Portland International Airport

Capacity Enhancement Plan

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October 1996

Prepared jointly by the U.S. Department of Transportation, Federal Aviation Administration, the Port of Portland, and the airlines, the Oregon Air National Guard and general aviation serving Portland, Oregon.

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SUMMARY

Recognizing the problems posed by congestion and delay within the National Airspace System, the Federal Aviation Administration (FAA), airport operators, and aviation industry groups have initiated joint Airport Capacity Design Teams (Capacity Team) at various major air carrier airports throughout the U.S. Each Capacity Team identifies and evaluates alternative means to enhance existing airport and airspace capacity to handle future demand, decrease delays, and improve airport efficiency and works to develop a coordinated action plan for reducing airport delay. Over 35 Capacity Teams have either completed their studies or have work in progress.

The need for this program continues. Steady growth at Portland International Airport (PDX) has made it one of the fastest growing airports in the U.S. Activity at the airport has increased from 4.4 million passenger enplanements in 1983 to 8.2 million in 1993, an increase of 86 percent. In 1983, the airport handled 208,000 aircraft operations (takeoffs and landings), and, in 1993, 281,000 aircraft operations, an increase of 35 percent. PDX's growth continues as evidenced by the passenger traffic totals of 9,905,612 in 1994 and 11,219,152 in 1995, a one-year increase of 13.3 percent. Similarly, aircraft operations totaled 302,003 in 1995, an increase of 6.4 percent from the 283,924 operations in 1994.

A Capacity Team for Portland International Airport was formed in 1994. The PDX Capacity Team identified and assessed various actions that, if implemented, would increase PDX's capacity, improve operational efficiency, and reduce aircraft delays. The purpose of the process was to determine the technical merits of each alternative action and its impact on capacity. Additional studies will be needed to assess environmental, socioeconomic, or political issues associated with these actions.

Selected alternatives identified by the Capacity Team were tested using a computer model developed by the FAA to quantify the benefits provided. Aircraft classifications used were based on FAA separation standards prior to August 17, 1996. Different levels of activity were chosen to represent growth in aircraft operations in order to compare the merits of each action. These annual activity levels are referred to throughout this report as:

- Baseline — 281,000 operations
- Future 1 — 386,000 operations
- Future 2 — 491,000 operations

Based on the analysis completed during the study, the Capacity Team recommended the following capacity enhancement alternatives:

Alternatives	Future 1 Annual Delay Savings Millions of Dollars
• 1.5 NM Stagger, ILS Runway 10L (East Flow)	$20.3
• 1.5 NM Stagger, ILS Capability Runway 28L (West Flow)	$9.6
• Immediate North Divergent Turns for Turbo Props in Both Flow Directions	$4.3
• Peak Period Use of Runway 3 for Arrivals by Small Cargo Aircraft	$0.8
	Future 2 Annual Delay Savings Millions of Dollars
• Immediate Divergent Turns for all Aircraft	$42.1
• Build a N/S Taxiway Connecting East Ends of Parallel Runways (includes Improvements 7A, 7C, and 10)	$178.8

