facilities.

The control tower is at the center of the terminal area and is one of the landmark features of the airport.

In designing the airport, one of the overriding principles was to blend the airport architecture into the environment. White buildings and glass, not bright colors, were used for exterior building finishes. Emphasis was placed on landscaping, so that the airport would not intrude on the rural character of the surrounding area. To mitigate noise impacts, runways and flight tracks were planned to avoid overflight of nearby towns.

The type of service to be provided by the new Munich Airport was an important consideration in the planning and design process. The airport is basically an international hub airport, but with a substantial amount of local origination and destination traffic. The unit terminal concept, which minimizes walking distance from automobiles or trains to the aircraft gates, evolved based on these roles. The one drawback of this concept is the long distances between gates for connecting passengers.

Most of the international traffic to and from Munich is to southern Europe, the Near and Middle East, the Far East, Africa, and South America. An important consideration in the building design was handling connections between international flights within a secure area of the airport.

A separate ramp area is provided east of the main terminal area for parking aircraft that pose security risks. Aircraft can park remotely and be serviced separately from aircraft at the terminal area. General aviation facilities are located at the eastern edge of the developed area between the runways.

A ring-shaped road system was developed for circulating passenger cars and other ground traffic into and around the terminal area. The ring road provides access to the regional highway system from both the east and west. The direct rail link to the internal 400-

kilometer Munich rail network is currently from the west, with a possible future link to the east.

Government approval of the airport came with a set of environmental conditions, including restrictions on nighttime flights. A maximum of 28 flights are permitted at night. No flights are allowed from midnight to 5:00 a.m. for arrivals and 6:00 a.m. for departures. By 1996, only the quietest airline aircraft — those in compliance with United States Federal Aviation Regulations Part 36 Stage 3 and International Civil Aviation Organization Annex 16 — will be allowed to use the airport. In addition, minimal use of reverse thrust on landing is dictated, with the long runways providing for this capability. Land use restrictions designate areas where residential or noncompatible development will be prohibited.

The land utilization and functional plan for the airport, which became known as the "Munich Model", includes seven components:

- Terrain flexibility,
- Handling facilities in built-up area between runways,
- A decentralized terminal layout with short distances for passengers,
- A ring road around the passenger handling area,
- Integration of the airport into the landscape,
- Economic construction using modular elements, and
- Environmental protection considerations in the runway layout.

Each of these components of the airport plan are discussed in more detail in the following section.

AIRPORT COMPONENTS

Airfield

The two runways, 4,000 meters in length, have a lateral separation of 2,300 meters, with a 1,500-meter stagger in the thresholds. Each runway is served with a full-length parallel taxiway system and a series of high-speed exit taxiways.

All four runway ends have Instrument Landing System Category IIIb approach capabilities to allow for operations with the cloud ceiling at ground level and with minimum forward visibility of 50 meters (170 feet). This means that the airport will almost never have to close due to weather conditions.

Terminal

The terminal complex includes four unit terminal nodes, with above- and below-ground parking structures located across from each. Local passengers can drive their cars directly to their desired terminal node and park a very short distance from the aircraft gates. In the middle of the terminal area, centered on the four unit terminals, is the central terminal building, directly adjacent to the control tower.

The central terminal includes most of the passenger convenience facilities, including restaurants, travel agents, the main greeter area for the airport, and the station of the main rail line coming into the airport. Passengers entering the airport by rail disembark in the main terminal area and ride a series of moving sidewalks to the gates in the four unit terminals.

Each of the four unit terminals includes small concessions areas, such as snack bars and duty free shops. To have a meal in a restaurant, it is necessary to return to the main terminal area.

Twenty aircraft positions at the four unit terminals are accommodated with loading bridges. In addition, there are 14 remote boarding areas of a unique design on the apron. These consist of a series of loading bridges attached to "floating holding rooms." Access to these areas is provided by a bus from the unit terminals. Passengers board the bus at a ticket lift position in the unit terminal and then exit the bus under cover and enter a ground level boarding area, where they take a loading bridge onto the aircraft.

One of the compromises of the linear layout of the four unit terminals is that it results in a very long terminal of approximately 1,500 meters (4,900 feet) end to end. A passenger connecting from a gate at the most southerly unit terminal to a gate at the most northerly one must travel a very long distance. There is a Passenger Transport System (PTS) connecting the unit terminals. The PTS is basically a series of moving sidewalks. There are two PTS levels that carry passengers the length of the terminal area. One is in the secured area at the top level of the terminal; the other is at the baggage claim level.

The four terminal nodes contain 189,000 square meters (2 million square feet) of terminal space, and the central terminal area provides another 47,000 square meters (500,000 square feet). There are 142 check-in positions located throughout the four terminal nodes.

Each of the unit terminal modules is 230 meters (750 feet) long and can accommodate 3 to 4 million annual passengers. The four modules provide the airport with

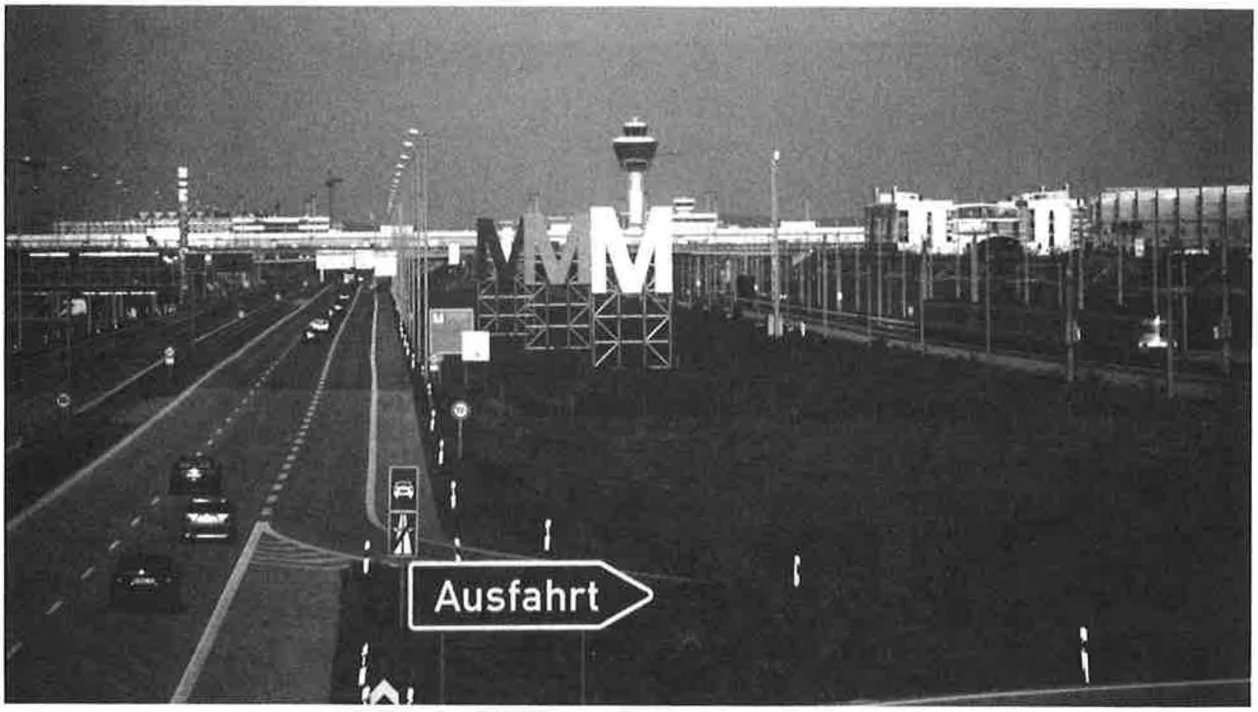


FIGURE 2 Main access road to the new Munich Airport.

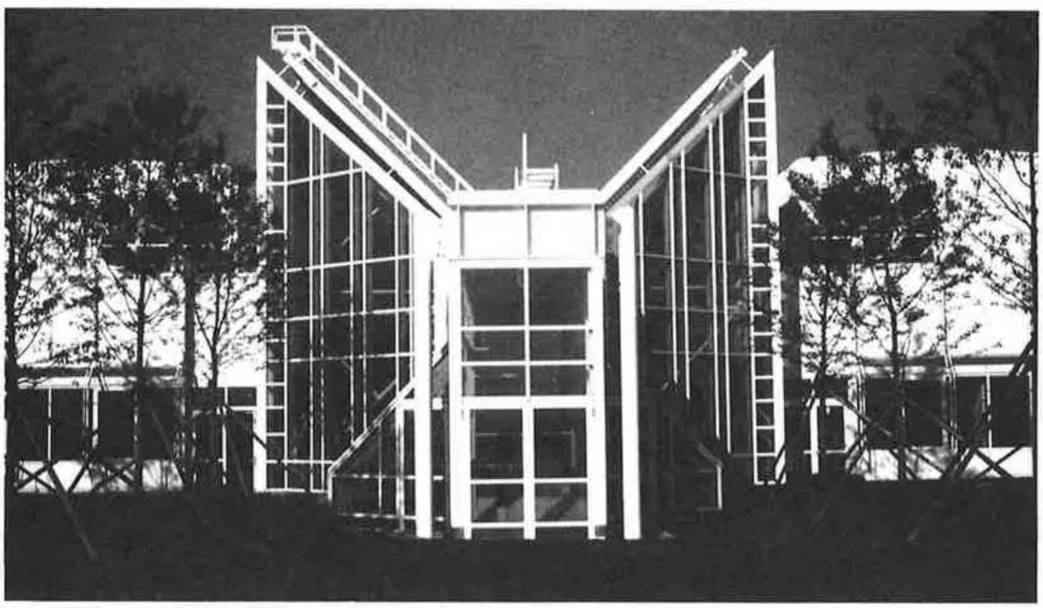


FIGURE 3 Terminal building, new Munich Airport.

the capacity to handle 15 million passengers per year. The entire passenger complex can be mirrored on the east side of the road system, to nearly double the capacity.

The main terminal apron is 614,000 square meters (7.9 million square feet). There is a total of 34 gates — 20 with loading bridges attached to the terminal building and 14 others with remote bridges. An additional three

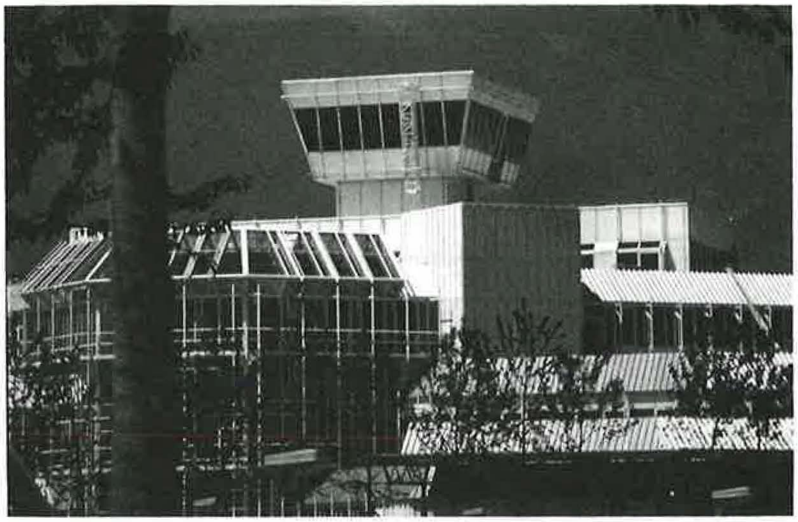


FIGURE 4 Control tower, new Munich Airport.

FIGURE 5 Terminal check-in area.

FIGURE 6 Baggage claim area.

aircraft can be accommodated on the special handling ramp. The gates can handle a combination of widebody and narrowbody aircraft. Most of the gates are designed for widebody Boeing 747 and Airbus 340-type aircraft.

There is parking on the airport for 10,000 cars. Three five-story parking structures are above ground, and between those structures and the unit terminals are three underground parking structures for short-term parking closer to the terminal buildings.

Sixty percent of airport passengers arrive by car, 40 percent by public transportation. These percentages are typical for a European facility. A very strong emphasis is placed on mass transit; airport buses and trains connect with the rest of the Munich public transit system.

The terminal is configured with departures on a single level. Departing passengers arrive at the curbside at the ticketing level and have a straight-through connection to the loading bridge onto the airplane without changing levels.

An arriving passenger exits the airplane, goes up one level over the departures, and then goes down to baggage claim. A passenger changing terminals goes down to the baggage claim level and takes the main PTS through the linear unit terminals.

A large number of signs is required inside the terminal building. The four terminal modules are almost identical in appearance, so signs are needed to help orient the passenger. Many other airports employ some type of visual coding (such as color) to differentiate terminals. The Munich unit terminals are all white and glass. Without extensive signage, passengers could easily become disoriented, particularly during the 1,500-meter journey through the linear unit terminals.

The baggage system for the Munich Airport automates baggage transfer between check-in and aircraft gates, and from the gates back to the baggage claim area. There are 1,800 motors driving the system, which is capable of moving 14,000 pieces of luggage per hour. The system is continuously monitored by the airport computer system.

Support Facilities

There are two support areas on the airport, both to the west of the terminal area between the runways. The north support area has facilities for police, airport maintenance, fueling, flight kitchens, the power plant, and the Munich Airport Authority offices. The second train station for the airport is also located in this area. The south support area includes air cargo facilities and aircraft maintenance facilities. The control tower, adjacent to the central terminal building, is 78 meters (255 feet) high.

Munich Airport is highly automated, relying on computer technology for systems monitoring and baggage system monitoring. All of these systems are tied together in a master control area, called the Central Technological Command Center.

The aircraft maintenance facilities on the airport were built by the Munich Airport Authority. They include three large hangars in the built-up area west of the terminal area. The largest hangar, used by Lufthansa, is capable of accommodating six Boeing 747s. It is 305 meters (1,000 feet) long, with a 22-meter (72-foot) clear door height. About 125,000 square meters (1.35 million square feet) of apron area are provided for maintenance facilities.

The cargo area, which also is in the built-up area between the runways west of the terminal area, is called the Munich Air Cargo Center. It is a very important aspect of the airport because of the amount of freight that moves into and out of the Munich area by air. The center can accommodate about 250,000 tons of cargo per year; with expansion it could handle up to a million tons per year.

The 68,000 square meters (720,000 square feet) of apron in front of the cargo building can accommodate seven Boeing 747 positions. The cargo center building — 490 meters (1,600 feet) long, 100 meters (330 feet) wide, and 12 meters (40 feet) high — has the latest in sorting equipment technology. There are numerous rooms in the cargo facility to handle special cargo, including high security cargo or cargo that needs refrigeration, freezing, or heating. There is an extensive truck interface to handle the large volume of freight distributed throughout the area.

General aviation was another important component in planning the airport. The terminal building has an area of 3,800 square meters (360,000 square feet) built exclusively for general aviation purposes, as well as an apron of about 110,000 square meters (1.2 million square feet) to accommodate 250 aircraft. The general aviation facilities are located at the eastern end of the built-up area between the runways.

ENVIRONMENTAL CONSIDERATIONS

Landscape planning was an important consideration in designing all of the airport facilities. Almost every building is surrounded by trees, with the landscape plan blending the facilities into the landscape.

Water quality was another key issue in the design of the airport. The airport site is in an area with a high water table. A considerable amount of work was necessary to lower the ground water level through use of dikes and hydraulics. All water from the airport is discharged directly into a nearby treatment facility.

Another important and innovative feature of the airport is the deicing facilities. The airport uses a system of gantries located on the taxiways near the ends of the runways. These gantries are 70 meters (230 feet) wide and 25 meters (82 feet) high and can apply deicing agents to aircraft as large as the Boeing 747 as they taxi through them. The deicing agents are then recycled and reutilized on the airport.

An innovative aspect of the deicing facility is a recovery system for chemicals that drain off the runways. Large foil sheets 20 meters (65 feet) wide lie 1 meter below ground level along the runway edges to contain runoff and seepage. The system is designed to allow only water to seep back into the groundwater. The deicing agents either biodegrade on the foil sheets or are carried away for treatment. This system demonstrates a very high regard for environmental protection, specifically the protection of the ground water system. The total expenditures for the deicing facilities were about $78 million.

THE AIRPORT TODAY

The New Munich Airport has been open for business since May 1992. In its current configuration, it stands ready to accommodate 15 million passengers a year. While not a large airport compared to some of the new airports built in the United States, it provides a very important balance between airline and airport needs on one hand and community and environmental needs on the other. The German government can be very proud of the results of its persistent efforts to build this world-class facility.

GENERAL DISCUSSION

MR. MADGWICK: As we open the floor for questions that you may wish to direct to the speakers, I suggest that we might get the maximum benefit from the discussion if we address comparisons between the four airports that have been described — specifically how the airports differ and how these differences are a response to the factors that I identified in my opening remarks.

QUESTION: Are lodging and related facilities provided for travelers at the Munich Airport?

MR. FUTTERMAN: There is not a hotel on the airport itself, but there are plenty of accommodations in nearby towns. The airport, only 18 miles from Munich itself, is readily accessible to travelers. Recall that the airport plan attempted to minimize developments around the airport and to preserve the rural character of the area. The trains that run between airport and Munich are especially configured to handle passengers' luggage, making for an easy connection to the city.

QUESTION: There is one striking difference among the four airports. The area occupied by the Munich airport is quite small — 15 square kilometers, something less than 6 square miles. The Denver Airport is very large, approximately 50 square miles. The Hong Kong Airport sits in the middle of water, but it, too, covers a large area, as does the New Bangkok Airport. These areas are intended to provide a noise buffer zone around the airport. Given that noise protection was an overriding concern, how was Munich able to accomplish this on such a small property?

MR. FUTTERMAN: Bear in mind that the activity levels at these four airports differ greatly. The Munich Airport was planned to accommodate for 15 million passengers a year, a traffic level equivalent to Washington National Airport. The expected passenger volumes for the other airports discussed today are much larger.

It is also worth noting that the new Munich airport is twice the size of the old airport that it replaced. There is adequate land for three runways. The plan started out small, but the final size is certainly ample to meet the objectives of the airport.

MR. WITTEVEEN: Let me speak first about Denver and then Hong Kong. In the case of Denver, the 53 square miles or 34,000 acres of land acquired for the airport was based on a 12-runway configuration at final build-out. The aim was to place as much of the airport land as possible within the 65 LDN noise contour The City of Denver also purchased avigation easements on the parcels that fell beyond three miles from the runway ends and one-half mile from the runway sides, where noise above 65 LDN would occur. The objective was to draw on the experience of Dallas-Fort Worth and to eliminate future cases of inverse condemnation and lawsuits on noise. The very large amount of land acquired at Denver is to protect against future noise problems.

In the case of Hong Kong, almost all the area within the sensitive noise contours is over water. The Hong Kong airport does not need additional land; the waters around Chek Lap Kok Island provide an adequate noise buffer.

MR. MADGWICK: There is one other aspect of the European situation that is pertinent to the question. In Europe, the land has been densely occupied for a thousand years, and the tradeoff between acquisition of a noise buffer for the airport and taking land away from the surrounding communities was much more difficult than at the new Denver airport which is surrounded by thousands of acres of virtually empty high plains. Denver did not have to make the tradeoffs that were essential at Munich or in almost any other European setting.

MR. REVIS: Aircraft noise is a critical factor in the case of Bangkok. Large areas of swamp are not noise-sensitive and provide adequate noise protection. Even so, the Thai Government acquired an especially large area to allow for expansion. Some of these "reservation areas" have been assigned uses; several others are being kept open for unanticipated developments. The Thai government thought far into the future many years ago and reserved very large tracts to preempt their use for incompatible purposes.

QUESTION: Three of the airports described here today are replacement airports How much consideration was given in each case to keeping the existing airport in operation?

MR. FUTTERMAN: The motivation for the New Munich Airport was to eliminate the noise problems that threatened to close down the old airport. There was never a possibility of retaining the existing airport. The Germans place a high priority on safety and safety zones, and overflight of populated areas is discouraged. Thus, for reasons of safety and noise protection, the new airport site is far removed from the city. About 70 percent of the airport property at the new Munich airport is classified as "green", i.e., undeveloped. So, as small as the airport property is, only 30 percent of the land is actually developed.

MR. WITTEVEEN: Provisions will be made at the new Chek Lap Kok airport site for a general aviation facility and the Hong Kong flying club. There is also a significant amount of government aviation activity consisting of helicopters and several fixed-wing aircraft for patrol of harbor waterways, police functions, and military reconnaissance. These activities will be accommodated at the new airport.

MR. REVIS: In Bangkok, planning started with the assumption that the new airport would be a replacement for the present Don Muang Airport. The land occupied by Don Muang is very valuable, and removal of the airport would open up that land for development. As it turned out, Don Muang also houses a military facility that is not going to be closed. One runway will have to be kept in operation, and a large number of buildings will have to be maintained on a thin slice of land that is up against a highway and very hard to use.

An economic and financial evaluation indicated that maintaining a portion of Don Muang for military use would be of substantial benefit to the government in that it would postpone the time when a new military facility would have to be built.

QUESTION: I have a question about the Munich Airport concerning reduction of aircraft noise from maintenance run-ups. I understand that Munich has no provision for mitigating ground run-up noise.

MR. FUTTERMAN: Munich has an enclosed unit to contain run-up noise from engine tests.

MR. WITTEVEEN: The recommendation for the new Hong Kong airport was to designate an aircraft maintenance area on the island, including a "hush house" for engine run-ups The government is proceeding on that basis, although the proposed franchise agreements to provide aircraft maintenance are still under evaluation.

QUESTION: How much was spent on ground access systems for these airports?

MR. WITTEVEEN: In the case of Hong Kong, the PADS program included the airport, seaport development, and a corridor for a new express highway and train service. The entire PADS budget, is in the range of $17 billion to $19 billion. Of this, about $8 billion to $10 billion has been allocated for the roadway and rail system from central Hong Kong to the airport site.

MR. MADGWICK: Hong Kong is a very unusual situation in that there were very few options available to the developers other than putting in an immensely expensive transportation system.

MR. WITTEVEEN: Although the airport is the reason for building the highway and rail system, there are some other nonairport benefits that government will derive from it.

In the case of Denver, I don't recall the exact amount, but there will be a 12-mile limited access highway from Interstate 70 up to the new terminal.

QUESTION: As these airports get larger and larger in terms of the number of gates, baggage handling problems grow exponentially. How is the baggage system being approached in these large and new airports?

MR. WITTEVEEN: Denver is equipped with the first really totally automated destination-coded vehicle (DCV) system built in the United States. The United Airlines system installed in San Francisco two decades ago and the Eastern Airlines system in Atlanta were somewhat automated. But the baggage handling system at the United Airlines concourse of the new Denver Airport will be a truly automated DCV — totally automatic, right from the check-in counter to the tail of the aircraft.

Each United gate will have a structure that comes from underground up to the ramp, where bags will be placed right onboard without going into a tug-drawn cart. The other airlines at Denver have chosen a semi-automated system in which the bags are taken off the DCV in a bag makeup area under their concourse and moved in a tug-drawn cart from the basement into the tail of the aircraft in the traditional way.

At Hong Kong the preliminary design is a semi-automated system consisting of a series of laser readers with a matrix of high-speed conveyor belts, somewhat similar to the arrangement that United has at Chicago O'Hare.

QUESTION: What kind of value will be derived from the old airport in these cities, and is it in the equation of financial justification for the building of the new facilities?

MR. WITTEVEEN: In the case of Denver, the revenue bond program and the resolution of the old indenture agreement dedicates the revenue generated from redevelopment of the Stapleton property to paying the debt service on the bonds sold for construction of the new airport. It will be a long time before this payback stream begins to flow, but it is included in the financial plan for the bond program.

In the case of Hong Kong, the government intends to redevelop Kai Tak Airport, but the details are not yet worked out.

MR. MADGWICK: I'm going to exercise my prerogative and ask a question of the panel myself. To what extent did cultural and political factors enter into the design at these airports? For example, did the notion of making the airport a gateway to the country or region lead to making the terminal building more prestigious and expensive than it would have been if were designed simply for functional purposes?

MR. REVIS: The countries that are currently building airports have a great deal of pride and a very strong sense of national identity. In my mind there is no question that desire to invest resources in making these airports unique and special is a motivating force.

In the case of Bangkok specifically, national pride and cultural identity have been embedded in the design. On the airport property there will be a "natural area" displaying indigenous vegetation and landscapes, a kind of wild preserve, which will include a hotel. It will be the largest landscaping effort I have ever seen in an airport. In part, this is an environmental matter, but it also reflects the government's desire to have visitors see very quickly the character of the plant life and scenery of Thailand.

MR. FUTTERMAN: The Munich airport tries to strike a balance between prestige and playing down the airport. The German Government gives high importance to showing the Munich airport as a major cargo center and a national center of air commerce. But at the same time, the government wants to show the neighboring communities that the airport is not ostentatious. The design is very simple, low-keyed, and functional.

MR. WITTEVEEN: The City and County of Denver has an executive order requiring that one percent of the budget for a public building project be dedicated to art. The new Denver airport has a very substantial art program in the terminal and concourses.

In the preliminary planning for Hong Kong the government has shown sensitivity to user-friendly design and aesthetic features, but it has placed higher priority on cost-effectiveness and functional considerations. Overall, the design of the new Hong Kong airport does not attach as much importance to architecture, aesthetics, and user-friendliness as we seem to do here in the United States.

QUESTION: As a follow-up, I would like to repeat a point that was made at another session earlier today about the Vancouver airport. In Vancouver one of the two prime design goals was to create a terminal reflecting the character of the Pacific Northwest, to make a statement of what the visitor will find there. Vancouver feels it is a unique place, and aesthetic considerations ranked very high in the design of the terminal.

QUESTION: I have two questions relative to the new Denver airport. Which runways will open first, and is the configuration of three parallel runways unique?

MR. WITTEVEEN: Five of the 12 runways will open in 1994. One other runway in the Northwest quadrant of the airport, the 16,000-foot "international" runway, will be completed within the next four years

The three runways that will be in operation on opening day will be equipped with Category IIIb ILS and approved by FAA for triple parallel instrument approaches — the first such installation in the world as far as I know.

QUESTION: Will the new Denver airport eventually, have four parallel runways in the southeast quadrant?

MR. WITTEVEEN: Yes. Part of the rationale of the master planning process is that these two pairs of dual runways will be able to meet the ultimate traffic demand even if one or two runways have to be temporarily closed for snow removal in the winter. Not all four will be used at the same time. Denver expects to be authorized to operate four independent ILS runways, although not all four would be in use at the same time.

QUESTION: Was any consideration given to possible future increase or decrease in runway separation criteria?

MR. WITTEVEEN: At Denver all parallel runways meet current FAA spacing criteria. The minimum runway separation is 2,500 feet for VFR and 4,300 feet for IFR.

MR. FUTTERMAN: The runways at Munich are widely separated. A change in runway spacing minima would not be a problem.

MR. REVIS: The same is true for Bangkok. The runway separation meets ICAO standards, which are identical to those of FAA.

MR. MADGWICK: Will these new airports be able to incorporate new aircraft technology that may be 10 o r 15 years downstream?

MR. FUTTERMAN: Munich already has the capability. From examination of the master plan alone, an observer would not be able to tell whether the design was for a 1994 or a 2035 airport. The plan shows two parallel concrete runways and a terminal in the middle. This will meet all foreseeable needs for aircraft operations, passenger terminal facilities, and baggage handling people. Even over a 40-year span of time airplanes are not going to change radically in terms of how they land and take off.

MR. MADGWICK: Aircraft are getting larger. Will that affect the airport's ability to meet future needs?

MR. WITTEVEEN: At both Hong Kong and Denver the airfield is designed for future large aircraft. In the case of Denver, the standard was airplane design Group 6. Over most of the airfield the runway-taxiway and taxiway-taxiway separations are based on the use of Group 6 aircraft. Only the first apron between Concourse A and the main terminal, where the passenger bridge crosses over, is limited to Group 3 aircraft. The airfield geometry at Hong Kong is based on ICAO code F, a future aircraft that could be even larger than FAA Group 6.

MR. MADGWICK: Did you give any consideration at Hong Kong to high-speed commercial transport (supersonic) aircraft and requirements such as the manufacture and storage of cryogenic fuels on site?

MR. WITTEVEEN: There are no specific criteria for high-speed commercial transport at Hong Kong. Early in the design process enough property was set aside to isolate cryogenic fuels in case it became necessary in the next 20 to 30 years. This gave the city comfort that they had the space available to respond to this new technology if it ever becomes a reality.

MR. REVIS: At the New Bangkok Airport the first phase plan has only two positions for larger aircraft, but this increases to 26 in later phases of development.

QUESTION: Have you considered double-deck aircraft?

MR. REVIS: Double-decking will not change the airfield or apron situation in a basic way. What changes is the number of people who would enplane on these very large aircraft. This would have a far more significant effect on facilities inside the terminal and concourses than it would on airfield geometry.

MR. WITTEVEEN: Double-decking did enter into the planning rationale in Denver. Each of the concourses is stressed to provide for a future passenger distribution system at the mezzanine level. The structures can accommodate double-level loading or unloading.

QUESTION: You load both decks at once?

MR. WITTEVEEN: Yes, but a cubicle would have to be added up at the second (mezzanine) level. At Hong Kong double-decking was not included in the schematic design.

MR. FUTTERMAN: Munich has a five-level concourse with an upper level for transit of passengers. This could be reconfigured to accommodate dual-level loading.

MR. REVIS: Bangkok has a multi-level design.

QUESTION: What has been the reaction of the airlines to these new airport projects. In the case of Denver, for example, the airlines were very reluctant to agree to the new construction of the New Denver International Airport because of the anticipated cost increases. What are the costs of these new airports for the airlines? Mr. Witteveen mentioned the competition among six major airports in the Eastern Pacific rim. What will be the costs of these airports? Do you anticipate marked differences among airports?

MR. WITTEVEEN: The planning at Hong Kong included very close coordination and workshop meetings, with the International Air Transport Association (IATA). The chairman of the airport committee at IATA was from Cathay Pacific, the airline headquartered in Hong Kong. Cathay Pacific was not included in the budgeting process, and cost estimates were keptvery confidential by the government. But decisions about the size of the airport, the concept, the configuration, and the recommended systems were decisions made in close coordination with IATA's airport airspace committees.

In Denver the city was dedicated to this project without airline support. The airlines opposed the project for a long time. At the last moment, just two weeks before the first major bond program was sold, the city negotiated a settlement with Continental Airlines. This gave the bond market confidence that Denver had the support of one of its two hubbing carriers for the construction bond program.

United Airlines continued to fight the project until well into the construction phase, but once it became clear that the project was going ahead and that the Federal Government was very strongly behind it, United Airlines became one of the strongest supporters of the new airport. In fact, United increased its facility requirements substantially, both in the passenger terminal and in the aircraft maintenance and air cargo areas.

MR. REVIS: The financial analysis in Bangkok was quite extensive. A series of simulations were conducted under a range of about 10 to 12 alternative sets of assumptions about financing, operating costs, and revenue sources. For the moment, planning is based on the existing relationships at Don Muang Airport. A number of strategies are being developed to give the airlines an opportunity to do some of their own designing and to play a much larger role.

There is little doubt that the airlines currently serving Bangkok will continue to do so. The airport-airline relationships may change because of a desire on the part of the government to increase the role of the private users of the facilities and to give them much more involvement in the design of the facility.

QUESTION: If you had it to do all over again at Munich and Denver, knowing what you know now, what would you have done differently about of the design of either of these airports?

MR. FUTTERMAN: The German government found a site that was not too distant from the Munich area. They built their airport, and it is operating well. It has not been a major environmental problem for the community. They have enough land for many years to come. Altogether it is a first-class success story, so I doubt if they are second-guessing themselves at this stage.

MR. WITTEVEEN: This is strictly my opinion and I do not speak for the City and County of Denver. The physical plan of the airport, particularly the airfield, seems to be highly satisfactory. Compromises were made in the design of the terminal, but this was to be expected. In a huge program like this with so many different interests groups, change is normal.

Again in my opinion, the airlines would have liked a lower-cost project. They would have liked the city to make a smaller initial investment in infrastructure, especially for features that will not be needed until farther in the future when the airport undergoes incremental expansion. For instance, the investment in the people-mover system is an up-front cost that will benefit all three concourses. Ten years from now, when the airlines want more gates, the incremental expansion with the people mover already in place is going to be simple, really simple.

The full benefit of a substantial part of the investment in infrastructure will not be realized until well into the future. In their present financial state airlines would have preferred to avoid commitment to the full project from the outset. On the other hand, the airlines are extremely happy with the airfield configuration; and so for that matter is FAA.

WHAT DOES IT TAKE TO BE AN INTERNATIONAL AIRPORT?

Jody Yamanaka, Session Moderator
Port of Seattle

More people are flying than ever before. Airports, once thought of only as a place for aircraft to land and take off, have become part of the total travel experience, especially for international passengers. What does it take to be an airport that serves international passengers?

Airports now actively compete for international passengers who bring significant revenues to the airport and to the communities surrounding the airport as well. Airports are now being marketed as if they were a product or service.

Passengers themselves are more discriminating about which airport they choose to use as a gateway to the United States, Europe, Asia, or wherever else. They ask questions like: Are the landside connections between the airport and the surrounding metropolitan area simple and inexpensive? Can customs and immigration inspections be completed quickly? Is the staff courteous? Are connections to other flights easy to make? Are there activities to keep children and adults entertained and occupied during long waits? Are there are variety of concessions that are interesting and reasonably priced?

Airports are taking steps to differentiate themselves from other gateway airports. Many airports have become a showcase for their locality, region, or country — most visibly through terminal building architecture and concessions.

Public services and amenities are growing in number to meet the needs of a more diverse international flying population. International symbols and multilingual signs are proliferating in gateway airports. More and more visitors who do not speak the local language must be helped to find their way through the airport. Airport managers, municipal officials, and local business owners are asking themselves how they would like to be a passenger at their hometown international airport

The experts who have written the following articles provide answers to the question of what it takes to be a modern international airport.

CANADA'S WEST COAST INTERNATIONAL GATEWAY: VANCOUVER, BRITISH COLUMBIA

Joseph L. Grogan
HNTB Corporation

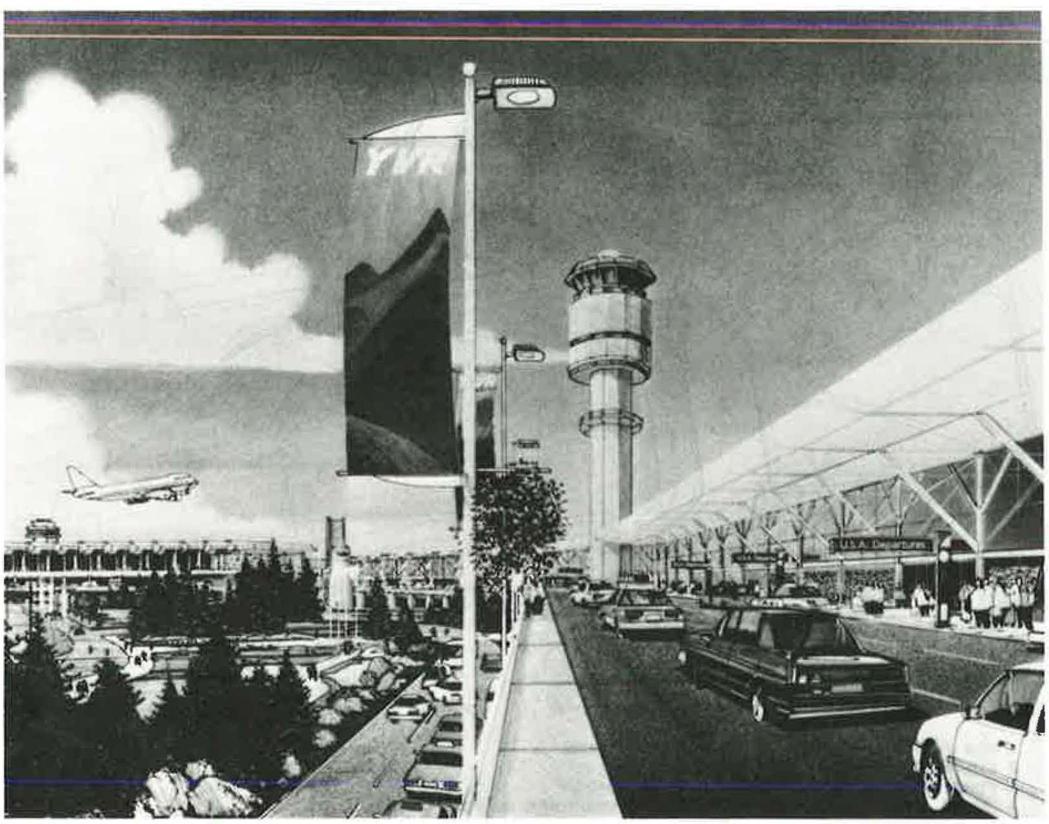
Vancouver International Airport enjoys the dual distinction of being Canada's principal gateway to Asia and an attractive destination and transfer point for North American and European passengers. To maintain that lead, the Vancouver International Airport Authority launched an ambitious $350-million expansion program in 1992 that includes a new runway and international terminal building. The new terminal, now under construction, will secure Vancouver's future as one of the world's premier gateways.

POISED FOR GROWTH

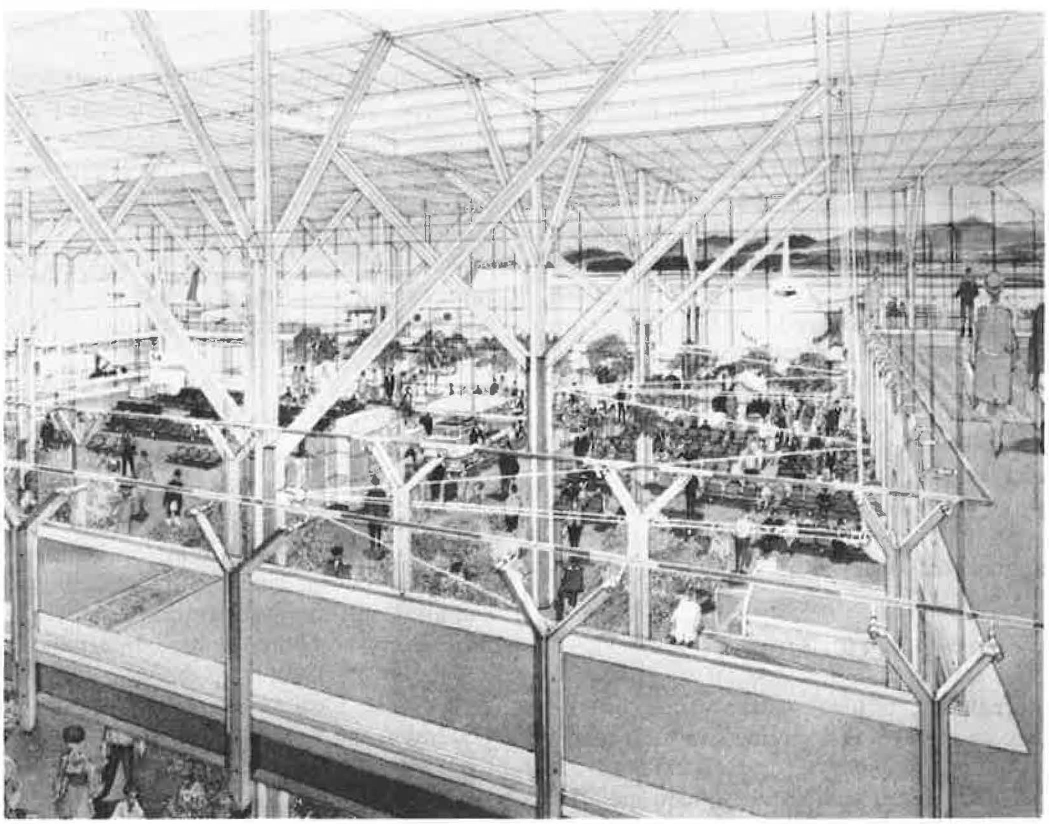
Increased international activity at Vancouver is inevitable. British Columbia's commerce and industries — including the seaport, cruise ship lines, and ski resorts — draw travelers in growing numbers from around the world. Vancouver's proximity to Asia, Europe, and the United States makes it aa attractive transfer point for connecting passengers. Already Vancouver has captured 15 percent of all air traffic from the Pacific Rim to the west coast of North America.

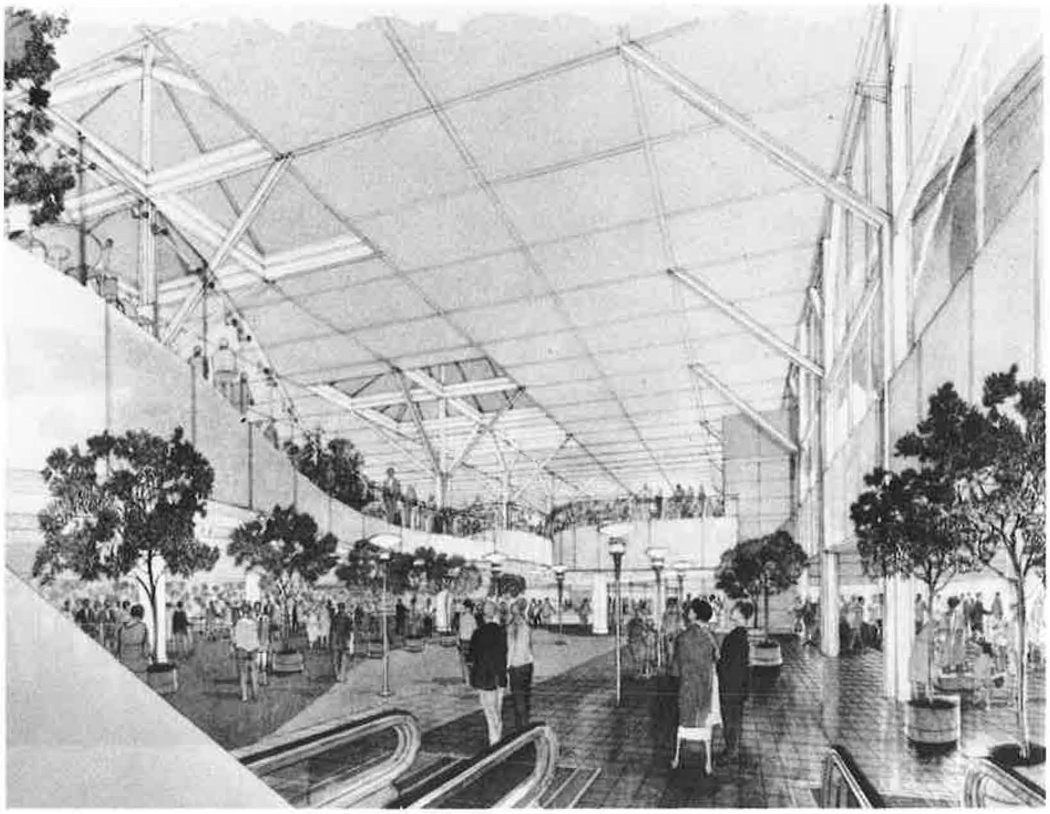
SITE PLAN
1 NEW INTERNATIONAL TERMINAL
2 EXISTING TERMINAL
3 PUBLIC PARKING
4 RENTAL CAR PARKING
5 METERED PARKING
6 BUS PARKING
7 ARRIVALS ROADWAY
8 ELEVATED DEPARTURES ROADWAY

FIGURE 1 Site plan of Vancouver International Airport terminal.


YVR


21-36
Continental
DELTA
Canadian
Air Canada
UNITED





Currently 16 major carriers and 14 regional airlines serve Vancouver. Approximately ten million passengers flowed through the airport in 1993. By 2010, more than half the airport's projected 20 million annual passengers will be international.

Today the existing passenger terminal struggles to handle both domestic and international passenger activity. It operates at capacity during peak periods, experiencing overcrowding and reduced levels of service. The new international terminal will change all that.

Designed by HNTB Corporation in association with Vancouver architects Waisman Dewar Grout Carter, Inc., the new terminal building with an area of 1.1 million square feet will be twice the size of the existing building. Initially it will serve up to 6.2 million annual passengers, and it can later be expanded to handle over 10 million annual passengers.

A TASTE OF BRITISH COLUMBIA

The new international terminal will have high ceilings, large skylights, and glass walls offering panoramic views of the surrounding mountains, coastal waters, and Vancouver skyline. Local stone and wooden materials will add warmth and character to the public spaces. Captivating displays, including giant murals, museum artifacts, and specially commissioned art will depict British Columbia's past and present.

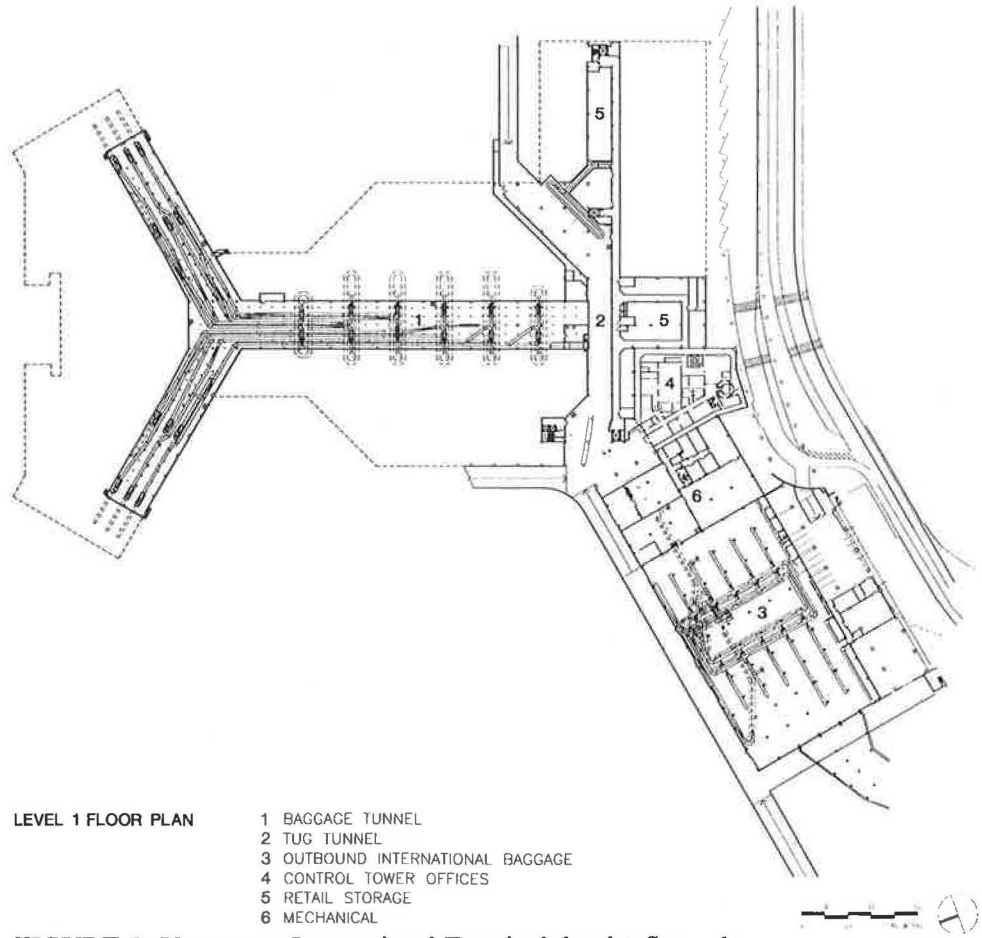
Graceful steel columns that mimic trees in a forest will support the roof and floors. Branch-like column struts will reduce roof beam spans, allowing widely spaced columns. The structure will efficiently resist the forces of man and nature while allowing passengers to see through the building to the distant landscape.

TERMINAL BUILDING DESIGN

Passenger Flow

Passenger circulation within the building has been a particular design challenge. International passengers cannot legally mix with "transborder" passengers bound to or from the United States. International passengers will depart from gates on the west side of the terminal. Transborder passengers, after processing through a U.S. Federal Inspection Services (FIS) facility, will depart from gates on the east side.

Arriving international and transborder passengers, if not connecting to another international flight, will walk



LEVEL 1 FLOOR PLAN

1 BAGGAGE TUNNEL
2 TUG TUNNEL
3 OUTBOUND INTERNATIONAL BAGGAGE
4 CONTROL TOWER OFFICES
5 RETAIL STORAGE
6 MECHANICAL

FIGURE 2 Vancouver International Terminal, level 1 floor plan.

in secure corridors to a Canadian Inspection Services (CIS) facility, where they will claim their baggage and officially enter Canada. Arriving international passengers transferring to transborder flights will have the convenience of a dedicated baggage claim area and streamlined CIS facility next to the FIS facility.

Flexible Facilities

The building will have common-use ticketing, check-in, baggage handling, and gate facilities to reduce the required building area and operational costs. Common-use facilities are feasible because not all airlines experience peak activity simultaneously. The shared use of counters, baggage-sort piers, departure lounges and loading bridges, for example, lets an airline use facilities not needed by other carriers at a given time.

The 120 ticketing and check-in counters in the new terminal will use common-use terminal equipment (CUTE), which allows any airline to use any counter without change of equipment. Automated outbound baggage sorting systems will efficiently distribute baggage to flight-assigned sort piers. Most of the terminal's 15 jet gates will handle B747-400 size aircraft, with expansion capability for even larger future-generation aircraft.

Baggage Handling

There are eight separate baggage systems, two of which are automated. Each will read 10-digit bar-coded baggage tags and automatically sort the bags to appropriate piers for manual loading into carts or containers. The outbound international baggage system

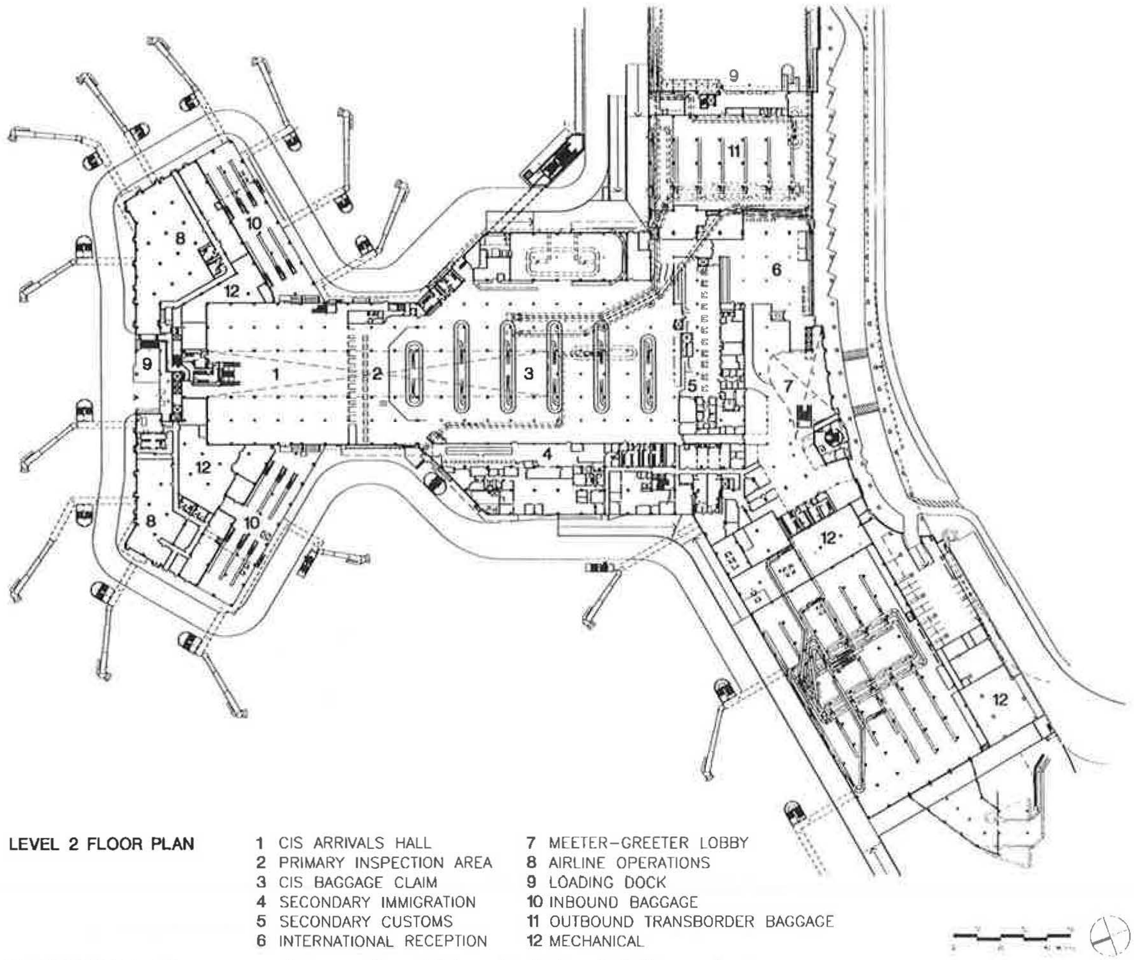


FIGURE 3 Vancouver International Terminal, level 2 floor plan.

has two sorting loops and 14 piers to handle up to 120 bags per minute. The outbound transborder baggage sorting system with a single loop and seven piers will handle up to 60 bags per minute.

Inbound international and transborder baggage conveyors will feed six sloped-bed claim carrousels in the CIS hall. Each of these claim units, among the largest in the world, will display the baggage from a fully-loaded B747-400. There are five other baggage conveyor systems in the building for handling special transfers such as international-to-transborder, international-to-domestic, and cruise ship passenger baggage.