Figure 1. Portland International Airport

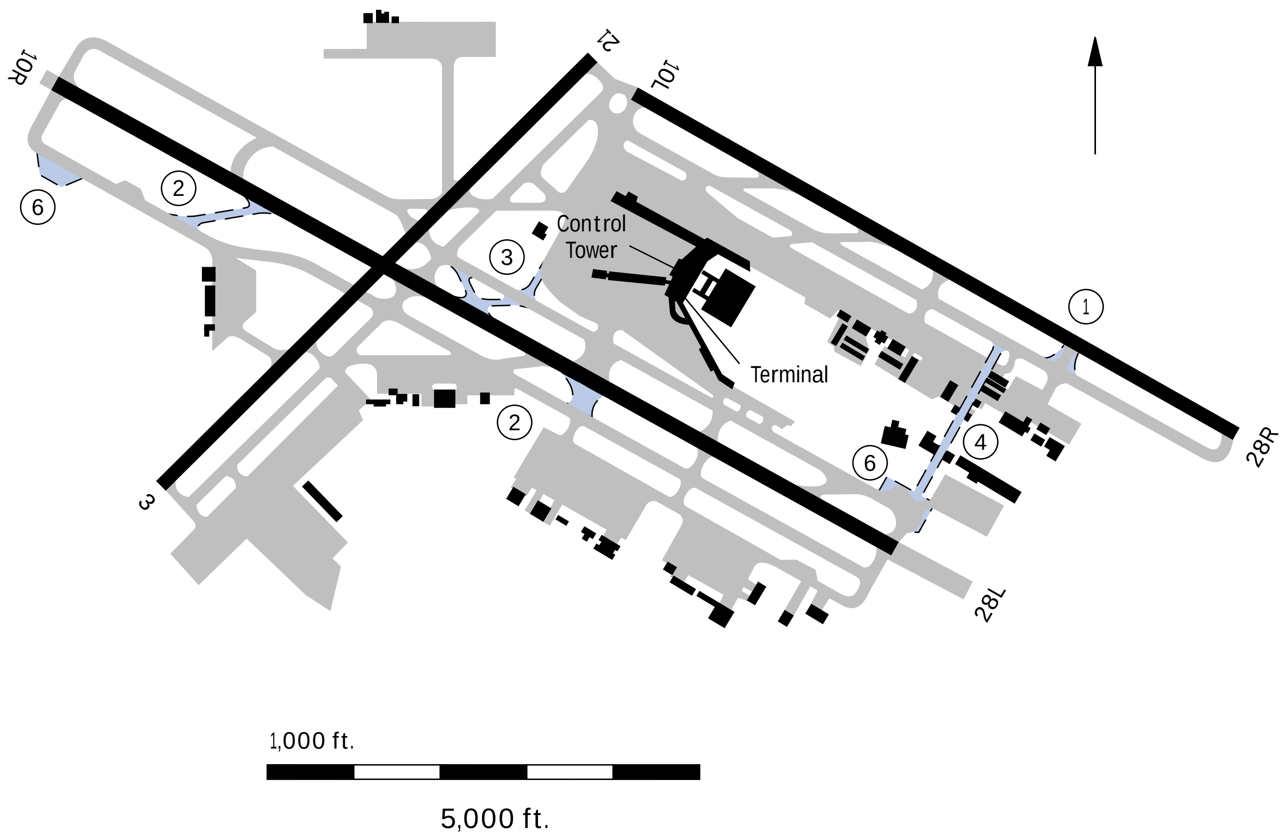


Figure 2. Capacity Enhancement Alternatives and Annual Delay Savings

Basecase	Estimated Annual Delay Costs (in hours and millions of 1994 dollars) Baseline (281,000)	Future 1 (386,000)	Future 2 (491,000)
2.5 nm In-trail ifr Spacing Between Like Class Aircraft on Final Approach	5,670/$6.8	40,938/$49.1	201,837/$242.2

Airfield Improvements	Estimated Annual Delay Savings (in hours and millions of 1994 dollars) Baseline (281,000)	Future 1 (386,000)	Future 2 (491,000)
1. Improve Exit Taxiways on Runway 10L/28R		Narrative	
2. Build New Exit Taxiways for Runway 10r/28L		Narrative	
3. Build Taxiway Exits B-3 & B-4 (with enlarged fillets) North of Runways 10R/28L		Narrative	
4. Build a N/S Taxiway Connecting East Ends of Parallel Runway			
Combined Savings of 4 and 10			
Without 7A and Without 7C	684/$0.8	4,977/$6.0	45,200/$54.2
With 7A and 7C	2,515/$3.0	30,801/$36.1	149,015/$178.8
5. Build Penalty Boxes		Narrative	
6. Build Departure Pads on the Ends of Runways 10R/28L, 28R		Narrative	
Operational Improvements			
7. Staggered CAT I Instrument Approaches			
A. 1.5 nm Stagger, ILS Runway 10L (East Flow)	1,111/$1.3	16,952/$20.3	65,457/$78.5
B. 1.5 nm Stagger, MLS Runway 28L (West Flow)	269/$0.3	4,706/$5.6	9,775/$11.7
Combined Savings of 7A and 7B above	1,380/$1.6	21,658/$25.9	75,232/$90.2
C. 1.5 nm Stagger ILS Capability Runway 28L (West Flow)	530/$0.6	7,971/$9.6	32,273/$38.7
Savings of 7C over 7B above	261/$0.3	3,265/$4.0	22,498/$27.0
Combined Savings of 7A and 7C above	1,641/$1.9	24,923/$29.9	97,730/$117.2
8. Simultaneous (Independent) S Approaches to All Parallel Runways	1,753/$2.1	25,334/$30.4	98,647/$118.4
9. Immediate North Divergent Turn for Turbo Props in Both Flow Directions	487/$0.6	3,596/$4.3	32,897/$39.5
10. Immediate Divergent Turns for All Aircraft	684/$0.8	4,018/$4.8	35,089/$42.1
11. Peak Period Use of Runway 3 for Arrivals by Small Cargo Aircraft	84/$0.1	679/$0.8	2,342/$2.8

Note: The savings for Improvements 9 or 10 may be added to those of Improvements 1 through 3 and Improvements 5 through 8.