Retail Development

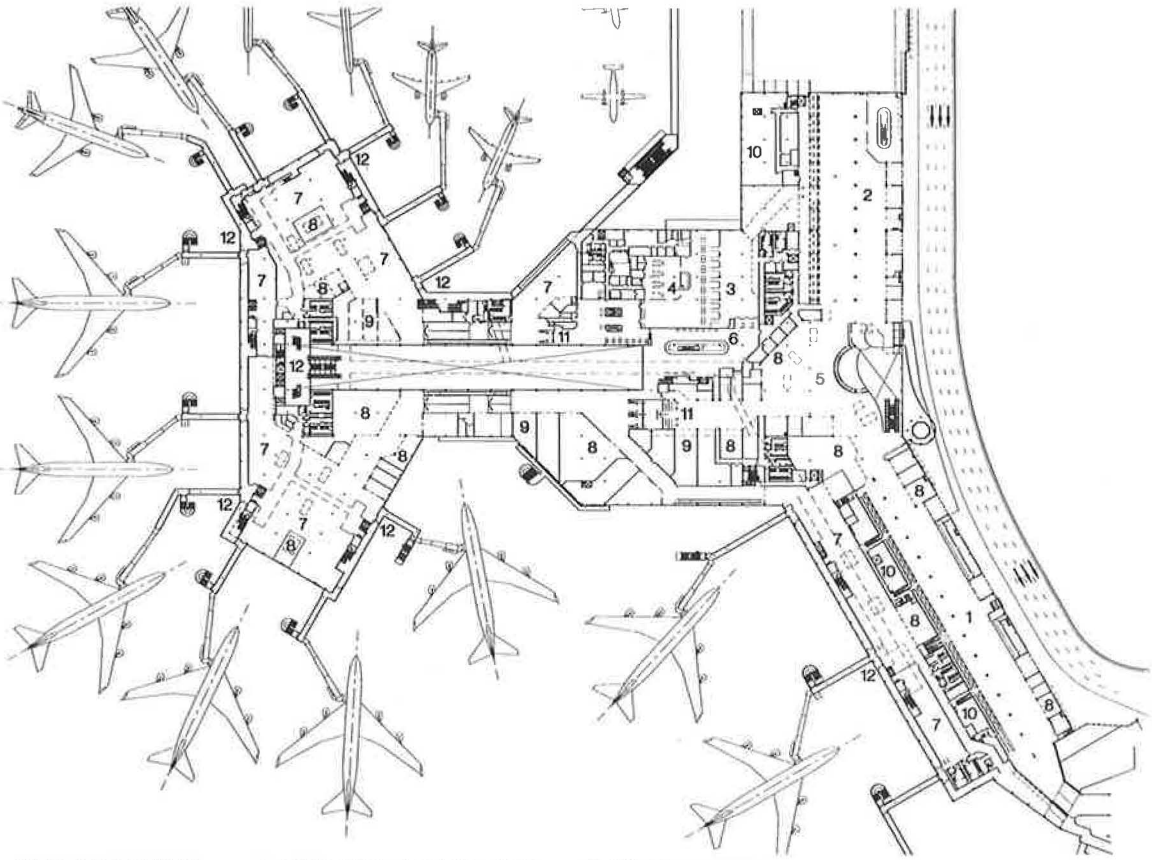
About 7 percent of the floor area in the terminal building will be dedicated to concessions, including a consumer-oriented mix of retail and eating establishments located where passengers are most likely to linger.

At the center of the terminal a concession court, flanked by the international and transborder check-in lobbies, will mimic the ambience of Vancouver's popular Granville Island marketplace. This colorful, diversified shopping environment will attract departing passengers and their well-wishers, as well as some early "meeter-greeters" from the international arrival lobby below.

There will be even more shopping and eating opportunities for passengers blended into the lounge seating areas near the departure gates. Passengers will be able to shop or buy refreshments only a few feet from their gates while awaiting their boarding calls.

Customs Facilities

Almost one quarter of the total floor area of the terminal building will be devoted to CIS and FIS



LEVEL 3 FLOOR PLAN

1 INTERNATIONAL TICKETING LOBBY
2 TRANSBORDER TICKETING LOBBY
3 FIS PRIMARY INSPECTION
4 FIS SECONDARY INSPECTION
5 MARKETPLACE/SCULPTURE COURT
6 INTERNATIONAL TRANSFER FACILITY
7 DEPARTURE LOUNGE
8 CONCESSIONS/RETAIL
9 AIRLINE LOUNGE
10 AIRLINE TICKETING OFFICES
11 SECURITY
12 STERILE CIRCULATION

FIGURE 4 Vancouver International Terminal, level 3 floor plan.

inspection facilities. The CIS portion, with over 196,000 square feet of space, will have 30 primary inspection and 22 secondary customs positions to process up to 2,900 arriving passengers per hour. From the gates, arriving international passengers will walk or ride moving walkways on an interior sky bridge overlooking the departure level and CIS facility below. Passengers will then descend by escalators or elevators to the CIS hall.

On average, a passenger will walk only 525 feet from an arrival gate (not including the assistance of moving walkways) to the inspection hall. This distance compares favorably to 800 to 1,200 feet at most other airports.

The FIS facility, comprising 34,000 square feet, will process up to 1,400 departing passengers per hour. FIS processing at Vancouver, called preclearance, allows passengers to arrive at any airport in the United States without the need for further FIS passenger inspection.

CONSTRUCTION FUNDING AND SCHEDULE

The estimated construction cost of the new terminal project is around $250 million (Canadian). Funding will come from an Airport Improvement Fee (AIF) paid by departing passengers (41 percent), a loan from a consortium of financial institutions (48 percent) and revenue from airport operations (11 percent).

Construction will take 24 months, with a scheduled June 1996 completion date. There are multiple construction contracts, including separate contracts for baggage conveyors, passenger loading bridges, and structural steel. The airport expansion is currently British Columbia's largest public works project.

When completed, the new international terminal will offer all the conveniences of a modern air terminal while portraying British Columbia's vitality and heritage to

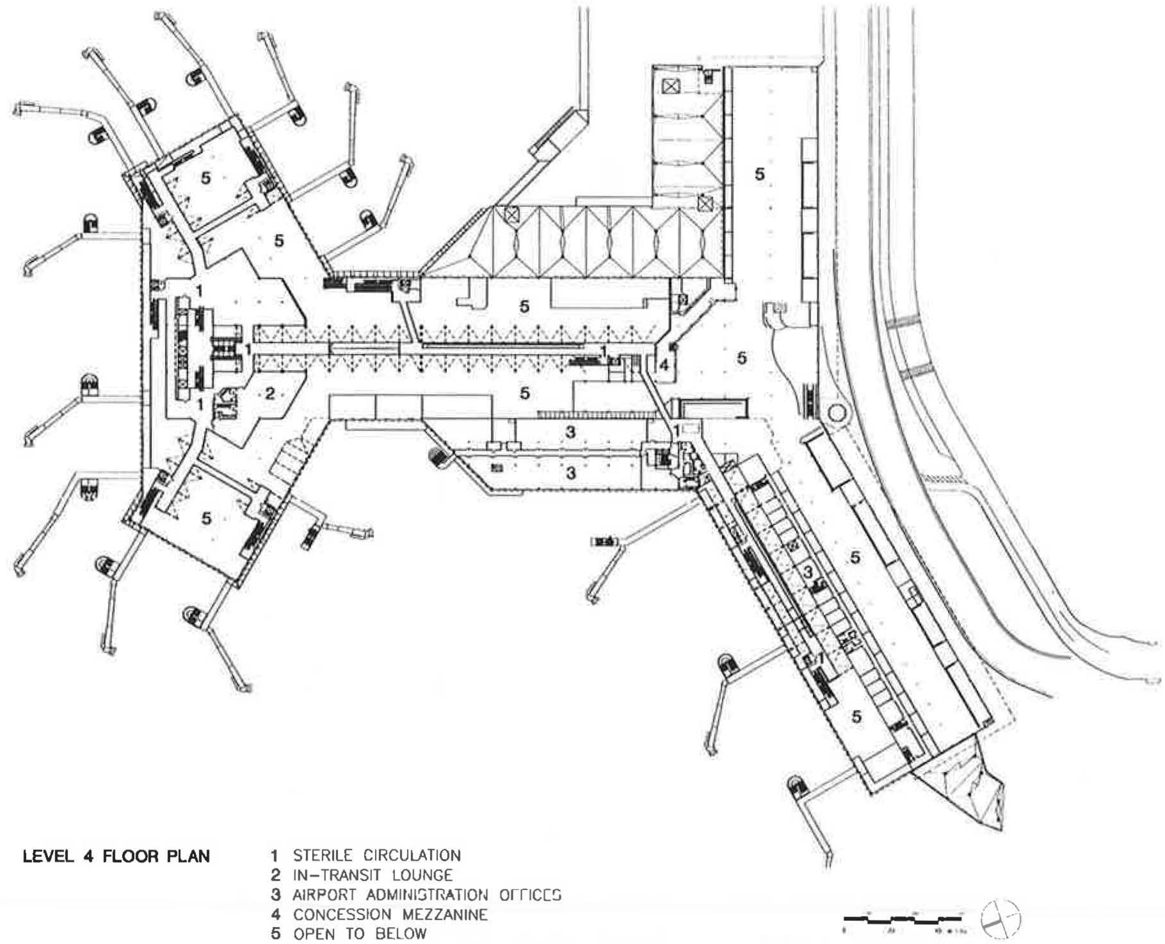


FIGURE 5 Vancouver International Terminal, level 4 floor plan.

millions of visitors each year. With new facilities, Vancouver will be a more competitive gateway, able to achieve a greater share of global air traffic.

SURFACE ACCESS TO INTERNATIONAL AIRPORTS

Carl Robart
*TRA*Black & Veatch Airport Consulting*

INTRODUCTION

Great circle routes are not always as easily understood on flat maps as they are on the globe. On the globe, it is possible to draw a great circle route between Tokyo and Rio de Janeiro as a straight line. This line crosses the United States, entering at about Seattle, Washington, and exiting at Houston, Texas. It is interesting to consider what is going on at the major U.S. cities along this line.

In Denver, an entire new international airport has been built. Houston International Airport sees itself as having the potential to become the second international gateway to the Caribbean and to Central and to South America. An important component of the reasoning in these two cities is that most of South America is located east of North America, making Denver and Houston logical transfer points for traffic to and from the south.

The midpoint of the great circle route between Tokyo and Rio de Janeiro is line is near Seattle. A perpendicular to this line at Seattle leads directly to London and Paris. Those who live in the Pacific Northwest have historically thought of themselves as living in a corner of the country. In realty they are at a potentially important hub in a global air transportation system. Recognition of this advantageous geographic position has led many airports to rethink their role as international gateways.

The topic of this paper is surface access issues at international airports. It begins with a brief review of the history of aviation technology and its relationship to airport design and then addresses how they have influenced access to airports by surface transportation.

AVIATION TECHNOLOGY

The following premise is set forth as a starting point: in air transportation, in fact in all modes historically, the focus has been on vehicle technology. As various forms of transportation technology were invented, entrepreneurs sought to find a transportation problem that the new technology could solve. Each advance in vehicular technology was a solution in search of a problem. The consequence of this approach has been that transportation planners are typically in a catch-up mode. They tried to accommodate pieces of technology that have been invented without a purposeful focus on market demand and need.

Until 1903, no powered aircraft had ever flown. When the first one did, it turned out to be the creation of two bicycle mechanics from Dayton, Ohio, whose primary purpose was to demonstrate that a heavier-than-air object could be held aloft.

Immediately after it was invented, nothing very productive could be found to do with the airplane except its military applications.. It took quite awhile to realize that airplanes could used to carry the mail. It was not until nearly 20 year later that the first airlines were formed, and even then there was no clear perception of a need to move large numbers of people quickly over long distances. Jet-powered airplanes, which first flew in 1939, did not enter commercial service until 1958. When they did, they were a bold gamble on the part of Juan Trippe and Pan American Airlines. Trippe took a military aircraft that the Boeing Company had designed and not been able to sell and put a civil version into commercial service.

AIRPORT DESIGN

What does this tell us about airports? Because of the fascination with vehicle technology, the airport design process — both for the airside and the landside — received relatively little attention. At first, in fact, airplanes were simply landed anywhere that was high, dry, and flat.

In the early years the interface between the surface transportation network and the airplane was pretty simple. Proximity was the principal rule. To this day, there are parts of the United States, like Alaska, where that proximity rule still applies, but they are increasingly few.

What will happen to air travel in the future? From a base of about 450 million enplaned passengers worldwide in 1992, the number of enplanements will increase to about 800 million by 2000. This number will grow to about one billion early in the next century before the normal S-shaped growth curve begins to appear and the air travel industry starts to mature.

Will electronic communication cut into this growth? The S-shaped growth curve suggests that ultimately the answer is yes. But for now electronic communication is actually driving air transportation growth more than it is cutting into it.

If the number of passengers is likely to double within the next decade or two, what will need to be done with airport infrastructure? Will the number of air carrier runways at the world's international airports need to be doubled? The answer is no. Aircraft manufacturers have a plan. They do not intend to double the number of airplanes; they intend to double their size. This is the 600- to 700-passenger airplane that manufacturers like McDonnell Douglas and Boeing are talking about. By doubling aircraft size, the hope is that it will be possible to double the number of passengers and still accommodate them on approximately the same number of runways as today.

What impact will these new large aircraft have on landside transportation at airports? Will they require that the existing infrastructure be doubled in size? The answer to this question, too, is no. A 600- to 700-passenger airplane, to borrow a term from surface transportation planning, is a high-occupancy vehicle. On the landside of airports, the principal vehicle used for access is the private automobile. In most cases these vehicles carry on average only slightly more than one passenger per trip. The result is landside congestion. One reason for this is the large number of airport-bound trips. Another reason is that airport trips tend to coincide with the hours when the roads are busy with other rush-hour traffic.

Clearly at issue is the need to balance the airside and the landside of airports. To do this requires incorporating public ground transportation into airports and encouraging its use.

Airport terminals must be carefully evaluated in terms of their ability to accommodate public transportation. In this evaluation airports can be grouped in two categories: centralized and decentralized. Centralized airport terminals are those that concentrate ticketing and bag claim in one location. Decentralized terminals duplicate and disaggregate these primary passenger processing facilities. Some examples of each follow, decentralized airports first.

Kennedy International Airport is decentralized; each airline has its own terminal. Dallas-Fort Worth (DFW) has a similar design. It consists of a series of unit terminals. Twelve are planned at full build-out. Kansas City has three separate unit terminals. Salt Lake City is slightly different in form from DFW or Kansas City, but it is still decentralized. The terminal has several concourses, each of which is a unit terminal. That is, each structure contains ticketing and bag claim facilities. The terminal at Boston Logan Airport is made up of a series of unit terminals arrayed around a central arc. Auckland, New Zealand, has a similar plan with separate domestic and international facilities.

The following are examples of airports that have centralized terminals. Tampa has a central terminal, a series of airside concourses, and a linkage between them. All baggage claim and ticketing occurs in the central terminal. Orlando has a central terminal complex, adjacent automobile parking, and connecting links to the airside concourses. There is no ticketing or bag claim in the concourses; all these functions are located in the central terminal. Atlanta Hartsfield Airport has a central terminal and a series of concourses. Seattle-Tacoma International, which was built at the same time as Tampa, was really the second airport in the United States to incorporate a centralized design. At Sea-Tac, there is a central terminal, a south and a north satellite, and four concourses. All ticketing and baggage claim is concentrated in the central terminal building. McCarran International Airport in Las Vegas, Nevada, is a centralized airport. Although at present it has only a single concourse, the master plan calls for several more, with all ticketing and baggage claim located in the central terminal.

The new Denver International Airport, follows the same scheme. The central terminal and a series of airside concourses are connected by a people mover. The new Hong Kong airport will have a similar layout. Like Denver and Sea-Tac, Hong Kong will have underground people movers. The new Auckland,New Zealand, airport is moving toward a centralized arrangement. I.M. Pei was working on a new centralized terminal at JFK, but this project fell on hard times as the economy slowed down a few years ago. The project included a massive central passenger processing building that was to be used exclusively for access by public transportation. A series of umbilical people movers were to have been constructed to connect the central passenger processing building to the existing unit terminals.

Washington Dulles International Airport was the first to have a centralized form. Eero Saarinen, the architect who designed the airport, set out to develop a new concept. He came up with the idea of concentrating ticketing and baggage claim in one location, rather than allowing it to be scattered to several buildings. Dulles has often been criticized as a poor design. However it is important to remember that the criticism has not been of the plan itself, but on the rather clumsy form of people mover that was provided at the airport. Once more efficient and effective forms of people movers were developed, the centralization of airport terminals really came of age.

SURFACE ACCESS TO AIRPORTS

What differentiates these two airport design schemes with respect to landside access? Both attempt to serve the same fundamental goal: to minimize the distance that a passenger has to walk. The decentralized schemes do this by catering to automobile users. The goal is for passengers to be able to park their cars as close to the airplane as possible. Both Dallas-Fort

Worth (DFW) and Kansas City International accomplished this brilliantly. Until the new Denver airport opened, they were the two newest major air carrier airports in the United States. At the time they were designed and built, they were heavily advertised as the airports where the length of the walk from car to plane was the shortest possible.

The problem at an airport like DFW becomes apparent when trying to devise a way to integrate public transportation into the design. There is actually public transportation at DFW today. Public bus service is available at the airport. The bus stops three times at each of the unit arches,s once at each end and once in the middle. The problem arises as new unit terminals are added. (A total of 12 terminals are planned.) If the bus stops three times at each, 36 stops are required to make a full circuit around the airport. This is where one of Robart's rules comes into play. This rule states that if there are more than three stops, public transportation at an airport will not be used. Therefore, to improve the efficiency of surface access at large airports, terminals need to be centralized.

Over the years TRA*Black & Veatch has studied passengers using public transportation at airports. A pattern is evident. At both Boston Logan and Kennedy International Airports the split between enplaning and deplaning passengers using public transportation is about 70-30. That is, about 70 percent of the passengers who use public transportation are enplaning passengers, and only about 30 percent are deplaning.

The explanation for this imbalance is simple. First, enplaning passengers are generally willing to take whatever time is necessary to get to the airport. Thus, public transportation may seem a reasonable option. Moreover, for the airlines, going to the airport is a many-to-one problem. This means that an airline is happy to collect passenger baggage at some remote location because all bags are going to a central place. The reverse journey is more difficult. As passengers deplane, they are not interested in standing in the cold or heat or rain or, for that matter, standing at all to wait for public transportation. They want to get moving. Consequently, public transportation that is hard to reach, difficult to use, or not easy to understand is not likely to be passengers' first choice.

The lesson is clear. When airport terminal facilities are being designed, it is necessary to make access to public transportation for deplaning passengers one of the highest priorities. This is how to achieve a more balanced ratio of use between arriving and departing passengers.

A general comment about European compared to U.S. airports is in order. At European airports there is much more effective integration of public transportation than in the United States. This is due in large measure to the superior ability of European airports to build public transportation and efficient baggage handling in to the basic design. Also, most European airports have a dominant national carrier, which frequently has more than half of the traffic. This carrier processes traffic for other carriers, and this encourages centralization.

In summary, these three thoughts are important to remember. First, demand is going to continue to grow, and the bulk of this growth is going to be international traffic. Second, the size of airplanes is going to increase in response to this growth. Third, public transportation needs to be integrated into passenger terminals, and this points toward centralization as a principal design orientation.

INTERNATIONAL INSPECTION FACILITIES: PLANNING RATIONALE AND EFFECTS ON TERMINAL DESIGN

Joel B. Hirsh
Hirsh Associates

The number of U.S. international gateway airports has been growing rapidly. According to the Immigration and Naturalization Service (INS), there are over 100 U.S. airports designated as ports of entry. Many of these airports are not fully staffed. Others are general aviation airports along the Mexican or Canadian border which do not involve the types of major projects which will be discussed in this presentation.

However, issues such as open skies agreements (like the United States has negotiated with the Netherlands), more liberal bilateral air service agreements (like the new German bilateral), the potential of NAFTA, and route reallocations are resulting in more airports receiving scheduled international service. This means that facilities for international passengers will be needed at more airports.

Federal Inspection Services (FIS) facilities have major impacts on the design of terminals. For example, the recent establishment of a route between London and Nashville, will result in expanding the FIS program at Nashville from handling charters to processing scheduled flights on a daily basis.

The FIS facility can control and shape the entire footprint of the terminal building. Moreover, as inspection procedures change such as they have a number of times over the past 15 years, the cost of facilities increases and airport terminal construction projects are delayed.

The purpose of this presentation is to review some of these changes and how they have affected the design of FIS facilities. In addition to current procedures, examples will be given of past changes in inspection procedures that have caused FIS facilities to become outmoded or inefficient.

FIS PROCESSING CAPACITY

The size and configuration of an FIS facility are related to its capacity. Airport operators and the FIS agencies refer to capacity in terms of the number of passengers that can be processed per hour. There are many ways of determining capacity. What is the rated capacity? How is it measured? What are the peaking factors within the design hour? For example, a facility with a capacity of 800 passengers per hour could handle two B747s arriving at the same time, or 30 minutes apart, or 55 minutes apart. Each is the equivalent of 800 passengers per hour. It could also be equal to three DC-10s, 20 minutes apart, or any number of other combinations that result in 800 passengers being processed through the facility in the space of an hour.

The FIS agencies base their staffing and facility requirements on steady-state flow. However, facility planners and airport operators must also consider the various peaks and local characteristics. The FIS Guidelines, however have a caveat to cover this, which has appeared in every edition:

"This ratio can only be achieved under optimum conditions. Factors such as baggage delays, origin of flight, passenger mix, etc. are key determinants which could possibly mitigate against achieving these figures. These issues must be considered during early planning stages."

The ratio referred to above is the number of passengers per hour, a figure which has been changed periodically. The main determinant of capacity has usually been the Immigration and Naturalization Service (INS) inspection procedures. (Table 1)

In 1979, the FIS agencies established a procedure called "One-Stop", which had a major effect on terminal design. The concept was to have all passengers inspected at a combined INS and Customs Service (USCS) area after claiming baggage. The agencies rated the capacity of a double counter with two inspectors at 100 passengers per hour. This system quickly disappeared (almost before it was implemented) for a

TABLE 1 RATED CAPACITY OF ONE INS DOUBLE COUNTER (2 INSPECTORS)

1979	One-Stop	100 pax/hr
1980s	U.S. Citizen-Bypass	(varies)
1990	U.S. Citizen-Bypass	114-117 pax/hr
1993	100% INS Inspection	100 pax/hr

number of reasons, mostly related to the need to cross-train INS and USCS personnel.

The 1980s another system, generally referred to as U.S. citizen bypass, was tried. Under this procedure passengers carrying U.S. passports flashed their passports at the INS counter, kept walking, picked up their bags, and went to the USCS counter where inspectors took a closer look at the passport in the course of the customs inspection. Foreign passengers, green card holders, and others went into the INS counter and were inspected.

However, the FIS agencies never changed the guidelines published in 1979. Facility planners still had to follow the guidelines for a one-stop system even though the FIS agencies were using a different procedure. This caused a certain degree of confusion in terms of both physical layout and the processing rate to be used. The effective INS processing rate was increased, due to the bypass, but not formally codified. The effect on the physical layout was to reduce the queuing at INS, but to increase the queuing for customs inspection.

In 1990, new guidelines were published. Citizen bypass of INS inspection was retained, but new USCS procedures, referred to as "The Strategy of the 1990s" were instituted. The INS processing ratio was set at approximately 114 to 117 passengers per hour per double counter, but the basic inspection procedure, a variation of U.S. citizen bypass as set forth in the 1979 one-stop guidelines, was unchanged. The rationale was that automation was going to make it even better in the future. This did not happen. In the 1980s, when the designer of a new FIS facility talked to the INS personnel in Washington who approved such facilities, the guideline was still "use 100 passengers per hour, per double INS counter."

The FIS agencies are in the process of revising the guidelines and their procedures yet again. There is a draft circulating among the agencies and, as of September 1993, INS was back to using 100 passengers per hour, based on INS inspection of all passengers, including U.S. citizens. In effect, INS procedures have come full circle back to the 1979 processing rates.

If an airport had a 2,000-passenger-per-hour FIS designed in 1990 and implemented according to the then current guidelines, it would have had 17 pairs of INS counters. Today, however, if INS was to use its new guidelines, the facility would have a capacity of only 1,700 passengers per hour — theoretically a 15-percent loss of capacity. On the other hand, there may not be a practical difference since INS probably will not staffed more than half of the booths. It is also comforting to note that the draft guidelines do not supersede plans approved prior to publication or require retroactive construction. There has always been a problem in the difference between what the FIS agencies require of a facility in comparison with the level at which they are able to staff it. The continual changes in agency procedures have been a major uncertainty in FIS planning.

One issue generally avoided in the guidelines has been the goal for processing time. In other words, what does any given processing rate really mean to the arriving passenger? Previous presentations have discussed the goals of minimizing walking distances and waiting times, but the FIS agencies have not provided a clear statement of policy on how long it should take people to clear FIS.

Under the new procedures, all passengers are to go through immigration inspection. There are different lines for different types of passenger (U.S. citizens, Blue lanes, etc.) but everyone is to be inspected. There is now a reference to a 45-minute standard, but it is not clear how it is defined. It may mean either 45 minutes from getting off the plane or 45 minutes from the end of the INS queue to clear INS primary inspection. Either way, passengers will not yet have claimed their bags and passed through customs. They will have completed only the INS portion of entry inspections. If the passenger has a passport problem has to go to INS secondary inspection, clearance could take a long time.

Most people would be surprised to learn that 45 minutes is assigned to the immigration process. Some in Congress would like to see 30 minutes, but the FIS agencies have not as yet been able to staff facilities to attain the 45-minute standard. Most airports and their passengers would prefer a higher level of service.

The new guidelines do not supersede plans approved prior to the implementation of the regulations or require retroactive construction. That is the good news. The bad news is that this is not always what happens.

For example, the new international terminal at Atlanta was designed in 1991 with a rated capacity of 4,500 passengers per hour, potentially expandable to 6,000 passengers per hour. USCS did not submit floor plans for their support facilities and their requirements for counters to the design team until the summer of 1993 — two years after the design was accepted by the airport. The designers had to rearrange the customs inspection area because USCS changed their procedures. USCS also requested (i.e.,required) special conveyors, which added $2 million to the original budget. The lesson learned by Atlanta is that as procedures change so must plans, even approved plans.

EFFECTS OF INSPECTION PROCEDURE CHANGES ON FIS PLANNING

Changes in inspection procedures have caused some interesting problems in terminal design.

In 1979 the inspection procedure was to become a one-stop system. INS and USCS were to be merged, and the agencies would cross-train their inspectors.

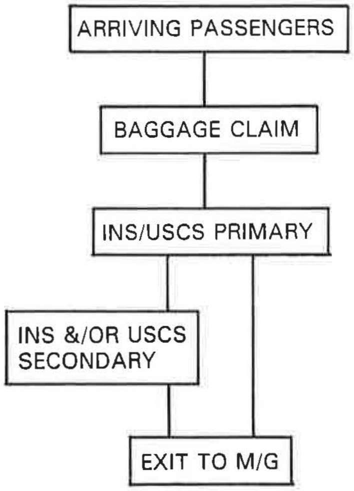


FIGURE 1 FIS procedures, 1979.

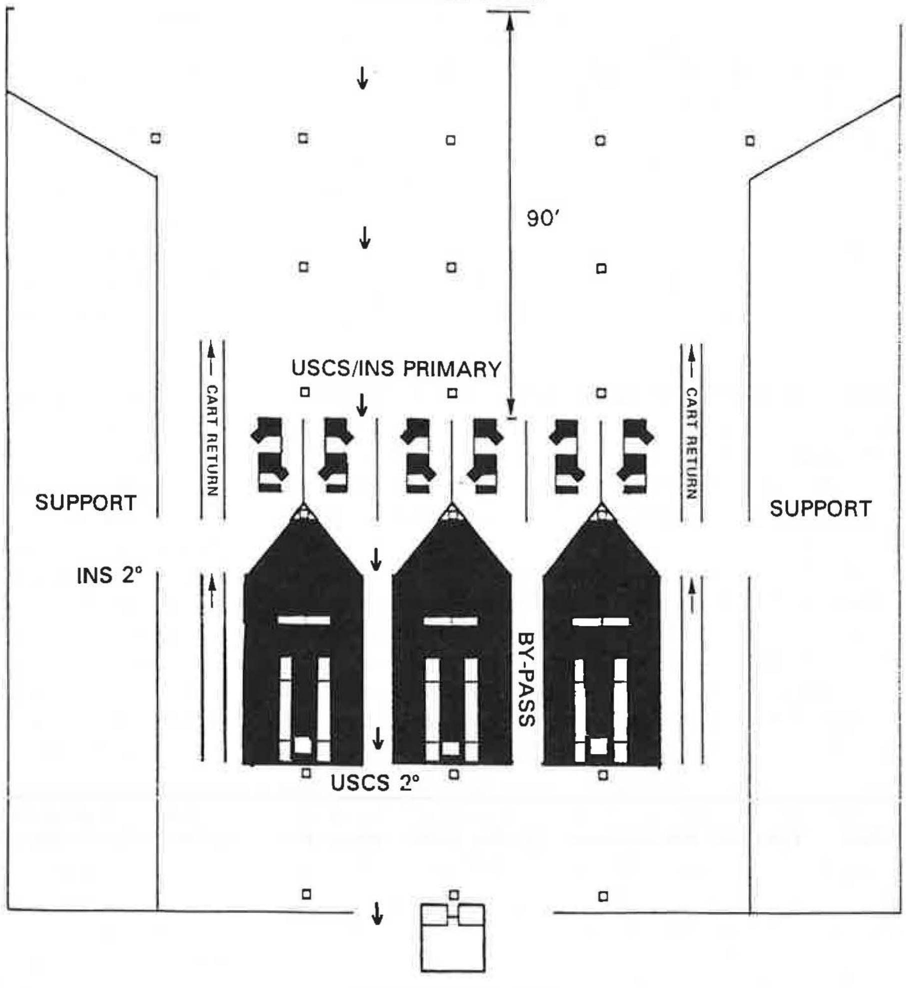


FIGURE 2 1979 one-stop module.

Passenger flow was to be as shown in Figures 1 and 2. Passengers would deplane, claim their baggage, then go through a 90-foot queuing area to a combined INS/USCS primary position. The small percentage of passengers with either immigration or customs problems were to go to the next inspection point for further questioning and/or to have their baggage inspected. It was expected that most passengers would bypass out to the meeter-greeter lobby. Parenthetically, examination by the Animal and Plant Health Inspection Service (APHIS) did not have the prominence in 1979 that it has today.

This procedure dictated a certain configuration for the FIS facility and the terminal building. FIS had one big queue, a relatively complex inspection area, and then an exit. This was a radical change from the way it had been done prior to 1979, which was immigration first, then baggage claim, and finally customs. The one-stop strategy lasted about two years on paper.

The current procedure does not yet have an official name. USCS calls their system the Strategy of the 1990s; INS has not given their procedure a name. Figures 3 and 4 illustrate the published procedure (1990 edition), which appears conventional and very similar to the pre-1979 and de facto post-1981 passenger flow. Passengers deplaned and went to INS primary, where the majority of the passengers were inspected. The only passengers allowed to bypass INS were those on flights which had been pre-inspected at a foreign airport. Passengers having immigration problems went to the

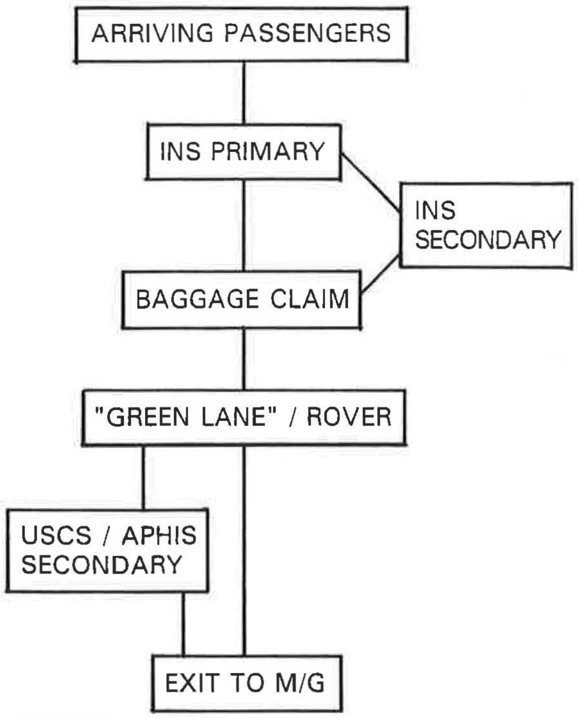


FIGURE 3 FIS procedure, 1990.

INS secondary area for further questioning. Passengers then claimed their bags and customs inspection took over.

The new inspection system involves using more roving inspectors, and pre-classifying passengers before they arrive in the United States using the Advance Passenger Information System (APIS). The APIS procedure begins when a passenger checks in at a foreign airport. Information about each passenger goes into the airline computer and is relayed back to INS and USCS and run against a series of federal and state data bases while the flight is in the air. From these data bases, the agencies come up with a small list of people who may be suspect. The concept is that passengers who have been screened through APIS go to the Blue Lanes at INS and are processed through much faster because the passenger manifest has already been reviewed.

Figure 4 is a simplified FIS layout from the 1990 FIS Guidelines based on the new Terminal Five at Chicago O'Hare Airport. Passengers enter immigration from the sterile corridor system at the back and sides, queue for immigration, and exit INS primary from both sides to the center. This forces passengers past INS secondary (the block in the center) so INS supervisors can be sure that passengers who are supposed to go to secondary inspection do not get lost in the crowd at baggage claim.

The Rover Command Center (RCC) has a major role in the new USCS inspection system. When a passenger pre-selected by the APIS process for customs inspection gets to an INS booth, the inspector sees the name on the hot sheet and pushes a button. In the RCC a light goes on and the USCS rover supervisor knows there is a suspected passenger at that booth. The supervisor notifies one of the rovers. A glass wall separating immigration from customs allows the rovers to see who is coming out of immigration and to follow them through. A single level FIS facility is necessary for optimum use of the new system.

At baggage claim a passenger who has been previously identified by APIS screening will be intercepted by a rover and taken to a USCS secondary counter for inspection. Some rovers work the crowd making observations and intercepting passengers within the claim area. Profiling criteria are secret, and the rovers have many tricks of the trade. It is fascinating to watch a good rover team mix with the passengers and pull people out using this profiling system. APHIS also has roving inspectors, some using dogs trained to search for food and plant materials.

There are also high-risk flights where USCS wants to look at everyone from that flight. If there are a large number of high-risk flights at an airport, USCS may require a movable barrier system to segregate the baggage claim unit for the high-risk flight and funnel the passengers directly to a USCS secondary inspection area.

Most passengers, however, will go to the green lanes, also known as profiling stations. The profiling stations are staffed by USCS and APHIS inspectors who look at the customs declarations. On average, approximately 90 percent of the passengers will be directed out of the FIS without baggage examination. The remaining 10 percent would be directed to either the APHIS X-ray units on the right, or the customs counters on the left, depending on the type of illegal imports the inspectors think the passenger might have. APHIS runs baggage through an X-ray. They are primarily looking for food, and plant materials, but they can also spot other contraband.

Once passengers leave the inspection area, there is a recheck counter where transferring passengers can recheck their baggage for a connecting flight. In the example of Chicago O'Hare, there is a large is a large percentage of transfers since both United and American have international flights. By having the recheck counters at a point before the meeter-greeter lobby, connecting passengers can be freed of their bags before

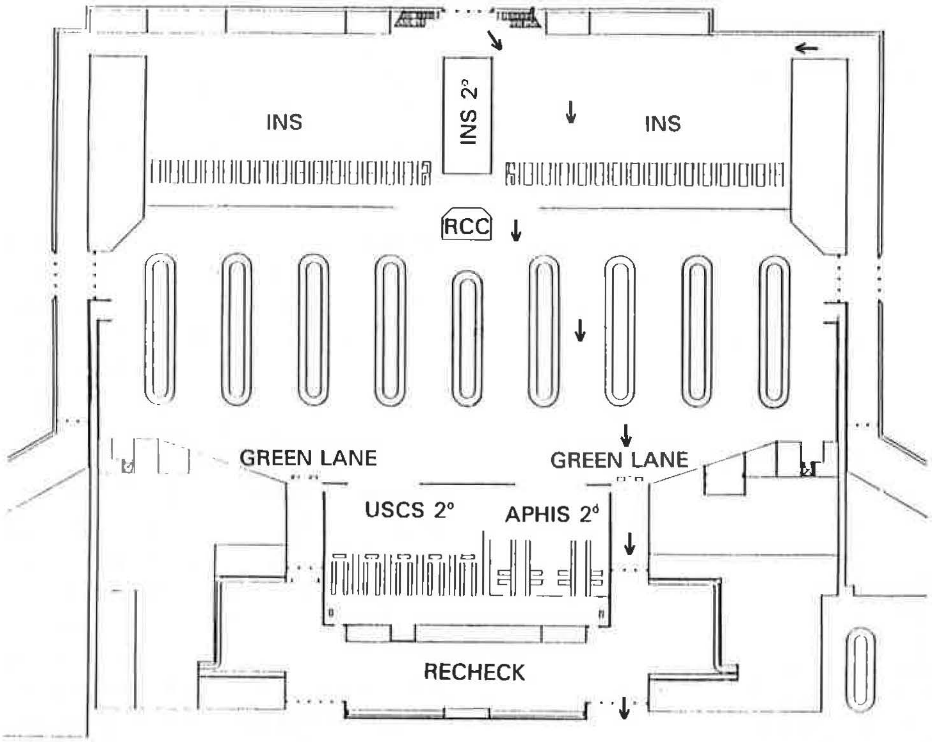


FIGURE 4 1990 typical FIS, O'Hare Terminal 5.

entering the crowds of the meeter-greeter lobby. It is also desirable to get connecting passengers out of the flow to the meeter-greeter lobby and back to the gates through a separate security check point. These passengers have no one meeting them, and the last thing they want is to push through a crowd.

In the Chicago example there is also an interesting point about the issue of capacity. When the international terminal was planned in 1988-1989, the capacity was estimated to be 3,500 to 4,800 passengers per hour. As built and opened in the summer of 1993, it had 34 double INS counters, which would be 3,400 passengers per hour under the current standards. (Figure 4 as taken from the FIS publication does not have the correct number of counters.) So far, the airport has not had enough experience to determine what is the effective capacity or the average passenger processing time.

CASE STUDY

Flexibility is a concept emphasized in the planning and design of all terminal buildings. As FIS agencies have revised inspection procedures, changes have been required in the physical configuration of the FIS. There have been some major changes, each of which was supposed to set a new standard. The lesson to be learned is that further changes in the future are inevitable, and new FIS facilities should be planned to have the flexibility to accommodate them.

One example of the need for flexibility is the Tom Bradley International Terminal at Los Angeles International Airport. The terminal, planned in 1981 to the 1979 one-stop standards, was to be opened in time for the 1984 Los Angeles Olympics. After final design and early construction process, the FIS agencies dropped the one-stop concept. This forced the designers to reconfigure the FIS, but the time pressure of the 1984 opening date limited the changes that could be made.

Figure 5 shows the original FIS layout of the terminal. This was a prototypical 1979 one-stop configuration. Passengers came in by way of sterile corridors or from a bus dock for remote aircraft stands (shown at the top of the diagram) and went to baggage claim. There was a very generous queuing space with ample room for primary and secondary inspection counters. The recheck counters and the meeter-greeter lobby are at the bottom of the diagram. Two baggage claim devices, one on either side of the lobby, were for domestic or precleared flights to get more flexibility out

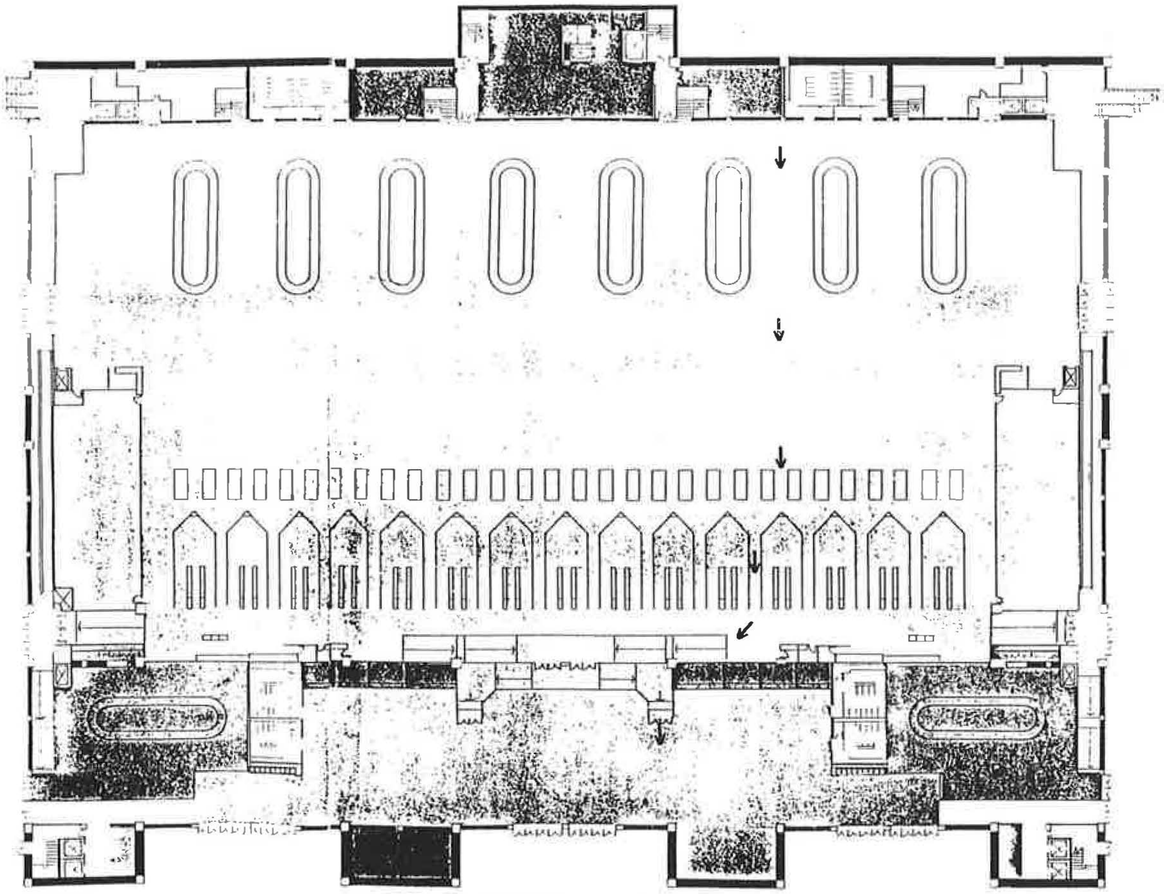


FIGURE 5 LAX Tom Bradley International Terminal, 1981 plan.

of the building. That is the way it was designed, and construction begun.

When the FIS agencies decided to abandon the one-stop concept, they went back to a conventional system. Because the terminal was scheduled for completion in time for the 1984 Olympics, the envelope of the building was already set and under construction. The baggage claim feeds from an interstitial baggage handling level above were already set. The claim units could be moved, but the amount of movement was limited. There was no room at an upper level for immigration inspection, and the designers had to fit a two-step process into a one-step design. The result was a very narrow queuing area for immigration. The immigration area had to be reconfigured and moved many times. Figure 6 is the current (1993) configuration. When the terminal first opened, the immigration counters had even less queuing, and it was like walking into a hallway. The worst conditions occurred when Asian flights arrived with high loads and a low ratio of U.S. citizens, resulting in a low amount of bypassing.

Most of the queuing was needed at immigration, but the baggage claim areas could not be moved further without totally disrupting the baggage make-up area as well. Baggage systems are the most critical system to design because bags do not go around corners very well. HVAC, plumbing and electrical systems can be rerouted with relative ease, but baggage conveyor systems are very difficult to change once they have been installed. Los Angeles International now has a very generous queue area for customs, but the new procedures minimize customs inspection resulting in a space imbalance.

The international terminal at Atlanta faced a similar situation. It was designed for one-stop, and then FIS procedures changed. The airport was able to find room for an INS processing area on another floor of the terminal, but the level of passenger service was greatly reduced from what was intended. As with Los Angeles International there is a surplus of queuing for customs, but queuing for immigration is less than desirable. A new international terminal will eliminate these problems.

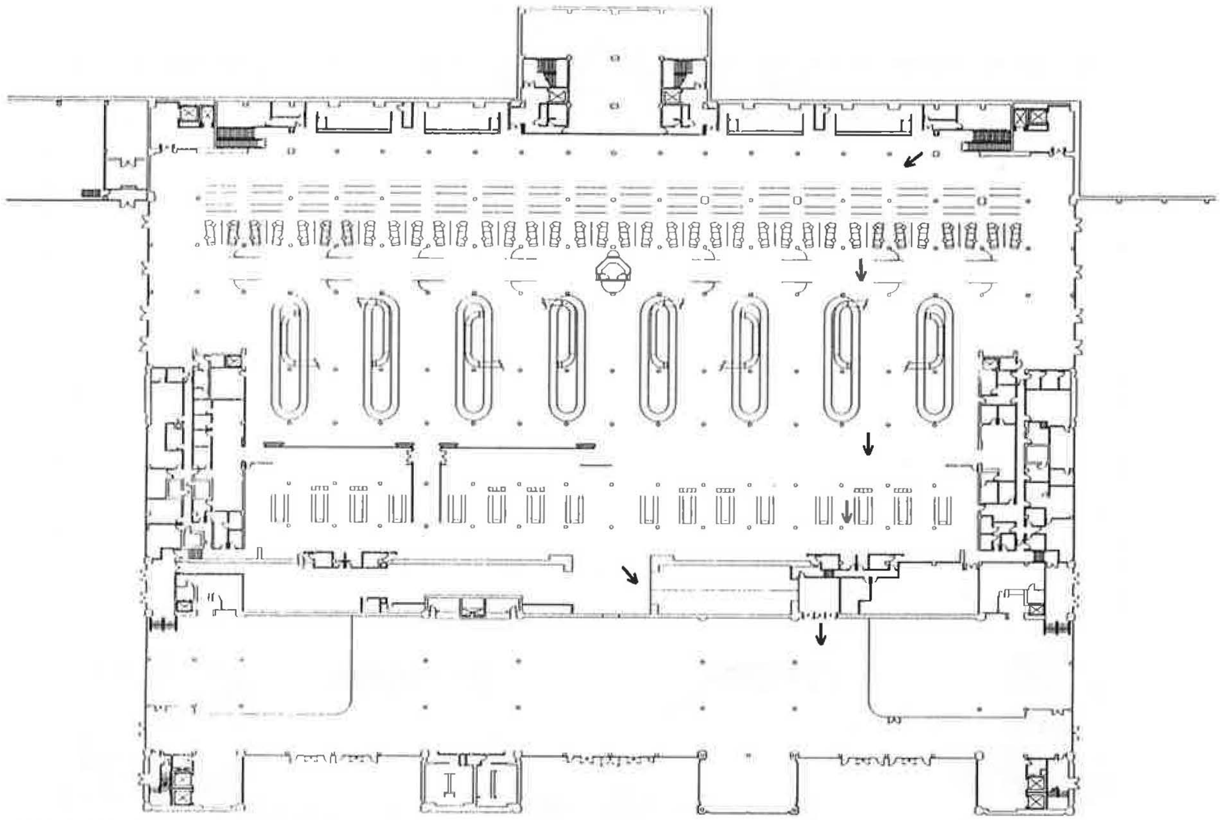


FIGURE 6 LAX Tom Bradley International Terminal, 1993 configuration.

DESIGN ISSUES

The previous examples were selected to make a point. FIS agencies have changed procedures in the past. Each time they change, it generally requires more space. The design of FIS processing areas should be as flexible as possible to accommodate these changes.

This can make a terminal planner a bit cynical. However, one must plan the facility for the procedures that the agencies say will be used and try to provide as much flexibility as physically and financially possible. The amount of space, and the dimensions of an FIS facility can be substantial. Figure 7 represents the typical dimensions and inspection sequence of a one-level FIS facility designed to the current guidelines. It provides the desired straight, flow-through facility that the agencies and passengers prefer. Passenger orientation is best in such a facility because the various inspection steps are more readily apparent, and passengers can see where they are going.

The queuing space for INS and USCS/APHIS recommended under current guidelines, is at least 70, but preferably 90 to 100 feet. The INS inspection booths are 15 feet long, with 10 feet of cross-circulation behind them. This layout assumes the INS secondary inspection is to the side rather than in front of the primary counters as in most older facilities. By placing the INS offices to the side and dividing the INS inspection area from the baggage claim by a glass wall, the USCS rover function is enhanced.

Next is a circulation space with room for bag carts and the rover command center, typical sloped-bed baggage claim units with 200 to 220 feet of claim frontage; queue space for USCS and APHIS inspection, cross-circulation to one exit (or two in a very large facility), and some USCS/APHIS support space.

The overall length is 350 to 420 feet for a straight-through FIS facility. If the baggage recheck area and meeter-greeter lobby are also in line, the total length can expand to well over 500 feet for a large terminal. Most airports would have a difficult time accommodating this much space on a single level. It is interesting to note that at Chicago O'Hare the new terminal has only 65 feet for INS queuing. There is usually a limit to the space which can be wedged into a building,even a brand new one,- when there are site constraints.

One design feature stressed in this example is the single-level facility. The agencies prefer a single level because of the rover system and the visual contact that

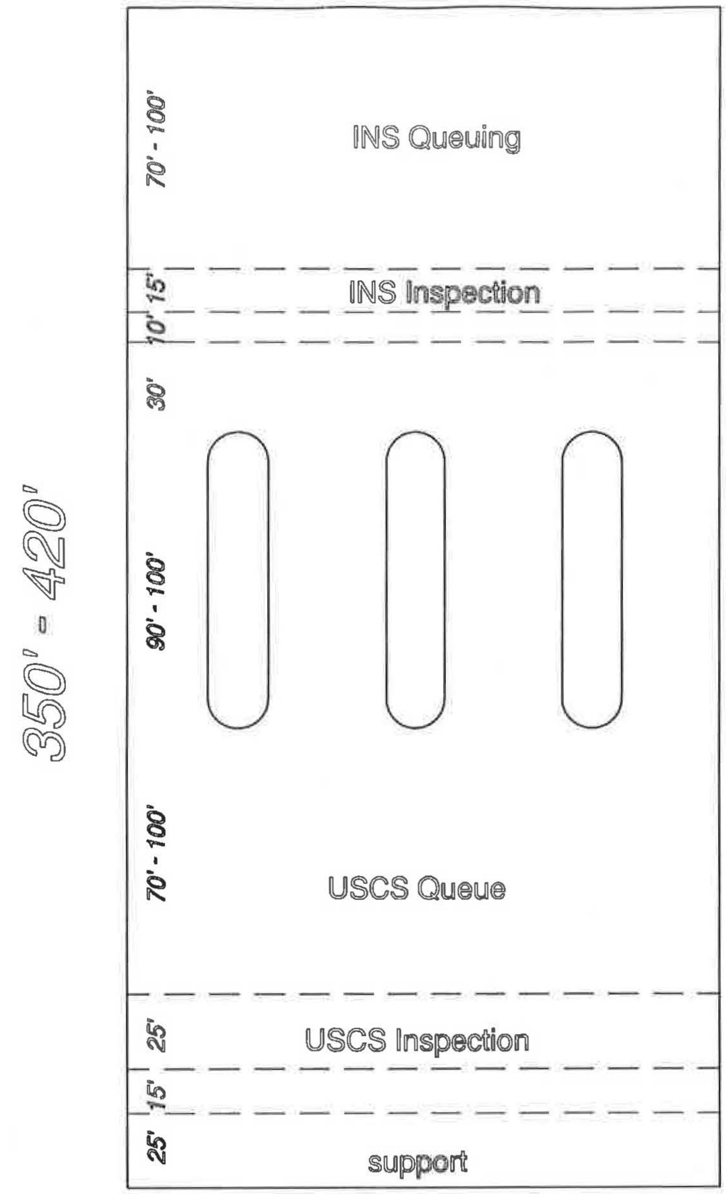


FIGURE 7 Typical dimensions.

is an integral part of the procedure. If an airport cannot provide a single-level FIS due to site and building constraints, the agencies will not refuse to staff the facility, but they may require a second rover command center in the INS area so that USCS supervisors can still see the INS counters. If the APIS screening has identified a suspect passenger, the supervisor can radio a description (such as "the man coming out of booth 14 is wearing a red Hawaiian shirt and carrying a straw bag") and the rovers in the baggage claim area can easily pick this person as he comes down the escalator.

There is another, more well known, issue — the glass wall. The official position for many years has been that the FIS area must have a physical and visual barrier separating it from domestic passenger facilities. The idea is to prevent communication between passengers and other terminal occupants and to prevent observation of enforcement actions.

There have been many interpretations as to what is acceptable. On the upper level of the International Arrivals Building at Kennedy Airport in New York formerly had big glass walls that'provided a view down into the customs area. The glass was painted over a long time ago. In contrast, the international terminal at San Francisco airport has a big glass well in the middle of the terminal. Visitors and enplaning passengers can look down into the FIS area, but visibility is limited to the baggage claim area. Visitors cannot see the INS or USCS/APHIS counters. The angles are such that onlookers cannot observe the areas of real enforcement action, and viewing a rover interception is not considered to be a problem. Seattle/Tacoma has a similar observation area where visibility is limited.

While the FIS agencies in the United States require this type of barrier to prevent visual signalling between passengers and visitors, some other countries have taken the opposite tack. In Singapore, there is a glass wall between the FIS area and the meeter-greeter lobby, and most passengers bypass customs inspection. Customs rover agents (mostly in plain clothes)watch for interactions between passengers and visitors. By allowing such visual communication, the rovers can identify potential customs violators. They achieve a very good interdiction rate.

The issue of glass sterile corridors has had many interpretations depending on the region of the country and how the agencies wish to enforce the guideline. Miami International is a great example of bending (some would say complete flouting) the rules. The third level of Concourse D, where American Airlines has a large number of international operations, is a sterile corridor on one side for international arriving passengers. The other side is an express outbound corridor with moving walkways going in both ways. A clear glass wall runs the entire length of the concourse. Domestic passengers can sit and wave to passengers coming in. The in-transit lounge is also visible.

In contrast, the new international satellite at Orlando has a high-tech, electronically controlled glass separating the holding rooms from the deplaning vestibules. This allows light into the hold rooms and maintains a view, but the glass can be made opaque electronically with the flip a switch. On the other hand, Terminal Five for Delta at Los Angeles International, built at the same time as Orlando, has clear glass in the vestibules where deplaning passengers go up the escalators. There is no tinting, no glass block, no electronic glass. Clear glass was acceptable in Los Angles but not in Orlando.