Section 1

Introduction

Background

Recognizing the problems posed by congestion and delay within the National Airspace System, the Federal Aviation Administration (FAA) asked the aviation community to study the problem of airport congestion through the Industry Task Force on Airport Capacity Improvement and Delay Reduction, chaired by the Airport Operators Council International.

By 1984, aircraft delays recorded throughout the system highlighted the need for more centralized management and coordination of activities to relieve airport congestion. In response, the FAA established the Airport Capacity Program Office, now called the Office of System Capacity (ASC). The goal of this office and its capacity enhancement program is to identify and evaluate initiatives that have the potential to increase capacity, so that current and projected levels of demand can be accommodated within the system with a minimum of delay and without compromising safety or the environment.

In 1985, the FAA initiated a renewed program of Capacity Teams at various major air carrier airports throughout the U.S. Each Capacity Team identifies and evaluates alternative means to enhance existing airport and airspace capacity to handle future demand and works to develop a coordinated action plan for reducing airport delay. Over 35 Capacity Teams have either completed their studies or have work in progress.

The need for this program continues. In 1994, 23 airports each exceeded 20,000 hours of airline flight delays. If no improvements in capacity are made, the number of airports that could exceed 20,000 hours of annual aircraft delay is projected to grow from 23 to 29 by 2004. The challenge for the air transportation industry in the nineties is to enhance existing airport and airspace capacity and to develop new facilities to handle future demand. As environmental, financial, and other constraints continue to restrict the development of new airport facilities in the U.S., an increased emphasis has been placed on the redevelopment and expansion of existing airport facilities.

Portland International Airport

Portland International Airport (PDX) is the 33rd busiest airport in the country when ranked by passenger enplanements. In the past decade, PDX has been one of the nation's fastest growing airports. Passengers at PDX rose from 4.4 million in 1983 to 8.2 million in 1993, an increase of 86 percent. PDX's total aircraft operations (takeoffs and landings) reached 281,000 in 1993, an increase of 35 percent over the 208,000 aircraft operations the airport handled in 1983. PDX's growth continues as evidenced by the passenger traffic totals of 9.9 million in 1994 and 11.2 million in 1995, a one-year increase of 13.3 percent. Similarly, aircraft operations totaled 302,003 in 1995, an increase of 6.4 percent from the 283,924 operations in 1994.

Portland International Airport is owned and operated by the Port of Portland. The airport is located on approximately 3,229 acres of land about five miles northeast of downtown Portland and primarily serves the surrounding five-county area — four counties in northwest Oregon and one county in southwest Washington. The airfield has three runways:

- Runway 10L/28R is 8,000 feet long and 150 feet wide.
- Runway 10R/28L is 11,000 feet long and 150 feet wide.
- Runway 3/21 is 7,000 feet long and 150 feet wide.

Satellite Airports

There are 21 satellite airports within the Portland approach airspace. Two of these airports, Troutdale Airport and Pearson Field, directly affect PDX operations. Figure 3 shows the relationship of Troutdale and Pearson to PDX.