Where to locate restrooms has always been an interesting issue. The guidelines state that the restrooms must meet FIS security requirements and be located prior to the inspection area. The new draft requires that restrooms be placed prior to the INS counters and states absolutely that there shall be none between INS and the FIS exits.

Looking back at the illustration of the recently completed Chicago O'Hare terminal (Figure 5), the trapezoidal areas to either side of the Green Lanes are restrooms in the customs area. The prevailing concept during the design of Chicago was that the agencies are only interested in keeping things from getting into the country. If passengers get cold feet and want to flush it, that's fine. Apparently the thinking has changed again. There are interesting signs over the trash cans in the San Francisco baggage claim area, which can be seen from upstairs. They read: "Declare it, drop it, or pay a fine." The agencies are still trying to give passengers have a chance to get rid of contraband, but now they just want it thrown in the trash can (perhaps so they can check it out later).

Another issue is the growing space requirements for FIS agency support areas. There are areas for certain functions, such as secondary inspection, that must be adjacent to the processing floor. These space requirements have been generally stable through the procedural changes, but the area required for support facilities has increased substantially.

For example, in the 1979 Guidelines a facility to process 2,000 passengers per hour (excluding employee lockers, restrooms, and the current requirements for an exercise room) required 12,200 square feet for support space. The 1990 guidelines called for up to 17,600 square feet, a 44-percent increase. The main reason was duplication of support facilities, training rooms, and other such space for INS, USCS, and APHIS. The draft currently in review require 19,620 square feet for a 2,000-passenger-per-hour facility. The 11 percent increase over 1990 is primarily for APHIS support.

INSPECTION FACILITIES IN OTHER COUNTRIES

Most countries have some form of border control for entering airline passengers and typically use a two-step immigration and customs inspection process similar to that of the United States. Basic layouts and passenger flows are also similar to those of the United States. However, processing times vary significantly from country to country.

Within the European Community (EC) borders between member states are in the process of coming down. In January 1993, the EC was supposed to become a single entity without internal borders, but this has not yet been fully achieved. Passengers between EC states are no longer subject to customs controls, but border checks are not yet totally gone. These changes are requiring major alterations in the design of international terminals, especially those at major European gateway airports.

Prior to the integration of the EC, passengers from outside Europe (North America, for example) would clear immigration and customs at their final European destination. An airport such as Amsterdam, which has a large percentage of transfer traffic, has a large in-transit area where passengers can move between flights, spend money on duty-free merchandise, and connect to their final destination without ever officially entering the Netherlands.

Under the new procedures, passengers who are transferring to a flight to another EC country will clear immigration, undergo customs inspection of hand baggage at the first point of entry to the EC, and then board a "domestic" flight to their destination along with other locally originating passengers. Passengers on a through flight from overseas to another EC country beyond the point of entry may remain on the aircraft and clear immigration at their destination. The final segment will still be considered a domestic flight. When such passengers reach their destination, they claim their checked baggage and clear customs. The domestic passengers who boarded at the stop-over airport have special bag tags that allow them to exit through the "blue lanes", while all others exit though lanes subject to customs inspection. This may strike an American or Canadian as a rather loose system, but represents the strategy of targeting higher risk flights and selective inspection that has been the European norm for many years.

On December 1, 1993, the nine Schengen States (Belgium, France, Germany, Greece, Italy, Luxembourg, the Netherlands, Portugal and Spain) removed immigration controls at their common borders and put into effect a common visa for 120 other countries. In this case, the definition of common borders extends to airline flights between any Schengen States regardless whether they are contiguous. This reduction in immigration inspection is expected to be expanded to the other EC states, but the implementation timetable is still under discussion. A number of problems remain. For example, Denmark is in the EC but is also part of the Nordic Travel area which includes Sweden and Norway. Thus, if Denmark drops border controls to the EC, it is effectively opening the EC borders to the nonmembers countries of Norway and Sweden. The UK has also been reluctant to drop border controls based on concerns about the movements of non-EC citizens within the EC (viz. terrorism).

The implications for airline terminals are significant due to the variations in how immigration controls are implemented. Customs baggage inspection appears to be working well, but this is probably due to the low rate of inspection prior to 1993. The major design problem will be with immigration at first point of entry. A major gateway such as Amsterdam has been built to handle large numbers of in-transit transfer passengers. Immigration facilities were sized for terminating passengers and located to direct these passengers to the landside. Under the new procedures, a large proportion of the transfer passengers will have to clear immigration at Amsterdam and then reboard "domestic" flights without mixing with non-EC passengers who are in transit. This will require new immigration facilities and the division of terminals into international and domestic zones. It has been estimated that it may take three to five years to convert the major European airports to the new system.

CONCLUSION

A fundamental principal of all terminal planning is to provide for flexibility and expandability. This is often easier said than done. Baggage systems, in particular, are more difficult to reconfigure than most other terminal components. The FIS facility can be the largest component of an international terminal, and the size and configuration of the facility is dependent on many factors. The facility should be planned for expansion, but also for reconfiguration if and when FIS agencies change procedures.

WHAT AIR TRAVELERS WANT IN AIRPORT CONCESSIONS

Allen Schiffenbauer
Marriott Corporation/Host International

The approach used by Host Marriott in planning concessions for air travelers at international airports is based on a relatively simple game plan:

- Review the research on passenger needs and expectations. (Host Marriott has carried out a very active research program on these matters for several years, interviewing thousands of people in a variety of settings.)
- From this information form hypotheses about the needs of international travelers in specific circumstances and locations.
- Conduct additional research to confirm these hypotheses.

This approach can lead to useful and sometimes surprising insights into the appropriate types of concessions to be offered: duty-free merchandise, duty-paid merchandise, food and beverage, and other amenities that travelers might want at an airport. What is the appropriate proportion and mix of these types? Take food and beverage facilities for example. What should be the mix of lounges and food facilities? Are fast-food facilities appropriate? Should there be sit-down restaurants? What should the menu items be? What range of meals should be offered? What are the price points? What should be the mix of relatively high-priced and low-priced products?

Similar sets of questions apply to the planning of merchandise shops and other amenities and facilities for passengers. In the interest of simplification, however, the focus of the discussion here will be food and beverage concessions.

The process used by Host Marriott in selecting food and beverage concessions is based on two principles:

- All decisions should be customer-driven. The goods and services provided should be determined by what customers want to buy.
- All decisions should be fact-based. The selection of concepts, products, and services must be based on hard objective data not opinion, speculation, or the personal taste of planners.

Experience has shown that these two principles eventually lead to one important implication. Each airport, and sometimes each location within an airport, demands a unique solution. The assumption is that success will be assured only by providing the products and services that meet customers' needs. Selecting offerings based on customer needs may seem so obvious that it is hardly worth mentioning, but it is frequently overlooked. People in the concession industry have often told me that the selection of products and services has been based on the personal taste of the concessionaire or the airport management. There is little reason to believe these tastes are representative of customers at the airport.

Host Marriott is dedicated to the proposition that revenue can be maximized and customers satisfied only if the selection is based on directly measured of the people who will use the concessions — travellers, meeters and greeters, and airport and airline employees.

When the selection is made on facts about the customer's point of view, when everything is passed through a customer screen, the inescapable conclusion is that not all customers are the same and that these differences lead to very different concession needs.

International travelers come from a variety of cultural backgrounds with a variety of food preferences. Not everybody wants to eat the same kind of food. To make matters even more confusing, sometimes travelers want a touch of home and familiar foods. Sometimes they want to experiment and try something representative of the country they are visiting. For example, Japanese travelers to the United States are strong customers for both traditional Japanese foods (such as udon) and American hamburgers. Determining which the traveler might want in any given situation is a daunting task.

Parenthetically, there is one nearly universal guideline. Nobody likes to be too adventuresome at breakfast. Breakfast is when people want familiar food. People are more willing to experiment for lunch or dinner, but breakfast is when people want to follow the waking up ritual to which they are accustomed.

Customers can also vary dramatically in their familiarity with national brands. U.S. brands work well at domestic airports because they have wide appeal and recognition. The selection of brands to use in an international airport must take into consideration the brands that are strong in the foreign traveler's home country. Some brands that are familiar domestically are international in nature and easily recognized by people from many countries. Other brands are not.

Customer preferences can also vary according to flight patterns. For example, United Airlines has several flights on North Atlantic routes at Dulles International Airport. Many of the passengers are making connections. They started their trip in some other U.S. city served by United and change planes in Washington for the next portion of their journey. Many of these flights are "red-eyes". Between 5 and 6 p.m. on any given afternoon at Dulles airport United has flights to Frankfurt, Madrid, Amsterdam, London, and Milan. These flights will not land at their destinations until the next morning. In other places, on the West Coast for example, there are many early morning flight taking off to the Far East.

Is it reasonable to assume that an American family on vacation red-eye flight to London will have the same needs as a Japanese businessman returning home on a flight leaving Los Angeles in the morning? Obviously they will have different needs. The trick is to determine these needs and how to satisfy them.

How can the concession planner effectively think about all of the customer differences and arrive at a correct solution? The first step is, make no unwarranted assumptions. Start out believing that each situation is unique. More trouble can arise from making inappropriate generalizations than from spending some extra time thinking through an issue. You cannot always trust the past. Things change. An example is the experience of Host Marriott at the Anchorage airport, which for many years had been a transfer point for traffic to and from the Orient. When political conditions changed in the former Soviet Union, traffic at the airport changed dramatically and quickly. What once was an airport bustling with business people going to and from the Orient is now much quieter. Anchorage is an extreme example but it makes the point.

The best way to avoid the problems associated with making inappropriate generalizations is to count the teeth. Let me explain by telling a little story. My son asked me, as all children do, what I did at work. If I were a fireman or a policeman the answer would have been easy, he could understand that. When I told him that I am a market researcher, he asked what that meant. To answer that question I told him a story attributed to Francis Bacon and the founding of the scientific method.

Some monks were sitting in a monastery debating how many teeth a horse had. One monk said the answer is 31 because Aristotle said so, and he quoted chapter and verse proving that this is precisely what Aristotle had said. Aristotle, of course, could not be wrong. Another monk maintained that a horse had 33 teeth because Socrates said so, and Socrates was obviously a better source than Aristotle because he knew more about horses. The debate continued until a young monk — a kind of out-of-the-box thinking, creative monk — said he was going down to the stable, open up the horse's mouth, and count the teeth. Thus the beginning of the empirical scientific method.

I tell my son is that I spend my life going down to the stable and counting the teeth. And that is what you need to do. Don't make assumptions. Don't trust the past. Don't rely on experts. Count the teeth. Go talk to travelers in the airport. Ask them what they want. Be fact-based. Gather objective data to guide decisions about airport concessions. Count the teeth and be prepared for surprises. The answers you get will not always be the answers you expect.

Two case studies show how customer differences result in different concession plans. One case is the United Airlines flights at Dulles airport mentioned earlier. This traffic is mainly North Atlantic flights. Most of the travelers are U.S. citizens connecting from a domestic flight. There is mix of business and pleasure travelers. Travelers are in small groups or alone. They have been fed on a plane coming to Dulles, and they know they are going to be fed going to their final destination. These are red- eye flights.

The other case is the Host Marriott concession at Kennedy International Airport in New York. This is a location that has a high volume of Latin American travel, primarily to and from Puerto Rico. In contrast with Dulles airport, many of the JFK customers are Hispanic from the Caribbean and Latin America. The mix is heavily pleasure travel. Many of the passengers have large groups of people who come to the airport to meet them or see them off. Frequently the meeter and greeters spend a protracted amount of time in the airport. These are mainly O&D flights, not transfers. Departure times are spread out during the day. The size of the traveling group can be large.

This is a very different group of people. If you ask these people what they want — if you count the teeth — they turn out to have different needs.

The Dulles passengers want light snacks, healthy food, gourmet coffee, and quick national brands. Somewhat surprisingly, these people do not want an international cafe that serves heavy food representative of either the United States or the European country to which they are going. They are getting ready to go to sleep. They have had a hard day, and they know they will have to wake up at 6 o'clock the next morning and get off the flight and do something. They just want a little something to tide them over. This is a very unusual pattern for what we tend to think of as international travelers, but that is what the Dulles passengers want. This is what is right for these passengers.

At Kennedy airport people want heavier entrees. They want a bigger meal and the opportunity to buy beer. These passengers want a bar in addition to the food offerings. Among the entrees chicken is a favorite. National brands are somewhat less important than at other locations.

Here we have two sets of international travelers, two very different passenger groups, and two very different set of food and beverage concession needs. There is no a priori guidelines to tell what concessions are appropriate at each of these two airports.

To return to the point made at the beginning of this presentation. It is hopelessly naive to think in terms of universal guidelines. There is, however, a universally applicable process that can be recommended. Be customer-driven, and count the teeth. Ask customers what they want and be prepared to offer them what they ask for even is it conflicts with initial hypotheses.

SIGNAGE AND MULTILINGUAL NEEDS IN THE INTERNATIONAL AIRPORT

Joseph Erhart
Apple Designs, Incorporated

One of the things I felt I wanted to talk about — everyone has talked about planning and design and facilities and operation and modes of transportation and all the things that make an airport what they are. People tend to ask us: well, environmental signing and graphics, what is that? What do you really do? The simplest thing that we say is: architects design buildings to function, and we tell people how to function within those buildings so they can find their way around.

That has changed a lot over the last ten years, in the sense that it used to be what we call static information systems, very few electronic systems. Now we find more and more information systems that are needed to deal with the international passenger, the foreign language problems that we deal with. Even though English is recognized and used world wide, there still is a concern and need here in the U.S. to make the foreign passenger feel welcomed.

Some of the ways that we do that, because of these changing needs, are through dynamic information systems. Where we miss in some recent facilities in the U.S. have just opened up, FIS facilities — "Can you show one of the best ones at work in the country?" I guess I'd have to say, even though we design systems, there aren't really that many great systems that just totally work.

One of the reasons is the concepts are developed, but through the lack of facility maintenance and the changing environment, they're not yet up to date. The standards that are developed are just not maintained. So a system is basically, excuse the term, bastardized after about five years and loses its entire integrity for information.

What makes us a good airport signage system? You have to talk about welcome to the U.S. displays, common use terminal electronic systems, immigration station systems, flight information display, arrival systems for departures and operations, station indicator displays, baggage claim directories, multilingual information, baggage information display systems, ground transportation information display systems, baggage loading directories, bis input devices, visual paging here in the U.S., (ecause it's now with the ADA compliance that affects our signage requirements significantly), and interactive information displays. Outside the facility you'll need to consider airline name displays, because of the need for sharing booths and counters. An airline may no longer have a fixed display but instead need one that can change every hour or whatever period of the day is needed. Electronic needs are needed there.

Electronic gate information is needed to help you know that you really are at the right gate, you're really getting on the right airplane, and you're doing what you're supposed to be doing. And master clock systems are needed, because everybody wants to know if they're going to make the flight or not, besides looking at the FIDs or BIDS information and seeing the little time on the bottom of them.

One of the clock information systems that I always like to point out, as we designed for United Airlines, their terminal C, terminal D complex at Dulles International. Unfortunately for us, they needed the project done in 60 days. They said, "We need a complete sign system done in 60 days, designed, built, and installed. Can you do it?" I said, "Sure, we can do that." And we did, and it was a temporary system. Well, the temporary system was put in six years ago, and they liked the temporary so much, they never did the permanent one. So it's all — and all the clocks are battery operated clocks. They were temporaries, and I'm not sure who goes and puts the new Duracells in, but it must be the little rabbit going down the concourse changing the batteries all the time. But they all work, and they're pretty accurate. Sometimes things work when you're surprised.

We designed a sign for Detroit Metropolitan's FIS facility, which basically in 33 languages says "welcome to the USA." And we can change that to "welcome to Maryland" or welcome to other places.

Some of the airport functions that we're always concerned about related to signing and graphics are architectural design, circulation flow, existing sign systems, new design, operations that are untested, concession locations and design, advertising programs, art and display, concourse design, gate operations, parking, light rail, Amtrak, and remote facilities. These are all things that impact us from an information point, because it's all got to go up on whatever's left for information in the facility if it hasn't been designed to the facility from the beginning, which we like to do.

Before we develop one piece of information, we'll work with the architectural design team and understand how a facility operates. Most of our staff's background is in architecture, and we take pride on helping complement the architecture, so that we really work with them to understand all the connecting passengers, how you get in, how you get out. And no matter what you do, as people, as we all do, whether it's driving on a highway or anyplace else, we learn how to beat the system. We're going to take the shortcuts and the rest of it. So many times, we wait to find out what the shortcuts are, and then we make signing modifications in the facilities.

But we're always concerned about the layout, the architectural details, the sign system, and the management on who is going to run the facility, how often it's going to change, and those kinds of things, try to build in as much flexibility as possible.

When you take an FIS facility and they build it and open it and then change it three times, you can imagine what that does to the information system. It was never intended, more than likely not planned, to deal with four changes.

We had originally proposed a $1.6 million information system for Newark FIS facility. They said, "This is great. We want all of this." I said, "Are you sure? I don't think that you really know what this means and can afford it."

Well, we went down to a $200,000 temporary sign system to operate this facility. We are now back up to a $1.2 million sign system, because as it has grown, they recognized that there is really no way to deal with the international passenger and the flexibility that they need in this facility without the one or more sophisticated information system, which includes static and dynamic information.

What I'm going to run you through here is just some of the quick changes. These are some of the study graphics that we did. You know, "Welcome to New York." One of the complicated issues here is dealing with English plus four languages. Now we grasped, when we did Houston's intercontinental facility, that they were requested by the city, "We want to use Spanish, but convince us that we shouldn't." So we did a nice convincing argument, and it was all English. They did not use Spanish because of the burden on the information system and the size of signs it requires.

Raleigh-Durham has used four languages on static signs. This is now a challenge with five. And what we were able to do was convince the authority as you go through, the port authority, that unless we go to dynamic information, this is really too much for people to understand with four languages plus English. So we have documents, a welcome to sign if you get in there real quick. All of a sudden, you see the languages start to disappear. We've included in the dotted matrix that you see above the logo and a dynamic sign, which we can then put up the passport information, the I-94 passport forms. We can start to change that and it can be in English and any other language we want. So we can do it with the mix of the aircraft.

As you remember, coming from the B-2 or B-3 connector you could have different flights coming on each one. It allows us total flexibility to provide that in English, and if one flight is a German flight and another is a French and another mixture, we can change the messages to deal with those to really help the people out.

The FIS people have always — and customs always wanted to do this. The problem has been in the U.S. They don't have any money. So they rely on the airports to implement the systems. The airports say, "It's not our problem, and we don't have the money." The airlines say, "We're sure not going to pay for it." So that's why in the last ten years none of this stuff has been implemented. No one has the money to implement the types of systems.

Jody and I, when we did some work at Seattle for her, talked about their facilities. How can we deal with it? And the conclusion on this study that we did was really that this was what they needed. They needed dynamic signs to do — just do it in English and have the dynamic signs deal with the other language requirements in the facility. I don't think it's been implemented yet, though, has it, Jody? Again, it's a money issue.

We took a look at what would happen to the sign faces just seeing an initial sign, an arrow, using the international symbols, which we highly recommend with FIS facilities, and then the word immigration. I've cut these off so they'll fit. And taking four languages and stacking the requirements. You see what it does to the vertical height of the sign system.

Here we've dropped it down and taken it into two lines below a graphic bar that separates the primary English statement and dropped it down into the other four languages. That in itself, based upon the length of the word and the foreign interpretation, can be very lengthy. If you start to put languages in a certain order, they may have to change on another sign because they just won't fit line to line. So it causes a lot of problems.

This was, again, using smaller copy. ADA — it was very interesting. We went to the Department of Justice to discuss this, because on directional signs ADA has indicated a minimum of three-inch copy. What you see there as immigration is three inches, and we dropped the other ones down to an inch and a half or two inches in the graphics. ADA says as long as the English message is in three inch, you can have the other in any size you want, because it is not the primary message. It is a foreign application and considered secondary as long as it's legible. They don't care about color for the field or anything. They're really saying you can pretty much do what you want. We hadn't thought about it, so you're starting to direct us what to do with it.

Here's a change where you start to take the word. The arrow is off the picture on — but to get a picture of the sign face. Now they've put a dynamic sign in there, that you can put that same mixup and just say immigrations and deal with it in whatever language you need to deal with it. The color of LEDs change, and that could be based upon what the color of the background the sign is going to be. But it gives you certainly a lot more flexibility in how to present the information.

This is comparisons. The top two panels are the left and right sides of the same sign, basically, that are giving you different direction. If you look at the bottom sign, that is what happens to the — this sign above, the messages on here, when you translate that using four languages plus English, that's what happens to that sign. To give you an idea, we've had to — what we've done is take the two symbols and stack them side by side. We've had to now put customs-agriculture and do a slash to help relate them, and then you've got the languages. You can see here, even on these large signs — and these are two feet high — trying to represent and separate — and we just say Japanese; we haven't even put it in Japanese. So, I mean, that's not the way the word will read. It's going to be in Japanese. But we thought that was a quick way to do it. The port authority thought that was a great idea.

But when you start to deal with it, you start to repeat the five-seven all the time with the messages for gates, for baggage claims, five and seven. It becomes a very complicated sign. The only way to deal with that and simplify it is through dynamic signing.

All right. I said I was going to be quick, and I'm going to be quick. The same type of thing represented here. I just wanted to show you some other complicated signs that are required in information and what happens down here and how you can change those. This becomes what we consider message overload. It is very tough to deal with. Many people, when they look at signage on a facility, read left to right; others do not. Others read just top to bottom in columns. Others will pick out the most important graphic pieces which will attract their vision and eyes and look at that and read it first and that may not be important. Then the languages, such as Japanese or Chinese, are attracted because of their features. You start to put a lot of things into information signs that can really confuse people.

Another example of it, dealing with exit and cashier information, connecting flights, the separation here is very difficult to deal with.

This is what we started to narrow down. Here's an example. When you get a primary sign of the immigrations and the symbol and call it pre-inspected passengers and then you change that, that's now taking it from all English to English and four foreign languages or taking it to the English with the dynamic, and you can pretty much say all of which you want here. But when there's no message, it just says immigration. This is actually blanked out. It's part of the sign. You really can't tell what it is. And that's the solution, basically, but we're going to another example of how it's complicated.

The same thing here, just in simple signs, even going on walls when you start to identify things. There's a lot more for people to look at. This being the primary selected — I'm not even sure if that's a word or not. We'll pretend it is, but I don't think so. I think my staff is playing games with me there. But if we start to look at how we might identify these — now the consideration, when you start to take the dynamics, if you're going to do it, where do you line up the information? Should this information start in a line here? Or do you have other options? Do you want to take the full length of it to give you flexibility?

Where we've said immigration on several of the signs, what we have done is what the FIS and immigrations people always do. They have 30 counters and today they decide they're going to operate number 1, number 7, number 15, and number 40, because those are their favorite numbers, and not because they want to put 4 counters together and have everybody together.

So we convinced the port authority this is a typical problem, and you don't know how many they're going to staff or where they're going to staff. The guy doesn't like to work at the north end because the sun's coming through the windows from the west and he doesn't want it in his eyes, so he's going to move to the other end.

Well, because of that, we've included the dynamics. Look, you can call any row whatever you want, wherever they're going to operate, by having these dynamic signs. You can change whatever counters they want open. It gives you that flexibility, and the port authority agrees that that's what they need, because they've seen it themselves; they know it's true.

Same thing here. When you start to — we have two signs dealing with dynamics. Where we're going to move information, we start to have a large dynamic matrix to handle that. This is the baggage claim display unit. As you might remember, at the end, when I said you came through customs, there was a unit at the end that provided separation for bag claims, and that's 5 through — 5, 6, and 7. This way is 1 through 4. And we start to incorporate an extra panel here, the visual paging requirements in the U.S. dealing with that.

There are much larger and more frequent pieces in there.

This is an example that is a stand-alone solid matrix so we can deal with any sizes of copy. We've also got an interpretation from the U.S. Justice Department about that, that they would like to see it three inches high in copy. Those who are displaying it currently on TV monitors are probably not meeting the requirement. They've never thought of it seriously enough to size copy, but a solid matrix gives us any amount of copy when we want to deal with electronics.

What happens when we start to deal with pylon directional signs, again what it does to the information system. Where you would just have four simple phrases now becomes very complex.

This is a — I'm going to go through just a couple terminals here real quick — Mickey Leland, which is Houston Intercontinental, terminal IB. This was, I think, a well-planned system when we worked with the design firm and having to integrate the sign system into the architecture. This in the U.S. was the first probably state-of-the-art facility done four years ago using a lot of electronic information and static information combined to complement one another.

The information that you'll see here — just some of the graphics — the large displays for changing flights and gate numbers as you come up the main escalator provide you with information work in with the commercial and the regular public signing, the bag claim identification areas in graphics. There are many more facilities. This is United's terminal one in Chicago. Again, we started this in 1987 dealing with curbside control because of flight information and using dynamic information. In many airports they're discussing this with airline names, particularly if we start to get a lot more of them back into the market. Where we have no room to display their names at curbside, we may find electronic signs at curbside.

Dealing with passenger information at the queuing booths and operation. But again, if you'll see, it's a mix of static, what we call static, and dynamic information, and that must be — I don't know if I should mention the name, but maybe I shouldn't; maybe I should — Pittsburgh new airport that opened up. I guess I did mention the name, didn't I?

I went through that facility, and one of the problems they have is they've taken a real nice approach to dealing with static and dynamic combined, and then they get you right to the counters where you start to have to know what the lineup — and they've done away with all static information. It's all electronic. So all you have are two bands of — some are green, some are red — all kinds of electronic information, and it just doesn't work. You do not know. They've now put up cardboard signs on stands to tell you what line you're supposed to be in, in English, because you really can't tell.

Those are the kinds of things we have to avoid. But the information system has got to be worked in with the architecture and the interior design. It's a real integral part of the entire facility, dealing with clocks and master clock systems.

I'm sure you've all seen most of this. This is BWI, which is a simple graphic piece. And then you can always get this. You can always decide that you're going to put static and dynamic up, and someone doesn't know what to put up. This happened at Newark. I wanted to go to Spain and they wouldn't give me a ticket. They said it was my choice. But the system's got to work. It's got to work for you, and someone has to program it and be aware of it. There's lot of checks and balances now built into electronic sign systems. It just doesn't have to happen at all.

What I'll do in closing is I'd just like to make one little statement, that information systems are changing in our facilities, not only in the U.S. but worldwide, and people really need to be comfortable wherever they go. They must have the reassuring effect. As they take a path to go to a specific place that it's easy to follow, that the information is clear, and that there's lots of backup information.

One of the things that our facilities do not provide are directories, which can orient you to food concessions, the types of concessions. If you're using a generic system that deals with functions, then you can go to an elaborate detailed system on the directories that say Burger King, McDonald's, the rest of it. So it can work both ways.

This information should support the traveling public's needs, and it should be expressed in other languages. And I think the U.S. is starting to take that approach.

MARKETING AN INTERNATIONAL AIRPORT

Susan M. Baer
Port Authority of New York and New Jersey

MS. BAER: My division is responsible for sign standards, and we had a lot to do with moving us back to dynamic signs at Newark Airport. We also do retail and food evaluations, as well as customer satisfaction surveys. We are also responsible for directories. So, I know a good deal about the host businesses at our airports.

Let me go quickly through our marketing program — a very short version of it. International passengers are extraordinarily important to us. Unlike many airports, we have air service that is provided by an unusually large number of carriers. This presents us with many unusual challenges, but it also presents a lot of opportunities. Twenty-five percent of all international seats departing from a U.S. airport depart from a Port Authority of New York and New Jersey airport. So you can see this represents a considerable challenge. When you look at the trans-Atlantic seat share, the number grows even larger. We've been doing this for a long time since trans-Atlantic traffic has historically been a growing entity. Our share represents 43% of the total. At our airports you can see that international traffic is very significant. At JFK, we have more international than domestic passengers.

Let's not forget cargo. Today we have really focused on all the air passenger issues, yet cargo represents enormous revenues for us, as well as using much of our total capacity, particularly at Kennedy. Kennedy and Narita keep taking turns as the world's busiest cargo facility. Last year it was Kennedy once again. Cargo is a very important sector of our operations as well as our marketing business.

It is evident that international traffic is really important to us. We were among the first "victims" of increased international air traffic to cities. This has been repeated all over the United States and, although our market share has declined over time, our volume of traffic has grown.

From a planning perspective, we decided that we needed to start marketing our airports, both domestically and internationally, and we have done so — primarily through tour operators, travel agents, and corporate travel arrangers. We use all the various travel intermediaries to promote travel to our region. If you think about our market and about 72 million annual air passengers and you consider where they're coming from — different carriers from all over the world — I'm not sure how we would or could target *individual* air travelers even if we had a budget for it, which we don't.

The strategy is to provide these people with high quality information about our airports. Our marketing publication has been around about ten years and it is something we are very proud of. The designers originally had control and it was getting increasingly elegant, but I wasn't convinced that it was getting increasingly useful. We actually did focus groups in a couple of cities outside of New York, and talked to professional travel people and asked them, "What do you want to see in the book? What would be useful?" They gave us a wealth of terrific information, which we've incorporated into our publication. Examples are: pages that are easy to Xerox and can be easily faxed, and a minimum of color pictures — just the things that they wanted. They don't need the updates about our construction program. Their interest focuses on how the information affects each one of their passengers passing through the airport.

We print it twice-yearly in English, and annually in German, French, Spanish, and Japanese. Although the English versions are produced 100,000 at a time, the last printing was so popular that we actually ran out. We even advertise it in travel publications. We have trade development offices internationally, and we use them to do a lot of the overseas distribution. Also, the airlines like it a lot. They give it to their reservation agents around the world, and they've been requesting the latest edition in very large numbers. We also use this publication as part of our gateway program.

The gateway program is another thing that we've been doing for some time, and we've modified and improved it as we've gone along. In cooperation with airlines, we go to Europe and Asia at least once a year, sometimes even more often. We now have small gateway presentations that we do more frequently. The big events are done in cooperation with an airline and they provide some of the funds or services such as our transportation and materials. We hold major events with travel agents, plus tour-operator luncheons and press events. We provide considerable information and distribute prizes donated by the airline. We promote our airports!

We also promote our entire region and it's the only opportunity for the region to be promoted as such. The rest of the time, New York has its own program and New Jersey has a smaller one. However, through the gateway program we actually go and promote them both as one entity with the tourism people, and it's very well received.

We discovered over time that we needed more product to market. About eight years ago we found that no tour operator was packaging a short stay in New York during travelers' stop-overs. This is the kind of visit that somebody would make on the way to or from another destination in the United States. So we packaged a stop-over program and, although it is now handled by tour operators, we continue to market it. We provide a discount bonus book that every stop-over passenger receives. We've worked extensively with the airlines to eliminate penalties or extra charges for a stay-over in New York. The program has attractive features such as a day or two at Atlantic City, visits to discount shopping centers, and time in New York City. It also has good hotel packages which work very well for unescorted travelers. We strongly promote this program. We place ads appealing to travel agents in travel trade publications. These ads encourage agents to sell the stop-over packages as an added service to clients.

We've sought also to strengthen our ties to the travel industry with tour package assistance brochures. We have a six-year-old program wherein we actually provide brochures to tour promoters and tour agents. The majority of travelers coming from Europe and Asia go through tour operators; very few book their own seats. So we work directly with the agents to make all the features of our stop-over programs readily available. We pay for the cost of printing some of our information and we provide the photos and the material to put in their tour books. Currently, we assist over 30 tour operators located in most of the major markets. Collectively they're distributing about $4 million in materials, including a New York-New Jersey tour package. So once again it isn't enough to have great airports and a great destination, you've got to work at creating a marketable product.

The other thing we market, as I mentioned before, is air cargo. We have an air cargo guide, similar to the airport guide for travel agents. This is distributed to forwarders, shippers, and the decision makers who determine the routing of air cargo. Emphasis is on our high quality and speed of air cargo service and the massive lift-in and -out of our airports, as well as the broad range of ground and specialized support services available to airlines and brokers who operate in our region. This guide is printed 100,000 at a time.

We also do a "quick caller," which is a detailed listing of air freight-related services. This is a cooperative effort done with a private publisher. In addition, we have an in-house magazine covering sea and air cargo, with a special air cargo edition which has a monthly circulation of about 40,000. We also do air-cargo ads. There is one which talks about the electronic data interface and the network of connections that we have to our airports. We also heavily promote our excellent connections to our airports as the Port Authority runs tunnels, bridges, bus terminals, and other related facilities.

Since deregulation, airports can no longer sit back and expect business to come to them. We've found that the key to success in our program is working closely with industry partners to extend our promotional reach. We're doing this domestically as well as internationally through a cooperative program — right now we're working with two airlines and we're always ready to talk with anyone else. We support them by producing videos for them and setting up events with them because we both share pieces of this market and we both have tremendous investments in facilities. So we're seeing a willingness on the part of the airlines to cooperate in promoting our airports.

QUESTION:
— How do you go about looking at airlines and cooperative programs?

MS. BAER: The international cooperative program, which we call the gateway program, has evolved over time, and the airlines that use our airports are aware of it. So they'll often come to us and say, "Gee, we'd really like to be next." We just did something with Delta Airlines in Frankfurt, and Lufthansa said, "Hey, what about us? We want it." We said, "Great. We'll do one with you, too." It's basically open to any and all.

Here is the way it works. There is always a team leader, and that individual varies. I conducted one in Asia last fall and I just completed one in Europe. We did the one in Europe with Delta Airlines in Frankfurt. Delta flew the team, consisting of a team leader, support person, audio-visual person, a huge amount of audiovisual equipment, and a tourism person from New York and New Jersey, to Frankfurt, and set this up in a venue that we paid for. Delta had already made all the contacts with travel agents and we had 300 agents for the event. We held a press luncheon, arranged by our press person for about 12 reporters. Everyone had ample opportunity to ask questions and discuss issues, and there were many questions. I discussed the redevelopment programs at the three New York airports. It's important for us to get the message out — about what we're doing to improve our airports — and we did this at the press event.

That night we invited the 300-plus travel agents to an hour-long seminar with slides, describing attractions in our New York, New Jersey region. We presented a video about the airport improvements. The video briefs our customers on what to expect when they arrive at our airports. We cover Immigration, Customs, what they're going to confront, ground transportation, an anti-hustling message, and all those kinds of essentials. Afterwards we offered an American buffet as interpreted by German cooks, which was very interesting. We then held a drawing for free tickets provided by Delta Airlines—the drawing provides the incentive to stay for the entire event—and some tickets were given away. The airline provided tickets; we provided the land package.

We then packed up and flew to London, where we repeated the program with the addition of a tour-operator luncheon and a press breakfast. Then we returned to New York.

That's how it works. It's very intense. We meet a lot of people. We try to contact all the major tour operators with whom we have a relationship. We try to do some press events so that we get some good local press, which helps all of us. We also try to get directly to the travel agent because you find, particularly internationally, that travel agents are very key players in affecting travel decisions.

We have a strong advantage. New York is the first destination for many foreign travelers.

IMPLICATIONS OF AIR QUALITY REGULATIONS ON AIRPORTS: ISSUES AND DIRECTIONS

Peter B. Mandle, Session Moderator
Leigh Fisher Associates

In the past, regional transportation planners often neglected or paid little attention to airport access needs or the air quality effects that airports have within the regional transportation network. In regional planning models the airport was often considered a "special generator." Airport operators, highway department staff, and regional planning agency members talked about cooperation, but frequently worked independently.

Now, however, transportation planners realize that large airports generate as much traffic as a central business district and that for every vehicle trip generated by an airline passenger, there is usually an additional employee, air cargo, or service vehicle trip. Traffic volumes entering and exiting airports are quite large. As many as 6,800 vehicles enter or leave an airport such as Boston Logan during peak hours. Over 40,000 employees work at Los Angeles International Airport, and many airports have over 5,000 employees, including airline tenants and airport staff.

As a result of the Clean Air Act Amendment of 1990 (CAAA) transportation planners and other professionals are considering airport-related measures to improve air quality and reduce vehicle emissions. Because of the large volume of trips generated by large and medium hub airports, planners are analyzing airport-related measures to improve air quality. Airport operators are also reviewing the air quality implications of new projects and measures to reduce vehicle emissions because of the CAAA. Current regulations require Federal Aviation Administration (FAA) Airport Improvement Program projects to obtain Environmental Protection Agency approval as well as FAA approval.

What types of air quality-related improvements (such as vehicle trip-reduction) can be implemented at an airport? What success will planners have in encouraging use of efficient access modes since 70 to 80 percent of all airline passengers travel in private vehicles and are less sensitive to travel costs than they are to travel time?

What can be done to reduce the volume of employee, air cargo, and service vehicle trips? At an airport, there may be more than 100 different employers (or tenants) employing from as few as 10 to as many as 1,000 people. Some employees work regular shifts and can participate in carpool and vanpool programs; others (such as flight crews) work unusual schedules and may be gone for several days at a time. These are a few of the challenges facing airports that are addressed in the following presentations.

PROSPECTIVE FUTURE DIRECTIONS AND POLICIES

Gary L. Honcoop
California Air Resources Board

INTRODUCTION

Prospective future directions and policies are particularly appropriate and timely topics in the context of airports and air quality. Airport operations are being closely scrutinized as a source of air pollution in metropolitan areas, and methods for reducing emissions from aircraft and surface vehicles are being explored. In some areas, airports are the largest source of ozone-producing emissions. For example, at Los Angeles International Airport, nitrogen oxides emissions from all activities (which includes aircraft, ground support vehicles, and passenger vehicles) are greater than from any single industrial source in the Los Angeles area. The same is true for hydrocarbons. Because most airports produce significant emissions and may be targeted for more stringent control measures, airport managers should become more involved in air quality matters in the future, if they are not already.

What can we expect in the future for air quality programs that apply to airports? My remarks are based on experience with California air quality programs; but, because airport air quality issues are very much alike across the country, what I say about California can be taken as generally applicable.

CURRENT AIR QUALITY SETTING

To paraphrase an old saying, "If you want to know where you're going, you need to know where you are." Therefore I will start by briefly recapping the current air quality setting in California and the air quality regulations that apply to airports now.

California's urban areas have the worst air quality in the nation. Figure 1 shows an all too typical example of what Los Angeles residents experience many days each summer. Ozone concentrations exceed health protective levels by about two and one half times in the Los Angeles area and cause enormous damage to people's health, to materials, and to vegetation. Although other areas of California have lower levels than Los Angeles, they are still generally higher than elsewhere in the Nation.

California has responded to its air quality problem with the most aggressive control program in the world. Our technology-forcing motor vehicle control programs require new cars to be dramatically cleaner. (Figure 1) For example, the hydrocarbon emissions of a new 1994 passenger car are about one quarter those of a new 1975 car. With California's low-emission vehicle and clean-fuels programs, cars built in 2003 will emission levels that average only about one quarter those the 1994 cars. California is also actively pursuing zero-emission vehicles, requiring that by 1998, 2 percent of all new vehicles sold in California by major manufacturers have zero tailpipe emissions.

Along with motor vehicle emissions, California has also reduced the ozone- producing emissions from other sources. Industrial emissions have been lowered by approximately 40 percent since 1975. Changes have been made in the composition of paints and even personal care products such as hair sprays and underarm deodorants to reduce their smog-forming potential.

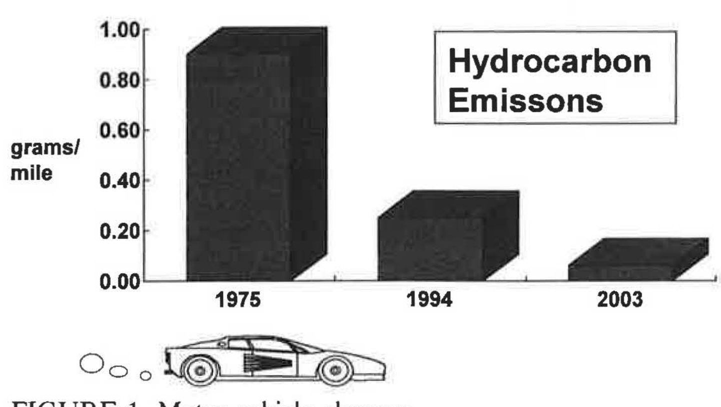


FIGURE 1 Motor vehicle cleanup.

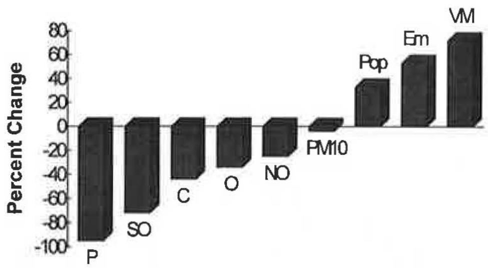


FIGURE 2 Comparing air quality and growth in Los Angeles, 1975-1990.

The results to date of these programs are encouraging for the 1975-1990 period in Los Angeles. (Figure 2) Ozone is down by about 35 percent since 1975; carbon monoxide levels continue to drop; and lead and sulfur dioxide are no longer problems. What is especially noteworthy is that these improvements in Los Angeles came during a period when population in the area increased by more than 35 percent, employment by 50 percent, and the number of vehicle miles travelled by more than 70 percent.

Although progress has been made, there is still a long, long way to go before California has clean air. For example, Los Angeles still has about 140 days with high ozone pollution each year. To have clean air some day, much less by the deadlines set out in Federal law, California will need to reduce the emissions from every source to the maximum degree possible. This includes airports, which are a large source of air pollution. The point is that air quality issues will become a priority for airports.

CURRENT AIRPORT AIR QUALITY REGULATIONS

Three types of regulation call for improvements in airport air quality

The Clean Air Act

The Federal Clean Air Act and Amendments (CAAA) lays out extensive pollution control requirements for areas with air pollution problems. Most of these areas, primarily the large urban areas, have, or shortly will have, plans for the pollution control measures to be carried out. These plans are referred to as revisions to the State Implementation Plan or SIP. An airport located in an area with an adopted SIP must comply with any measure in the plan that applies to it.

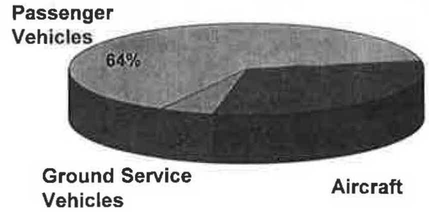


FIGURE 3 Hydrocarbon emission services at airports.

Aircraft Emission Standards

As laid out in the CAAA, the U.S. Environmental Protection Agency (EPA) alone has authority to set emission standards for aircraft, although for safety reasons, it must receive the concurrence of the Federal Aviation Administration (FAA). EPA last set aircraft engine emission standards for hydrocarbons in 1982. Despite these standards and the cleaner engines that have been developed, aircraft operations are still a significant portion (30 percent)of the total pollution at an airport. (Figure 3) The other two major sources are ground service vehicle emissions (relatively small) and ground access or passenger vehicles, which are the largest source of emissions (64 percent).

Airport certification

Some airports are subject to the requirement in the Airport and Airways Development Act for an air quality certificate. Before the FAA grants construction funds for certain types of projects, certification of compliance with applicable air quality standards must be obtained from the State in which the airport will be located, constructed, and operated. The Air Resources Board is actively involved in carrying out this responsibility in California, where two major airports are currently operating under conditional certificates. These conditional certificates contain a trigger clause that requires the airport to apply for an amended certificate when the specified levels are exceeded. These triggers include number of aircraft operations, passengers served, or parking spaces provided. When a trigger is tripped and the airport applies for an amended certificate, the Air Resources Board renegotiates the mitigation measures that the airport must undertake to offset the emissions associated with increased level of activity.

<u>**Specific**</u>

- **Conformity**
- **Airport Certifications**
- **Transportation Control Measures**
- **Ground Service Vehicle Emission Standards**
- **Emission Standards for Aircraft Engines**
- **Landing Fees**
- **Airport Bubble**

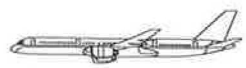


FIGURE 4 Future airport-related air quality programs.

FUTURE AIRPORT-RELATED AIR QUALITY PROGRAMS

As a general observation, it is clear that airport activities will be scrutinized for opportunities to reduce emissions. Airport managers should realize this will occur and likely lead to control measures or remedial actions that could directly affect airport operations. The full participation and cooperation of airport managers will be needed as measures are developed and selected. Cooperative working relationships and joint ventures maximize the possibility for "win-win" results. Nonparticipation by airport managers will mean losing the ability to influence decisions about how the airport is operated. The bottom line is that airports are a part of the air quality problem, and they must also become a part of the solution.

The measures that can be applied to airports fall into two categories: those that seek to control the existing conditions through regulatory actions and those aimed at reducing specific sources of air pollution from aircraft and surface vehicles. (Figure 4)

Regulatory Actions

Conformity

EPA promulgated final regulations on general conformity in late November 1991. General conformity means that all federally funded projects are required to conform with the State Implementation Plan (SIP). Although general conformity requirements have been around since 1977, the recently adopted regulations are far more specific than previous versions.

For airport expansion or other airport projects, the general conformity provisions require that, prior to funding a project, FAA must make a finding of project conformity. The best basis on which to make such a finding is for the emission increases from the project to have been specifically accounted for in the SIP. Other options include the State committing either to offset the emission increases elsewhere in the area or to revise the SIP in the future to accommodate the emission increases.

Airport managers should plan to work closely with the appropriate air quality planning agencies to ensure that future airport projects that will increase emissions are accounted for in the SIP.

Airport Certification

As new requirements to make conformity findings are implemented, such findings could simultaneously fulfill the requirements for certification to FAA that a proposed airport project complies with applicable air quality standards. In this instance, the finding of compliance with applicable air quality standards could be synonymous with a finding of conformity with the adopted plan for the area.

Transportation Control Measures

If offsetting emission reductions are needed for airport certification purposes, possible measures include those affecting passenger vehicles at the airport. Passenger vehicles collectively are the largest source of emissions at an airport.

One possible approach is an "indirect source rule." Indirect sources are those places or activity centers that indirectly emit pollution by virtue of the large numbers of motor vehicles that they attract. In addition to airports, shopping centers and sports complexes are common examples of indirect sources. The specific actions associated with an indirect source rule are typically of a transportation control nature. Indirect source rules reflect the realization that further emission reductions from the transportation sector may need to include actions to reduce motor vehicle activity. Some actions to reduce the number of vehicle trips include bus service, shuttle vans, carpooling, preferential parking, and parking price adjustments.

Source Control Measures

Ground Service Vehicles

Ground service vehicles are a small but nevertheless significant source of emissions at an airport. The Air

Resources Board has not yet developed formal proposals for reducing emissions from the ground service vehicles under its jurisdiction, which are generally those with engines of 175 hp or greater. California's long-range plans do not propose setting emission standards for off-road vehicles, including those used at airports, until 1998 or later. EPA, meanwhile, has published proposed emission standards for "compression ignition" engines (diesels) of 50 hp and greater used in off-road applications. A strong cooperative effort involving the technical staff of the airports and the Air Resources Board or the EPA staff, as the case may be, will be needed to ensure that all the pertinent information can be considered when developing and selecting the most efficient and cost-effective measures.

Emission Standards for Aircraft Engines

EPA has the sole statutory responsibility for identifying and proposing new emission standards for aircraft engines with the concurrence of FAA. Although it has been more than 10 years since EPA last set aircraft engine emission standards, aircraft engines have become cleaner. As aircraft engine manufacturers worked to make the engines more fuel-efficient, there have been side benefits in reduction of hydrocarbon emissions. Unfortunately, the same is not true for NOx. And for many areas, NOx emission reductions are and will be a high priority. Finding a way to reduce NOx continues to be a challenge. EPA research on the potential for NOx emission reductions from aircraft should be a high priority.

Landing Fees

Landing fees raise very sensitive issues, as shown by the recent experience in Los Angeles. However, some European airports are exploring or have implemented regulations that tie landing fees to the amount of pollution an aircraft emits. The objective, of course, is to provide the airlines with some economic incentive to use the lowest emitting aircraft at that airport. Although such an approach is attractive from an air quality perspective, the issue is fraught with legal questions at the present time. As the legal issues are resolved, there may be opportunities to use this incentive approach to encourage airlines to move expeditiously to the least polluting aircraft.

Airport Bubble

The airport bubble is more a management approach than a specific emission control measure. The concept of an airport bubble is for the regulatory agency to treat the entire airport as one unit for pollution reduction purposes. The airport manager would be given an emission "budget" for the facility as a whole, a bubble, which would decline over time. Within the bubble, the airport manager could select which sources to reduce and by how much to meet the emissions budget.

This approach would give the airport manager increased responsibility, but also greater flexibility, to determine how, when, and where to reduce emissions in a manner that is least disruptive to airport operations. The weakness of the approach is the issue of the extent of the airport manager's control over all the emission sources on the airport property. However, lease conditions and pricing mechanisms are possible avenues to explore for answers to these concerns.

SUMMARY

The remarks presented above can be reduced to a single message: airports will be included in the future consideration of air pollution control strategies. Airport managers should become more active participants in air quality issues to ensure that their concerns are considered when pollution controls are developed and selected. If they opt not to participate, airport managers will find that the decisions on pollution control measures will be made without their input, and perhaps to their disadvantage.

AIR POLLUTION MITIGATION MEASURES FOR AIRPORT-RELATED ACTIVITY

Allan S. Taylor
Energy & Environmental Analysis, Inc.

Over the past three decades, all aspects of the transportation industry have been subjected to regulations, emission standards, and mitigation measures designed to reduce air pollution. Traditionally, on-road cars, trucks, and buses have borne the brunt of these controls. More recently, however, additional sources such as off-road vehicles, mobile equipment, and aircraft and airport-related sources have been targeted for control.

Presented here is a discussion of the nature of airport-related air pollution sources and mitigation measures. While these measures can be applied at airports throughout the United States, the illustrations are drawn from airports in Southern California, which seems to be everyone's favorite laboratory for trying out new cures for air pollution.

Three areas of activity at an airport are important from an emissions standpoint: aircraft operations, ground support equipment (GSE) for servicing aircraft, and other activities that relate directly or indirectly to the operation of the airport. Aircraft operations and GSE operations, which are considered part of the airside operations are discussed here. Airport landside operations, such as passenger pickup and dropoff, and activities of airport tenants such as rental car agencies, commercial services, parking facilities, etc., are covered in a separate presentation that follows

TRENDS

Growth in air travel in the United States has averaged more than 5 percent per year for the past decade. The growth in California has been even higher since it is the U.S. gateway for travel to Asia, the fastest growing segment of international air travel. The growth rate of California air travel, measured by millions of annual passengers (MAP) or landings and takeoffs (LTO), is not expected to diminish through the first half of the next decade. (Figures 1 and 2) To accommodate this growth, many airports have plans to expand their runways, their passenger facilities, or both. As many as six California airports have major construction projects either under way or in design.

Robust growth of this sort can lead to congestion on both the airport airside and landside. Aircraft may wait in line to take off, and upon arrival, wait for an empty gate. During peak periods, passenger traffic to the airport can overload access roads and parking facilities. Construction, congestion, and general increase in airport activity all result from this growth, with the net effect that emissions of hydrocarbons (HC) , carbon monoxide (CO), and oxides of nitrogen (NO_x) from activities on and adjacent to airports are a growing part of the emission inventory. (Figure 2)

SOURCES

Table 1 is an inventory of the sources of aircraft and ground support equipment emissions. Emission inventories for aircraft are based on a landing and takeoff (LTO) cycle, which begins at the time an aircraft starts its engines and continues through taxi to the runway, takeoff, and climb to cruise altitude, and concludes with approach, landing, and taxi to the gate where the engines are shut down. HC and CO emissions are very high during taxi and idle operations when aircraft engines are at low power and operate at less then optimum efficiency. These emissions decline, on a per-pound-of-fuel basis, as the aircraft moves into the higher-power operating modes of the LTO cycle. Thus, operation in the taxi and idle modes, when aircraft are on the ground at low power, is a significant source of HC and CO emissions. When considering mitigation methods for HC and CO, the objective is to minimize the aircraft operation at idle and low-power taxi.

NO_x emissions, on the other hand, are low when engine power and combustion temperatures are low, but

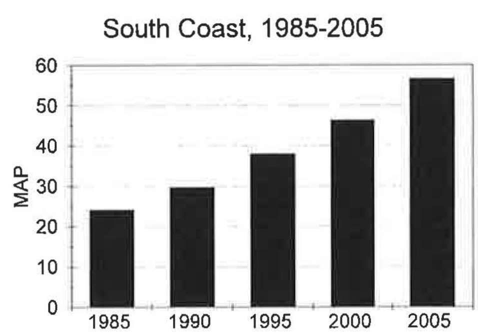


FIGURE 1 Millions of annual passengers (MAP), South Coast 1985-2005.

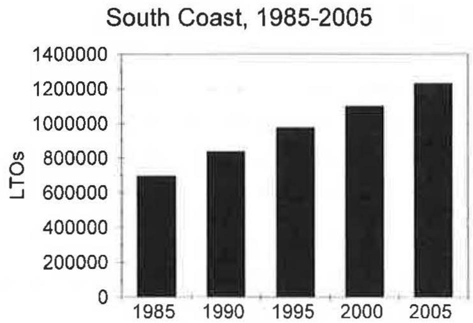


FIGURE 2 Aircraft landings and takeoffs (LTO), South Coast 1985-2005.

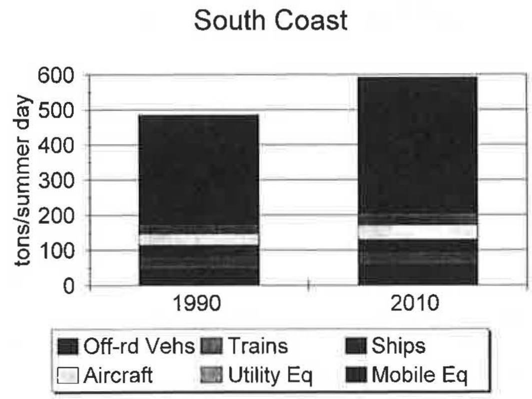


FIGURE 3 Sources of nonroad mobile hydrocarbon and nitrogen oxide emission, South Coast.

rise as the power level is increased and higher combustion temperatures are reached. Thus, the takeoff and climbout modes have the highest NO_x emission rates, and the most effective NO_x mitigation measures target reducing the number of LTO cycles.

A second source of emissions is the wide variety of equipment used in ground support of aircraft operations (GSE). The three distinct categories of GSE included in the emission inventory are: mobile equipment with engines certified to on-road emissions standards, other mobile equipment, and transportable equipment. The latter two are currently unregulated. This equipment produces tailpipe HC, CO, and NO_x emissions, plus evaporative, refueling, and crankcase HC emissions. Table 1 lists the GSE typically in use.

AIRCRAFT MITIGATION MEASURES

The most desirable aircraft mitigation measures are those that reduce emissions without disrupting the safe transport of passengers and freight. Table 2 lists examples of mitigation measures: decreasing engine operation, decreasing aircraft time in inefficient modes such as taxiing and idling, decreasing fleet average engine emission factors, and decreasing the number of LTOs.

As an example, consider one of these mitigation measures, single or reduced engine taxiing. Large commercial aircraft have two, three, or four engines. Since low thrust is needed to taxi an aircraft, one or more engines can be shut down during taxi. Not only does this eliminate emissions from the engines shut down, the remaining engines operate at higher RPM. The result is more efficient operation and lower the HC and CO emissions per pound of fuel consumed. The longer the taxi time, the greater the emission benefit from single or reduced engine taxiing. As a consequence, this mitigation measure is most useful at crowded airports where aircraft cannot proceed directly from the gate to the runway. Since all engines must run for at least two minutes prior to takeoff to achieve thermal stability, this measure may not be as useful at uncrowded airports. However, at a busy airport like Los Angeles International, single or reduced engine taxiing can reduce HC and CO taxi and idle emissions by almost 15 percent.

Table 3 illustrates additional mitigation measures, all of which have the potential to dramatically reduce all emissions from aircraft operations. Measures such as modernizing the aircraft fleet and establishing new engine emission factors are either expensive to implement, or can take years to fully implement, or both. Discussion of these is beyond the scope of this brief overview.

GSE MITIGATION MEASURES

GSE emissions range from 2 to 6 percent of total emissions at commercial airports. When parked at a terminal gate, today's large commercial aircraft require an electrical power source and, during warm weather, air conditioning. The electricity operates the avionics, on-board lighting, etc. Air conditioning keeps the passenger compartment comfortable and sensitive electronic equipment within its design operating temperature range. There are two commonly used ways to provide for these needs. In the absence of other support, the aircraft's Auxiliary Power Unit (APU) provides the electricity and air-conditioning. Alternatively, ground support equipment can provide electricity from a mobile ground power unit (GPU) and air-conditioning from a mobile air conditioning cart. Both types of GSE use

TABLE 1 AIRPORT EMISSION SOURCES

Aircraft
• Idling at gates and on taxi/runway; • Taxiing to/from runway; • Take off/landing; and • Auxiliary power for air conditioning, electrical, and engine starting needs.
Ground Support Equipment
• Ground units for air conditioning, electrical power, and engine starting needs; • Service tractors for baggage, push-back, and towing; and • Others (baggage belts, fuel service, lavatory carts).

TABLE 2 AIRCRAFT MITIGATION MEASURES

Objective	Measure
Decrease Engine Operation	• Single/reduced engine taxiing; and • Lengthen runways to reduce need for reverse thrust.
Decrease Times in Mode	• Tow aircraft to runway; • Take passengers to aircraft near runway; and • Reduce airport congestion.

TABLE 3 ADDITIONAL AIRCRAFT MITIGATION MEASURES

Objective	Measure
Decrease Fleet Average Engine Emission Factors	• Modernize fleet; • Establish new engine emission standards; and • Derate takeoff power.
Decrease LTOs	• Use larger aircraft; • Increase load factor; • Limit number of operations; and • Manage fleet.

TABLE 4 GSE MITIGATION MEASURES

Objective	Measure
Reduce Aircraft Engine Idle Time	• Provide central ground power and air conditioning.
Reduce GSE Emissions	• Alternative fuels or electric power for GSE.

TABLE 5 RESPONSIBLE PARTIES

Measure	Responsible Party
• Single/reduced engine taxiing; • Modernize fleet; • Derate takeoff power; • Use larger aircraft; • Increase load factor; • Manage fleet; and • Alternate fuels for GSE.	Airlines
• Lengthen runways; • Tow aircraft to runway; and • Take passengers to aircraft near runway.	Airports
• Provide central power and air conditioning.	Airports/Airlines
• Reduce airport airside congestion.	FAA/Airports
• Limit number of LTO.	FAA/EPA
• Establish new engine emission standards.	EPA/FAA

either gasoline or diesel fuel and emit HC, CO, and NO_x.

Table 4 lists two major mitigation measures. The first consists of replacing APUs or GPUs with fixed power and air conditioning systems. Fixed or central power systems draw electricity from the main power grid and convert it to the electrical current used by aircraft. Fixed air conditioning systems supply chilled air from a central unit. Fixed systems provide all of the services needed by an aircraft parked at the gate with none of the on-site emissions that come from the GSE and APUs. Several air carriers currently require the captain to hook up to fixed power and air conditioning systems whenever it is available.

The second GSE mitigation measure listed allows for the continued use of GSE in essentially the same way as it is currently used, but it requires modernizing the GSE fleet with either engines powered by alternative fuels or, ideally, electrically powered equipment.

RESPONSIBILITY

Table 5 shows who is currently responsible for implementing these mitigation measures. In general, it is up to the airlines to implement those measures that require changes in the way aircraft and support equipment are used, while airport authorities (sometimes with airlines' assistance) are responsible for physical and operational changes at the airport. Finally, Federal agencies take responsibility for imposing and enforcing the various control measures.

AIRPORT TRANSPORTATION CONTROL MEASURES

Thomas J. Higgins
K.T. Analytics, Inc.

GROUND ACCESS TRIPS AND EMISSIONS

There is a fairly predictable relationship between airport usage and ground access vehicle trips. As Figure 1 shows, the higher the level of airport use, as measured by million annual passengers (MAP), the fewer vehicle trips per day per passenger. This observation is based primarily on data from California airports, in particular the California Aviation System Access Plan (Wilbur Smith Associates, August, 1991). However, the general form of the curve in Figure 1 is found in other studies of airports as well.

The data can be summed to estimate total ground access vehicle trips, which consist of passenger and employee trips to central terminals, not cargo vehicle trips or employee trips to cargo areas. Using vehicle trip data from the California Aviation System Plan or, where unavailable, estimating the volume of those trips based on MAP and the relationship to vehicle trips as in Figure 1, the total vehicle trips across all California airports can be determined. The result is about one half million vehicle trips per day, exclusive of trips associated with cargo areas. About half of this trip volume is associated with the Los Angeles International and San Francisco airports. Cargo-related trips add perhaps another 40 percent to the vehicle traffic for these particular airports.

It is possible to estimate emissions associated with vehicle trips to and from airports. One quick method relies on trip speed and trip length information. For example, the California Aviation System Plan has data on trip lengths and travel times, enabling one to derive speeds, average speeds, and vehicle miles of travel. Combining these data and local air district emission levels based on the vehicle population in the area, it is possible to estimate emissions associated with vehicle trips at any California airport, or airports anywhere, provided the necessary data are at hand. Using this method for the Oakland Airport, the result is about 20,000 pounds per day of CO, HC, NOx, sulfur oxides, and particulates.

TRANSPORTATION CONTROL MEASURES

Employees

Table 1 examines the estimated effect of certain trip-reduction strategies on airport employee vehicle miles of travel (VMT). Effect is estimated in terms of reduced vehicle miles of travel. The table also gives some cautions about each strategy.

To put Table 1 into context, employee vehicle trips make up anywhere from 10 to 20 percent of total vehicle trips for smaller airports, not a great amount. However, at larger airports such as Los Angeles International or San Francisco, when employee trips to cargo areas are included, employee trips can make up to 40 percent of the daily vehicle trips. How trips translate into VMT and ultimately emissions is a function of trip length. Employees tend to make shorter trips than passengers. When all is said and done, it appears employees contribute about 5 or 10 percent of airport VMT at the low end and up to 20 percent of all daily VMT at the high end. Thus, employee trips can be a significant part of airport VMT, depending on the size of the airport.

To illustrate the reasoning by which VMT reductions were derived, consider the entry for variable work hours and telecommuting in Table 1. There is a fair amount of experience on variable work hours and telecommuting suggesting it may reduce either trips or VMT by as much as 30 percent among participants at selected employer sites. Of course, not all employees participate. When the reductions are translated across all employees in the case study sites, the reductions are much less. In terms of all employees at a participating company, the reductions are in the neighborhood of 4 to 7 percent.

How might this experience translate to airport employee trips? One consideration is that airports tend

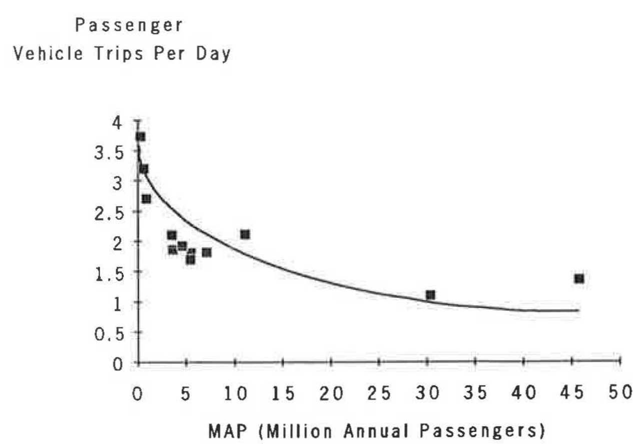


FIGURE 1 California airports: MAPS vs. Trip Generation.

TABLE 1 EMPLOYEE TRIP-REDUCTION EFFECTIVENESS CONSIDERATIONS

Stategy	VMT Reduction Across Airport Employees	Cautions
Variable Work Hours/Telecommuting	2 to 5 percent	Limited application among many shift employees
Preferential HOV Parking (Price/Location)	0 to 5 percent	May switch transit users to auto use.
Transit Fare Discounts and Passes	0 to 3 percent	Reduced revenue for transit operator
General Alternative Mode Subsidies	5 to 7 percent	Limited experience.
Parking Pricing/Subsidy Cash Out	10 percent or more	May generate spillover parking.

to have high levels of shift work. In fact, data from the Sacramento airport indicate only 40 percent of employees arrive in the peak, and many need to be on site at other times for ticket handling, baggage work, and so forth. Therefore, the reductions listed above (4 to 7 percent) probably would not hold among airport employees. Consequently, the chart shows an estimate ranging from 2 percent at the low end to 5 percent at the high end. A similar kind of reasoning underlies the other strategies. First, the experience with the strategy is examined, then it is translated to the airport environment based on characteristics of the airport and its employees.

Cautions are listed in the last column in Table 1. For example, preferential parking for HOV users (carpools and vanpools) has been modestly successful as a trip-reduction strategy, although there is very little experience at airports. It has proven most successful among larger employers with large parking lots and where employees can save time or feel enhanced security by a shorter walk to entrances. However, this strategy sometime draws transit users into carpooling. Obviously, this result is not good for air quality. Thus, it is very important to monitor the prior mode use of carpool and vanpool users of preferential parking spaces.

There is a similar caution with transit fare discounts. The literature suggests such discounts tend to boost usage most among people already using transit. Discounts also can draw people from car and vanpooling as much as from solo driving. Another caution is that discounts can depress revenues for transit operators. There is some experience at Los Angeles International airport with the so-called "Fly Away" discount transit program that has depressed revenues. Besides the loss of revenue, transit operators may face increased costs from expanded service to accommodate increased demand.

There is very limited experience with general subsidies for carpools, transit users, and vanpool patrons. Two cases in the literature include Ventura County and Arco in Los Angeles. However, the experience is so limited as to suggest more evaluation before implementation.

The last strategy in Table 1 holds the most promise. There is substantial evidence that imposing parking fees on employees or removing parking subsidies shifts drivers to carpooling and transit. Notice the table indicates it is the most effective strategy. And unlike other strategies with more limited application to airports, this strategy might be highly applicable for airport employees. Specifically, there is evidence airport employers subsidize employee parking. If somehow employers could be persuaded to reduce or cash out these subsidies, employee solo driving might be considerably reduced.

In California there is new legislation requiring employers in nonattainment areas to offer their employees cash instead of the parking subsidy. Thus, the implementation mechanism for this strategy is already in place.

There is one final caution that applies to all these measures. The reductions in Table 1 refer to employee VMT, not airport VMT. As noted previously, if employee VMT is 20 percent of airport VMT, a reduc-

TABLE 2 PASSENGER TRIP-REDUCTION EFFECTIVENESS CONSIDERATIONS

Stategy	Airport VMT/Emissions Reduction	Cautions
Parking Pricing	1 to 4 percent	Uncertain effect on drop-off; large price hike to be effective; best combined with HOV improvements.
Rental Car, 85% Methanol	2 to 6 percent (emissions)	Fuel not always easily available.
Access Fees/Circulation Controls	2 percent?	Trip fees require AVI.

tion in employee VMT of, say, 10 percent translates into a reduction in airport VMT of only 2 percent. In short, it is important to keep the figures in the proper perspective.

Passengers

Table 2 shows strategies and projected VMT or emission reductions for passengers. Passenger trip-reduction works on the largest segment of ground access trips. Employee trips are only 5, 10, or perhaps 20 percent of airport daily VMT; passenger trips can be 80 to 90 percent,or higher, depending on the balance of cargo trips. In contrast to Table 1, Table 2 gives reductions in VMT for the airport as a whole, taking into account the proportion of VMT attributable to passengers.

Unfortunately, there is very little experience with trip or emission reduction strategies aimed at passengers. There is need for much more experimentation and evaluation in this area.

Look first at parking pricing for passengers. There is some literature on how parking prices affect parking demand, but little on how pricing shifts passenger use among ground access modes. Does pricing reduce solo driving? Does it increase carpooling? Does it cause passengers to park elsewhere? On these issues there is very scanty information.

Experience at Boston Logan airport reveals some of the possible effects of changing passenger parking prices. A boost from $8 to $10 per day in the mid-1980s was associated with some increases in HOV use. At the same time, however, there were improvements in the HOV systems, clouding the issue of what caused what. Furthermore, subsequent HOV improvements without any pricing changes resulted in nearly the same change in the HOV use. The evidence makes one wonder whether pricing played much of a role in mode change at Logan.

Other evidence on this subject comes from work by Greig Harvey. In 1988, he examined the San Francisco airport and concluded that very stiff price changes would be needed to induce mode shifts. Harvey also raised the issue of how price hikes might increase passenger drop-offs. For this reason, Table 2 notes "drop-off" as a caution. If drop-off is increased by parking pricing, it is adverse for air quality because two vehicle trips are replaced by four. If a passenger is driven to the airport by a family member or friend, this makes two trips (to/from) for drop-off and another two trips (to/from) for pick-up, compared to the case where a passenger drives solo, making only two trips (to/from) and parks in the interim.

Is drop-off encouraged by increased parking pricing? There are some data in California and at Boston Logan showing that higher prices are not necessarily associated with higher drop-off. In particular, the drop-off rate at a sample of California airports (as studied by the Metropolitan Transportation Commission) is not consistently higher at airports with higher parking prices. Also, at Logan, when long-term rates increased from 1984 to 1986, pick-up and drop-off actually declined. Still, Table 2 lists drop-off as a caution because it is a possible perverse effect worth considering.

Table 2 shows the estimated range of airport VMT reduction perhaps achievable with a hefty 40-percent price hike, putting aside the drop-off problem. It is based on low passenger sensitivities to price changes as estimated by Harvey and the proportion of passengers parking for the entire duration of their air trip, which ranges from 10 to 40 percent. The range for VMT reduction is 1 to 4 percent.

The second strategy for passenger cars is use of alternative fuel for rental cars. Vehicles running on 85 percent methanol and 15 percent regular gasoline (so called M-85 vehicles) can reduce ozone emissions by about 50 percent compared to vehicles running on regular unleaded gasoline. Using these reduction factors and information on typical VMT for rental cars, emission reductions from converting all rental cars to M-85 over the next couple of years might be from 2 to 6 percent. Notice the caution called out in the table. Methanol fueling facilities are not readily available. Current flexible-fuel vehicles are certainly more costly than average, and not all models of rental cars are so equipped. To ease this barrier, the California Energy Commission offers a $400 credit against the purchase of M-85 vehicles.

The last strategy listed in Table 2 is management of vehicles accessing and circulating airports. Hotel and parking lot rental car shuttles, limousines, scheduled buses, and on-call vans all create congestion and emissions as they circulate on the airport. One way to dampen the volume of vehicle access and circulation might be to price all airport access. The only airport charging a fee for all access is Dallas/Fort Worth. It imposes an entry fee of 50 cents on all vehicles whether parking or passing through. A fee of 50 cents obviously does not have a substantial effect on demand. However, the fee Dallas/Fort Worth system suggests it is operationally possible to impose such fees.

Another approach to reducing the number of access vehicles and encouraging better utilization is through restructuring the usual fees charged these vehicles. For trip-reduction, fees imposed per trip are better than flat fees or fees based on a percent of gross revenues. Trip fees are commonly levied on cabs and limos, but not commonly on courtesy vehicles. In fact, courtesy fees in California are usually based on a percent of gross or a flat fee. One exception is Los Angeles International, which uses an automatic vehicle identification (AVI) system to impose trip fees on rental car and parking lot shuttles and on on-call vans for circulation over the second circuit. Combined with some holding area regulations, it appears that airport circuits have been reduced by about one third.

Table 2 estimates how such circulation policies might reduce airport VMT. As the center column shows, the estimate is in the range of 2 percent, with a question mark to reflect several uncertainties in the calculation. The caution here is an AVI system is needed to impose trip fees of the sort imposed by Los Angeles International.

DIRECTIONS

This research suggests some promising directions for transportation control measures at airports. For employees, the parking cash-out is promising. It should be modestly effective and certainly more palatable than attempting to end employee parking subsidies "cold turkey." For HOV incentives, there are some promising results from improving transit service and offering fare discounts. However, there is a need for much better evaluations of the fiscal impacts of such policies. Preferential parking for carpools also deserves attention at large parking lots where walking distances can be cut by close-in parking.

For passengers, parking fees might be effective where high proportions of passengers park, especially if this is done in combination with some HOV improvements including better transit service. However, any changes in pricing structures should be carefully evaluated for the result on drop-off. Methanol is promising as an alternative fuel for rental cars. Methanol fueling facilities ought to be considered as part of any airport expansion. Some airports are considering consolidation of rental car facilities. Here again is a good opportunity to consider methanol fueling facilities. Evaluation of this strategy ought to focus on how flexible fuel vehicles are fueled away from the airport and on the effect of incentives such as no charge for refueling upon return of the vehicle to the rental car company. Avis has implemented such an incentive at the Sacramento Airport. Finally, fees for all airport access deserve attention, as well as trip versus flat fees, especially for courtesy and on-call vans.

IMPLEMENTATION OF PASSENGER AND EMPLOYEE TRIP-REDUCTION STRATEGIES AT BOSTON LOGAN INTERNATIONAL AIRPORT

Evelyn Addante and Diane Ricard
Massachusetts Port Authority

INTRODUCTION

The Massachusetts Port Authority, owner and operator of Logan International Airport in Boston, Massachusetts, has been engaged for several years in initiatives focused on reducing employee and passenger vehicle trips to and from Logan. Logan is the tenth busiest airport in the United States in terms of air passengers, handling about 24 million passengers in 1993. Because 90 percent of Logan's passengers either begin or end their trip in Boston, Logan ranks fifth among United States airports in the number of ground access passengers.

Reducing air passenger and employee trips to and from Logan Airport is important to the Authority from the perspective of both air quality and airport management. This presentation discusses a few of the more successful initiatives the Authority has undertaken, the basis for the particular initiatives, what the Authority has learned, and where the next steps might br taken in the ground access program.

LOGAN INTERNATIONAL AIRPORT

Boston's proximity to the airport, less than two miles from downtown, is a plus and a minus for air passengers as they plan their ground access trips. The proximity of the airport is a plus for ground access passengers, but they must travel in a traffic mix that includes traffic from the regional highway and roadway system. Access from Boston and points south and west is currently limited to two cross-harbor tunnels and a bridge. (A new third harbor tunnel is under construction at this time.)

PASSENGER AND EMPLOYEE ACCESS TRIPS

Table 1 shows the proportional distribution of passenger and employee access modes at Logan Airport. The information is based on air passenger survey data from 1990. The Authority periodically commissions surveys of both air passengers and airport employees.

The two highest categories of ground access users are employee parking (employees who drive to work and park at the airport) and air passengers who are picked up and dropped off. Although the Authority has had considerable success in influencing air passenger and employee mode choices, the primary access mode to and from Logan Airport remains the private automobile.

Table 2 illustrates the Authority's preferred method of categorizing air passenger access modes for the purposes of its analysis, planning, and policy making. Recognizing that all of the several modes of ground access transportation are, and will be, available for access trips, the Authority has developed an access mode continuum. Using an index called vehicle trips per person, known as VTPP, the Authority has established a hierarchy of modes, from the least-desirable mode, pick-up and drop-off, to the most-desirable mode, transit.

The purpose of the continuum is to facilitate planning and measurement of the Authority's goal to limit the growth in vehicle trips at the airport to a proportion less than or equal to air passenger growth. The Authority aims to attain this goal by encouraging mode choices toward the more desirable modes on the continuum.

PROGRAM TO INFLUENCE GROUND ACCESS MODE CHOICES

With the ground access mode choice continuum method in place for measuring the direction and success of the Authority's programs, policy decisions and implementation can be directed toward target groups in

TABLE 1 DISTRIBUTION OF PASSENGER AND EMPLOYEE TRIPS (AVERAGE WEEKDAY 1990)

Trips	Percent
Employee Parking	22
Pick-up/Drop-off	17
Transit/HOV	14
Taxicab	14
Long-Term Parking	13
Rental Car	11
Door-to-Door	5
Employee other	4

TABLE 2 PASSENGER ACCESS MODE CONTINUUM

Pick-up/Drop-off
Taxicab
Long-Term Parking
Rental Car
Door-to-Door
Scheduled HOV*
Transit**

* Includes Logan Express
** MBTA Blue Line to Massport Shuttle bus and the Airport Water Shuttle

an effort to influence their behavior. The Authority uses a market-based strategy to determine which types of passengers are responsible for the less desirable mode choice trips and plans its programs accordingly.

Any successful approach to trip-reduction strategies for airports begins with the essential realization that for an air traveler, in contrast to a commuter, the mode choice to and from the airport is very much secondary to the choice of making the air trip. Once the overall nature of the air passenger's ground access mode choice is understood, planning can be directed toward influencing choices.

There are three components to the Authority's market-based strategy. First, air passengers are segmented into distinct markets. Most airport authorities and aviation ground transportation industry operators, including the Authority, identify the airport access mode that air passengers will choose on the basis of characteristics such as the purpose of the air trip (business or non-business), where the air passenger lives in the vicinity of the airport (if a local resident), or whether they are visitors from outside the region. The second important component is the geographic origin of the ground access trip. The third component is a consideration of what services are available to the air travelers at the local origin of their ground access trip. In the case of Logan, there are a number of private services available and the Authority has programs in place to provide services to fill the gaps in service.

All strategies undertaken by the Authority are planned and implemented within the financial capabilities of the Authority based on a realistic appraisal in hand of what is feasible in terms of political and operational constraints.

SPECIFIC GROUND ACCESS INITIATIVES

Logan Express

Logan Express is a direct, non-stop bus service initiated by Massport in 1986 from two remote locations, one to the west of the airport about 20 miles away, and one to the south about 12 miles from the airport. In the last year the Authority has added a new express bus service about 15 miles to the north of the airport. These three express services are operated seven days a week with weekday service at 30-minute intervals from 5:30 a.m. until about midnight. They have dedicated parking at the remote locations and the Logan Express terminals are open 24 hours a day, providing a secure area for people to wait. In terms of pricing and incentives, the Logan Express offers below-market fares and a weekend versus a weekday fare to encourage ridership. The pricing of the dedicated parking is very reasonable at about $4 to $5 a day.

The principal users of the Logan Express service (85 percent) are residents; the other 15 percent are airport employees and non-resident air travelers. The Authority has conducted surveys of riders of the buses and found that they would have parked or been dropped off at the airport if the service were not available. Because Logan Express targets air travelers who would otherwise have chosen the least desirable mode choice along the ground access continuum (pick-up and drop-off in private automobile) and seeks to influence their choice toward a more desirable mode, the Authority considers the Logan Express a significant success.

This success is extends across all market segments. Ridership is a mix of business and nonbusiness travelers. The Authority's surveys and experience show that business and nonbusiness travelers alike have come to rely on this service for getting to and from the airport in a reasonable time and by a reliable mode.

Airport Water Shuttle

Another transportation access service initiated a number of years ago by the Authority is the Airport Water Shuttle, now operated jointly by the Authority and The Beacon Companies, owner of the Boston Harbor Hotel. Operating from edge of Boston's downtown financial district, the shuttle runs seven days a week on 15-minute headways from 6:00 a.m. to 8:00 p.m. The ride involves a short, 10-minute trip across the harbor and arrives at the south side of the airport, where water shuttle passengers board a bus that takes them directly to the airline terminals. There is no parking available on the airport, and the only parking available in downtown Boston is very expensive parking at the hotel. The principal users of the Airport Water Shuttle service are nonresident business travelers, who typically start or end their trip at locations within a short (5-10 minute) walk from the hotel.

Rapid Transit

Another part of the Authority's program that stretches back over several years is to provide linkages between other ground transportation services and the airport. An example is the linkage between the public rapid transit station located just beyond the airport premises and the terminals about one mile away on the airport roadways. Initially, a shuttle bus service was offered by the regional transit agency responsible for the train to the airport. The agency charged a fare, and the shuttle followed a single route through the airport curbsides. The Authority eventually took the shuttle service over, eliminated the fare, and split the routes to better serve passengers on their trips to the various terminals. The frequencies on the shuttle are consistent with transit frequencies, and the Authority has found that the service has increased in popularity in the recent years, particularly on those days of the week when it is difficult to drive to Logan.

Recent Modifications to Ground Access Initiatives

The Authority has made some significant modifications to its services, most notably the Logan Express. At the time Logan Express services were initiated, the southern corridor service operated out of a suburban transit station. The service carried only half as many passengers as the western corridor service, yet the southern market area held as many air passengers as the western market.

The Authority undertook to determine why the southern service seemed to be underutilized. Although the transit station had a garage for 2,000, it filled up very early in the morning. Although the pick-up location for the bus service was within the shelter of the station itself, the station was not climate controlled. In addition, the Logan Express station did not have an identity of its own separate from the facility.

In July 1990, the Authority acted to correct these deficiencies and relocated the service to the site of a former drive-in theater located across from a regional shopping center and at the intersection of a major circumferential highway and a radial route to Boston. The concession building of the drive-in was remodeled to resemble an airline terminal and a Logan Express sign that could be seen from the highway was installed. The facility has a comfortable waiting area and airline ticket counters at which American and Northwest sell tickets.

A year after the relocation and modifications, the ridership had increased by about 40 percent during a time when Logan air passengers overall numbers decreased by 4 percent and the western express service ridership had decreased by 4 percent. Presently, both the western and southern Logan Express services are averaging over 20,000 passengers a month.

MARKETING OF GROUND ACCESS TRANSPORTATION SERVICES

The Authority has established an advertising and marketing program that includes a toll-free number (1-800-LOGAN) that travelers can call to get information on transportation services to the airport provided by the Authority and by private firms. The advertising program, initiated in 1986 for the purpose of explaining to air travelers that Logan Airport had an access problem, was essentially a problem-awareness program. In recent years, after the problem was established in the minds of air travelers, the marketing program shifted to actively encouraging the use of ground access modes on the more desirable end of the mode choice continuum.

SERVICE CHARACTERISTICS

When the Authority plans to improve existing services or develop new services, the planning process begins with the understanding that the Authority's high occupancy ground access alternatives compete directly with the on-demand services on the ground access continuum available to air passengers, namely the private auto and rental cars, taxis, and door-to-door limos.

Over time, it has been the Authority's experience that certain service characteristics are most important to air passengers. The successful services offers frequent, direct service on evenly-spaced intervals so that air passengers need not memorize or refer to complicated schedules. While the frequency of HOV alternative service may be less than that of an all-purpose rapid transit service, it is more important for air travelers that frequencies relate to the length of the air trip. For the Logan Express, which provides service to air passengers who typically would need at least a half-hour and sometimes more than an hour to drive to or from the airport by private car, experience has shown that a half-hour frequency is sufficient.

Service reliability is very important to the success of an HOV service because of the severe consequences for an air passenger missing a flight. The hours of operation of an HOV service must be consistent with normal flight schedules and take into consideration flight delays. Parking must be available at the remote locations and, as is the case at the Logan Express terminals, public transit service must be either limited or unavailable.

The siting of remote terminals and services is crucial to success. The HOV stops must be along the traditional travel paths of the region's air passengers, and the air passenger must perceive the stop as a convenient interruption in the ground access trip. The market area study of each Logan Express service demonstrates that passengers from areas closer to the airport than the remote site of the service are unwilling to backtrack.

From a marketing perspective, it is it is equally important that the terminal be visible. In order to be successful, the service must be perceived as easy to reach from the highway. The Authority discovered that 44 percent of the south Logan Express service users did not begin using the service until after the terminal was moved to its new location and a sign visible from the nearby regional highway had been erected.

The Logan Express terminal locations are integrated with the regional highway system at or near the intersection of major highways. For each of the three Logan Express services, air passengers have a drive of five minutes or less from the highway to the remote terminal site.

OTHER ALTERNATIVES

High Occupancy Vehicles

Within Route 128, the primary beltway around the Boston metropolitan area, there are numerous paths available to air passengers as they choose access modes to the airport, and it becomes impractical to site a remote bus service facility. There are fewer passengers using each major road as their traditional travel path. At the same time, in comparison to travel times from outside the Route 128 beltway, travel time to the airport is perceived as short by air passengers inside Route 128.

Air passengers have traditionally relied on highways to reach airports. Where the highway system does not collect enough travelers at convenient centers to justify a high occupancy vehicle service, the Authority is developing new concepts designed to meet the needs of the air traveler within the Route 128 roadway (but outside the City of Boston itself). One service in the planning stages is a form of shared ride service where passengers going to the airport that take a van that does not make more than two or three stops between the origin and the airport.

The Authority is also considering adding a stop on the western-corridor Logan Express at a town with a high concentration of air passengers that lies inward toward Boston. During off-peak hours, the service would make a stop at this inner town during the trip from the remote western site. During peak hours, the Authority would provide a separate service to and from both the existing remote site and the new inner site along the route.

Remote Air Passenger Terminals

In an effort to increase market share, the Authority is in the initial stages of planning a program to transform Logan Express terminals into remote air passenger terminals with airport terminal amenities. Marketing efforts will include an advertising program to reach out to large corporations in each market area.

The Authority's plans also include fare incentives to attract certain air passenger groups that may not consider the Logan Express as affordable when compared to packaged services. Fare programs may include family discounts recognizing that the base fare, although it is below market price, may be less attractive for several people traveling together. Another fare program may include discounts for people traveling to the airport simply to greet or see off air passengers. The Authority is also considering offering round-trip fares (perhaps at a reduced rate) to air passengers on the Logan Express services, an option that is not curently available.

Curbside Enhancements to HOV Service

The Authority is considering providing HOV passengers dedicated ground transportation service waiting areas inside the airline terminal.sengers. Passengers would be able to buy an HOV ticket and wait in areas that are not exposed to the elements. A public address system would announce the arrival of the HOV at the curb.

Third Harbor Tunnel Project

A third tunnel under the Boston Harbor is under construction from downtown Boston to the airport and points north of Boston at this time. The new tunnel, scheduled to open in approximately two years, will provide direct access to the Massachusetts Turnpike from the airport and points north. (The Turnpike is the major radial highway linking to Logan Airport to western Massachusetts). In the initial stages, the tunnel will be open exclusively to commercial vehicles, which may provide the Authority with an opportunity to develop ground access HOV initiatives specifically for the Third Harbor Tunnel.

Commuter Rail

A commuter rail and Amtrak facility, called South Station, is located in downtown Boston. Although South

Station is not far from the airport, transit access to Logan from the station is not convenient because many air passengers on their way to Logan by transit must transfer up to three times to get to the station. To alleviate the difficulties involved in transit trips to the airport via South Station, the Authority is considering high-frequency bus service to connect South Station and the airport through the new Third Harbor Tunnel. South Station serves as the collection point for all the southern commuter rail lines, Amtrak, and many public and private buses. With development, the facility could serve as a natural multimodal transfer point.

EMPLOYEE VEHICLE TRIPS

Logan International Airport is directly responsible for 16,000 jobs in the air transport industry, aviation service industry, regulatory agencies such as the Federal Aviation Administration, and state agencies such as the Massachusetts State Police. The Massachusetts Port Authority also employs 500 administrative and maintenance workers, about 200 of whom work on the airport premises.

The Authority has been actively planning and aggressively implementing measures to influence the mode choices of employees at Logan Airport. In contrast to programs designed for downtown and suburban office workers, airport employee ground access programs must account for the fact that airport employees have different travel and demographic characteristics. At Logan Airport, approximately 25 percent of average daily airport vehicle trips are made by employees, compared to 60 percent by air passengers. There are 150 employers at Logan Airport and 16,000 employees. (Approximately 3 percent of these are Massachusetts Port Authority employees, over whom Authority has a some measure of direct control.)

Of these 16,000 employees, about one quarter are flight crew members. Their average length of time away from Logan on a tour of duty is three days. The remaining three quarterst are employees who begin and end their trip at Logan Airport on the same day. Of the 16,000 employees at Logan, approximately 60 percent commute to Logan on an average weekday. Almost all of them(90 percent) commute by private auto; the remainder take alternative modes.

Airport Workers vs. Office Workers

There are several important differences between the needs of Logan Airport employees and those of typical office workers. Logan Airport is a seven-day-a-week, 24-hour operation, including holidays. In other words, the facility needs employees on the airport at all hours. Many airport employees are subject to overtime (either scheduled or nonscheduled). The nonscheduled overtime is usually tied to flight delays and cancellations or unexpected maintenance work, events that are very difficult to predict and plan for. Only 25 percent of Logan employees arrive at the airport between 7:00 and 9:00 a.m. Another 25 percent arrive between 5:00 and 7:00 a.m., and 20 percent arrive between 1:00 and 4:00 p.m. The numerous shifts, which vary by company and seasonal workload,, make it difficult to formulate programs around particular time periods.

Employee Trips in Air Passenger HOV Modes

For several reasons, air passenger HOV services typically do not attract many Logan Airport employees. The hours of operation or frequency of service is not convenient to employee schedules. The concentration of employee origins is very different from that of air passengers. More than 50 percent of airport employee trips (compared to 10 percent of air passenger trips) originate in the corridor immediately north of Logan Airport. About 45 percent of air passengers start their trip to the airport either from Boston or the corridor west of Boston; only 10 percent of employee trips are from this area. Many private bus services have long layovers in Boston, which are not convenient for employees commuting to Logan Airport. The fares of many of the private HOV services are too high for airport employees who commute on a regular basis.

Employee HOV Incentives

About a year ago the Authority began offering a monthly Logan Express pass for all Logan Airport employees as an incentive to use HOV services. The pass is priced slightly lower than the monthly rate for employee parking and is equivalent to between 8 and 12 one-way trips on the Logan Express. Taking advantage of the price incentive, employees of at least one airline convinced their employer to subsidize their Logan Express pass in exchange for their parking privileges. The Authority expects that more employees will follow suit in the future.

The results of the employee programs have been encouraging. Ridership for employees on Logan Express services compares favorably to the concentration of employees in each of the markets areas. On each of the three Logan Express routes, for example, employees account for between 5 and 11 percent of ridership.

The Authority also offers ten-ride discount booklets to Logan Airport employees who do not find the pass convenient or economical. The Airport Water Shuttle service offers a discount for all Logan Airport employees, and some of the private high occupancy vehicle services offer slight discounts to regular users or Logan Airport employees. Currently, these discounts are not deep enough to change employee travel behavior.

Massachusetts Port Authority employees receive a subsidy for 50 percent of the monthly cost of commuting by alternative modes instead of single-occupancy vehicles. The employee share of transit passes may be paid through payroll deduction.

Future Program Elements

Future program elements planned or under consideration include a remote employee parking lot in a town west of Logan Airport close to where many airport employees live. The lot is scheduled to be opened sometime in 1995, and the Authority plans to relocate employee parking to that lot and reduce the number of employee parking spaces available on the airport. A bus service will run between the airport and the lot. The Authority estimates that some employees will switch to alternative modes of access rather than drive to the remote lot and be bused to work at the airport.

The Authority anticipates offering ride matching and priority parking on the airport for those who choose ridesharing over single occupant driving to the remote lot. The program may include a guaranteed-ride-home element for HOV users and carpoolers.

Other elements that may be incorporated in the future include: adding trips to some of the HOV modes (including the Logan Express) to better accommodate employee schedules, working with private carriers to offer a limited amount of direct service to accommodate employee schedules, encouraging private carriers to offer deeper discounts, and adding services (or links to existing services) that are based on employee rather than air passenger concentrations.

MEASURES TO REDUCE VEHICLE EMISSIONS AT AIRPORTS

M. Allen Hoffman
Leigh Fisher Associates

INTRODUCTION

Federal and State legislation relating to air quality is beginning to affect how airports operate. The key to reducing overall emissions of pollutants at an airport is to reduce vehicle trips to the airport. Particular emphasis has been given to reducing vehicle trips generated by airport employees. Because State air quality regulations in California are among the strictest in the country, methods to reduce vehicle trips and emissions at several large and medium hub California airports are emphasized in this paper. Finally, the need and potential strategies to reduce vehicle trips and emissions generated by airline passengers are discussed.

FEDERAL AND CALIFORNIA AIR QUALITY LEGISLATION

The Clean Air Act of 1970 established the current Federal air quality standards for the acceptable levels of air pollutants. In 1977, the Clean Air Act was amended to require that regional attainment plans be prepared for areas not meeting the national ambient air quality standards. The Clean Air Act Amendments of 1990 (CAAA) include current requirements and procedures for attaining the Federal air quality standards. For example, the CAAA requires that each State develop a State Implementation Plan (SIP) designed to attain minimum desired air quality standards within nonattainment areas. The CAAA also provides specific conformity definitions and guidelines for achieving these standards. Of considerable importance to airports is that a federally funded project will not be given approval or support if it is found to be not in compliance with the SIP.

As of November 15, 1993, States covering 98 nonattainment areas had submitted revisions to their SIPs, preparatory to a requirement that they file plans by November 15, 1994, committing themselves to a 15-percent reduction in urban smog by the end of 1996. The States are also required to achieve reductions of at least 3 percent per year thereafter until they attain compliance, in any case no later than the year 2010. Three strategies are envisioned in the CAAA framework for achieving these reductions in the nonattainment areas through cleaner vehicles, cleaner fuels, and a reduction in vehicle miles traveled.

The California Clean Air Act of 1988 required that all nonattainment air basins develop new attainment plans to meet State and Federal ambient air quality standards. In response to this requirement, the 1991 Air Quality Management Plan (AQMP) was adopted in southern California by the South Coast Air Quality Management District and the Southern California Association of Governments. The basic strategies of the 1991 AQMP include:

- Use of clean fuels,
- Rapid introduction of clean vehicles,
- Conservation of natural gas and electricity,
- Reduction of emissions from all sources, and
- Reduction of vehicle miles traveled.

At an airport, a variety of sources are responsible for air pollution, including aircraft exhaust, fuel evaporation, exhaust from ground service vehicles, combustion of fuels from space and water heaters in terminals and other buildings, and exhaust from private and commercial vehicles (e.g., shuttle buses, courtesy vans, and taxicabs). Of all these sources, vehicular traffic has a high potential for exposing the general public to local pollutants, particularly in areas such as parking structures or enclosed lower-level roadways at the terminal building.

MEASURES EMPLOYED BY VARIOUS AIRPORTS TO REDUCE EMPLOYEE-RELATED VEHICLE EMISSIONS

At present, air quality legislation is being implemented primarily through employers in an effort to target work-related commuting trips. In the San Francisco Bay Area, commuting trips typically make up 25 percent of daily vehicle miles traveled (VMT) on the regional roadway system. Similarly, most air quality improvement measures being implemented at airports consist primarily of programs to reduce airport employee vehicle trips. Employee-related airport trips typically make up a significant portion of the total daily airport trips. For example, at San Francisco International

Airport about 40 percent of daily trips are employee-related.

In California, many large and medium hub airport operators are implementing various measures intended to reduce vehicle emissions. These airports include Burbank-Glendale-Pasadena, John Wayne (Orange County), and Los Angeles International airports in southern California and San Francisco International and Sacramento Metro airports in northern California. McCarran International Airport (Las Vegas, Nevada) has also recently implemented several measures to reduce vehicle emissions at the airport.

Burbank-Glendale-Pasadena Airport

In 1992, the Burbank-Glendale-Pasadena Airport Authority created the position of Employee Transportation Manager with the responsibility for such activities as planning ground transportation improvements, promoting the use of public transit, facilitating public transit access to the airport, and developing programs to encourage higher vehicle-occupancy rates.

To date, the Authority has implemented incentive programs to promote ridesharing (carpooling), use of transit, and walking or bicycling. Employees who carpool receive a $100 savings bond per quarter and park in preferential parking spaces. Employees who rideshare are also provided with a guaranteed ride home and are eligible for a quarterly prize drawing. Employees using transit are provided with a transit subsidy of $15 per month. Under the walking and bicycling incentive program, employees are given a $100 savings bond each quarter, shower and locker facilities, bike racks, and free uniform cleaning.

Also the Authority has recently completed an Environmental Impact Statement and Environmental Impact Review (EIS/EIR) for land acquisition and the development of a replacement terminal for the airport. As part of the planning for this project, specific measures were developed to mitigate the estimated impacts on air quality by vehicle trips. These measures included roadway improvements designed to improve traffic flow and reduce congestion at intersections near the airport. These improvements reduce vehicle delay and therefore the amount of time a vehicle idles at an intersection.

Other proposed mitigation measures include:

- Promoting the use of transit by providing adequate and prioritized curb space at the terminal building,
- Providing information signs and kiosks and disseminating information on the types of commercial high-occupancy vehicles (HOVs) using the airport,
- Promoting the expansion of transit and commuter rail service to the airport, and
- Conducting public parking demand and pricing studies to discourage excessive vehicle trips to the airport.

John Wayne Airport (Orange County)

At John Wayne Airport, Orange County is responsible for implementing employee-related air quality improvement measures. For example, County employees are eligible to work a compressed work week (i.e., the "9-80 Plan") where, during a two-week period, employees work eight 9-hour days and one 8-hour day and have the tenth day off.

The County has also implemented a "cash for commuting program" whereby employees are paid 75 cents for each day they travel to work by any method other than driving alone. In support of this program, the County supplies other amenities such as bicycle racks and locker and shower facilities.

Also, County employees and certain airline employees are provided with preferential parking spaces for carpool participants. A guaranteed ride-home program has also been implemented to ensure that no employee who carpools to work is stranded if he or she misses the ride home. The guaranteed ride home is usually provided by a supervisor or coworker. The County has also contracted with a local taxicab company for this service, as necessary.

Los Angeles International Airport

At Los Angeles International Airport, the TDM Rideshare Division has been created within the Department of Aviation to develop, implement, and monitor rideshare programs as required by the South Coast Air Quality Management District. Key programs to date include a vanpool program that utilizes department-owned vans. The Division also manages a carpool program and provides preferential parking for employees. Employees who participate in the carpool and vanpool programs are provided a guaranteed ride home.

Employees who use transit are also eligible for a transit rebate of up to $15 per month, and Department of Aviation employees have the option of working the compressed 9-80 Plan work week described earlier for Orange County.

The City of Los Angeles is currently reorganizing the structure of the Department of Aviation to provide for the creation of a Surface Transportation Division. This office will be given the responsibility of overseeing the employee commuting programs as well as managing and planning for all ground transportation activity related to airline passengers..

San Francisco International Airport

In addition to the Federal and State clean air legislation, the City and County of San Francisco Airports Commission is operating under an additional mandate to improve air quality at San Francisco International Airport. An EIR has been prepared in support of the Airport's master plan projects and resulting mitigation measures. The master plan projects now being planned include a new international terminal facility, a ground transportation center, and an automated people mover which will ultimately serve the entire airport and connect with the regional rail transit system.

To implement, monitor, and enforce trip-reduction measures at the airport, the Bay Area Air Quality Management District — at the request of the Airports Commission — has delegated its trip-reduction rule to the airport. The Airports Commission now assumes responsibility for ensuring that all airport employers — those with 100 or more employees at a single work site — develop and implement trip-reduction programs and measures to reduce the use of the single-occupant vehicle for employee commuting trips and to promote such activities as ridesharing, public transit, bicycling, or telecommuting. As a result, the Airports Commission effectively becomes responsible for a program encompassing about 31,000 employees and about 100 individual tenants -- rather than just the 1,100 persons who are direct employees of the airport.

Other trip-reduction measures at the airport include a free shuttle service between the airport and the commuter rail service, CalTrain. The Airports Commission has also undertaken extensive marketing efforts to inform both employees and airline passengers of alternatives to the single-occupancy vehicle. These efforts include billboards, radio ads, and skits which emphasize the theme "Share the Ride SFO." The airport is publishing an employee newsletter and has implemented an 800 number to provide the general public with transportation alternatives and employees with rideshare information and carpool matching.

In support of the carpool and vanpool program, the Airports Commission is studying the financial implications of implementing a guaranteed ride-home program using group-ride, door-to-door van service. The airport is also studying the potential for implementing ferry service between the Port of San Francisco and the airport using hovercraft ferry vehicles.

Sacramento Metro Airport

In 1992, the Sacramento County Department of Airports began several programs at Sacramento Metro Airport aimed at reducing emissions at the airport. Key components include rideshare programs and the conversion of airport fleet vehicles to methanol. As of January 1994, about 28 percent of airport vehicles had been converted to methanol.

In July 1994, the County is planning to open a remote rental car facility that will provide counter operations for all on-airport rental car companies. A consolidated shuttle bus system using vehicles operating on compressed natural gas will transport airline passengers between the terminal building and the remote facility. In an effort to further reduce VMT and improve air quality, the off-airport rental car shuttles will also be required to pick up and drop off their passengers at the remote facility. These passengers will then transfer to the consolidated bus to travel to the terminal building. The airport estimates that total pollutants from rental car shuttles will be reduced by about 60 percent with the consolidated shuttle system.

McCarran International Airport

At McCarran International Airport (Las Vegas), the Department of Aviation has implemented a clean fuels program that includes a compressed natural gas fueling facility and a program to switch vehicles to natural gas. The compressed natural gas fueling facility is for use by Department of Aviation vehicles, but it will ultimately be available for use by airport tenants and the general public. As part of the clean fuels program, airport parking lot shuttle buses have been converted to operate on compressed natural gas.

The Department is also attempting to reduce vehicle emissions at the curbside (and to reduce congestion as well) by adopting a policy to prohibit vehicle waiting on the curbside at the arrival level.

MEASURES TO REDUCE EMISSIONS GENERATED BY AIRLINE PASSENGER TRIPS

Airline passengers are often reluctant to use mass transit because they believe it is inconvenient. Transit schedules and travel times are often incompatible with travelers' plans, and travelers say that carrying baggage onto and off a bus or van is inconvenient. Also, air travelers (especially business travelers) are not particularly price-sensitive and are usually willing to pay for the convenience of driving to and parking at the airport or of using a taxicab.

One strategy that can be used to reduce vehicle trips related to airline passengers is to encourage the use of HOVs for airport trips. As a means of improving the convenience of the HOV mode, the airport operator could consider implementing remote airport terminals with ticket counters and luggage check-in facilities. These facilities could offer the passenger the opportunity to avoid airport congestion and airport parking fees. The development of a "ground transportation center" could also help to reduce commercial-vehicle VMT by allowing only one stop instead of repetitive stops along a terminal frontage roadway. Also, because ground transportation services would be provided at one location, the airport operator could promote transit services by providing a first-rate facility with a waiting area, concessions, and other amenities and a display of available transportation services.

The second strategy is to limit commercial vehicle trips and curbside dwell times. Methods of accomplishing this include implementing commercial vehicle fees to discourage unnecessary vehicle trips and circuits of the airport roadway. Individual vehicles can be monitored and controlled, and fees can be collected through a number of means including automated vehicle identification systems.

The airport operator could also discourage the use of private vehicles for passenger pick-up and drop-off by providing options to the congested curbside. One such alternative might be to provide HOVs with the most convenient curbside locations. Also, alternative drop-off locations could be provided to allow the driver to avoid congestion and delay at the curbside.

Finally, airport roadways can be improved to accommodate the expected level of roadway traffic, thereby reducing start-stop traffic and congestion that results in additional vehicle emissions. Also, the curbside should be designed to facilitate traffic flow through this area. For example, if room is available, pull-through parking spaces can improve roadway operations by eliminating the need for a vehicle to back into oncoming traffic. Also, the implementation of metered parking spaces near the terminal could allow curbside pick-up without the driver having to leave the vehicle idling at the curbside or to loop the roadway.

SUMMARY

Most strategies to improve air quality at airports are primarily aimed at reducing emissions related to employee and airport tenant activities. This in turn is mainly a result of air quality legislation directed at employers with 100 employees or more. Also, employee commuting travel is easier to modify than airline passenger travel to and from the airport.

However, airport operators planning federally funded construction projects are typically required to prepare an EIS. As part of this process, the operator is usually required to implement and monitor certain measures designed to mitigate the emissions generated by surface transportation. To meet these mitigation goals, airport operators should develop emission-reduction strategies aimed at airline passengers as well as airport employees.

GENERAL DISCUSSION

During the exchange of views between speakers and the audience that followed the formal presentations, the use of private automobiles for airport access by airline passengers received considerable attention. Two issues were raised: the adequacy of the models currently employed to estimate the demand for private-vehicle parking and curbfront access at airports and the effectiveness of measures used to shift modal choice to vehicles of higher occupancy.

QUESTION: The commonly used modal choice models classify private vehicle traffic at airports in one of two ways. Some distinguish between private vehicles driven to the airport and parked for the duration of the air trip and those driven to the airport for passenger drop-off or pick-up, treating each as a separate mode equivalent to other modes of access such as vanpools, limousines, coach service, or public transit. Others classify the private vehicle as a single mode and split it into two submodes: parking and drop-off/pick-up.

Mr.Honcoop made the point that one must distinguish between parking for the duration for the duration of the air trip and parking for an hour or so to run in and see off or pick up a passenger. Every model I know shows quite clearly that, if the cost of parking is increased and the number of parking spaces is reduced, some long-term parking will shift to drop-off. Some will also go to other modes., There is dispute about what this split might be, and mode-choice modelers argue furiously about it.

But to say that there is nothing in the literature indicating that drop-off increases as parking rates are raised is just simply not true. Studies, including the work by Harvey cited by Mr. Higgins, show a cross-elasticity between parking fees and drop-offs.

MR. HIGGINS: I certainly agree that models should correlate parking rates and drop-offs. What I was referring to was studies of the California and Boston experience with parking fee increases, which is a fairly scant literature.

For example, we examined drop-off rates and long-term parking at California airports. One would expect from the models that the higher the parking rates, the more drop-offs. No such relationship was found.

Similarly, one would also have expected that, when Boston Logan increased parking fees in the mid-1980s, the drop-off rate would have gone up. The exact opposite happened.

This is not to say that modal split and travel behavior models should not incorporate a correlation factor between parking fees and drop-offs. It simply means that there is some discrepancy between theory and real-life experience. Airport operators should monitor the results of parking rate increases and beware of unexpected outcomes, either in the direction you have suggested or that I have.

MS. RICARD: I would like to point to recent experience at Boston Logan Airport. Ms. Addante discussed the market-based approach to planning used there and identified four market segments that we examine: resident business, resident nonbusiness, nonresident business, and nonresident nonbusiness. These groups share many similar travel characteristics.

We conduct a major air passenger survey every three years. Comparing the 1987 survey, taken at the peak of air travel before the recession, with the 1990 survey when we were in the middle of the recession, we found that pick-up/drop-off declined in overall mode share. The reason was a decline in resident pleasure travelers — the primary users of pick-up/drop-off.

As we examined mode shares within each market segment, the changes that occurred were very logical. We saw an increase in HOV use due to the rise of the Logan Express between 1987 and 1990. On-demand limousine services increased and took away patronage from some of the private high-occupancy vehicle services. However, within the category of resident pleasure travelers going to and from Logan Airport, the pick-up/drop-off share did not change very much.

My point is that one has to be very careful in interpreting results and ascribing reasons for shifts in modal share. When looking into increases or decreases in pick-ups and drop-offs or any other modal share, one must have data on who is using a given mode and on what is happening in other segments that may have a corollary effect. With regard to parking, it is important to examine the mix of short-term and long-term parking. Short-term parkers are pick-ups and drop-offs; long-term parkers are staying for the duration of their air trip.

COMMENT FROM THE FLOOR: I would like to add a word from the perspective of someone trying to operate an airport and apply methods for reducing congestion and air pollution. Pick-ups and drop-offs can be allowed to remain at the curb or they can be diverted into short-term parking. It can make a great difference in terms of the ability to manage the airport curbside, but may have little beneficial effect on the level of air pollution.

It is important to strike a delicate balance in the supply of short-term parking — enough to reduce or eliminate vehicles idling at the curbside but not so much to encourage more drop-offs or pick-ups. One of the interesting things that happened with the Logan Express service was that quite a few people who did not really want to pick up or drop off their children going to or coming from college told them to take the Logan Express and they would be met at the remote terminals.

More incentives for changes of this sort should be provided. People will probably continue to go to the airport to pick up grandma, who can't get around very well, but there are many other pick-up and drop-off trips that can be eliminated. The Logan Express remote terminals provide an excellent opportunity for people to do just that.