Troutdale Airport And Pearson Field — Relationship to PDX

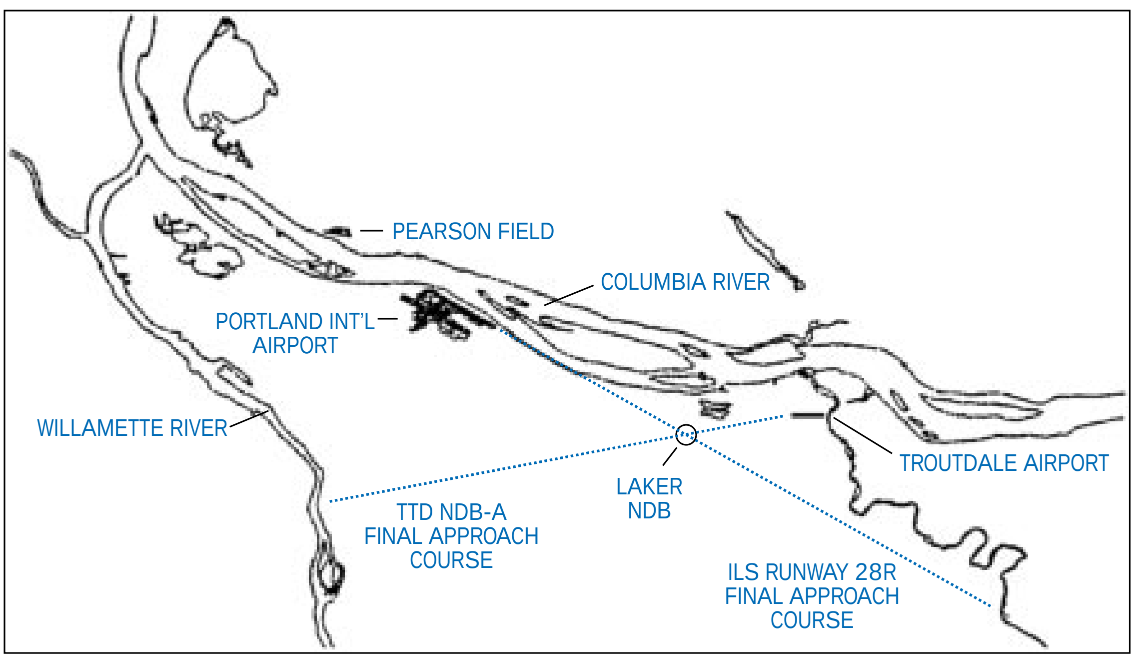
Troutdale Airport is situated on the south side of the Columbia River approximately eight miles east of PDX, and one and one half miles north of the final approach course for the Portland ILS Runway 28R. The final approach course for Troutdale's NDB-A approach (the only instrument approach to Troutdale at this time) starts south of the Portland ILS Runway 28R. Troutdale instrument arrivals and departures impact PDX operations.

Historically, the effect of instrument operations at Troutdale has been minimal, due to the low level of operations and the small percentage of time that Troutdale has to use an instrument approach. Due to the consistence of weather patterns, the percentage of time the Troutdale NDB-A approach is used should remain constant. Troutdale aircraft operations have decreased over the last three years. However, traffic has increased from July 1995 to the present and is expected to continue to increase due to growth in the Portland area.

When Troutdale instrument operations are necessary, it significantly affects the Portland Airport.

In an east flow, PDX Tower will hold departures for Troutdale NDB-A approaches. PDX departures are held from three to twelve minutes until the aircraft lands, cancels instrument clearance, or executes the missed approach procedure. PDX departures are also held for Troutdale departures. The length of delay for Troutdale departures is minimal because the Troutdale departures exit the PDX departure corridor rather quickly. In an east flow, PDX arrivals and the Airport Acceptance Rate (AAR) are not affected.

Figure 3. Troutdale/Pearson — Relationship to PDX



In a west flow, every Troutdale instrument approach will cause the arrival rate at PDX to be reduced by one to two aircraft every hour. PDX departures are not delayed. PDX arrivals are delayed because of the opposite direction flow between the Troutdale NDB-A and the Portland ILS Runway 28R.

Pearson Field is situated on the north side of the Columbia River approximately three miles west of the Portland Airport and directly underneath the final approach course for Portland's Runway 10L. Pearson instrument arrivals and departures mildly impact Portland Airport due to the limited number of Pearson operations.

In an east flow, every Pearson IFR arrival and departure will reduce the Portland AAR by one. Portland departures will not be affected.

In a west flow, every Pearson IFR arrival or departure will hold Portland departures until the Pearson aircraft is clear of the departure corridor. Portland departures could take from one to eight minutes of delay. Portland arrivals are not affected.

In conclusion, Troutdale Airport and Pearson Field affect capacity at PDX due to their proximity and airspace conflicts. Troutdale Airport should be considered in any modifications or improvements. Future use of Troutdale Airport at increased levels will require improvement of existing IFR procedures. A viable alternative would be to develop GPS approaches which would not conflict with PDX procedures. Pearson Field affects the current approach procedures to Portland at a much lesser rate due to the limited number of operations. Pearson Field should be considered in future operations only if there is evidence that traffic levels will rise to the point where it significantly impacts the Portland Airport.

Portland Airport Capacity Design Team

A Capacity Team for Portland International Airport was formed in 1994. The PDX Capacity Team identified and assessed various actions that, if implemented, would increase capacity, improve operational efficiency, and reduce aircraft delays. The purpose of the process was to determine the technical merits of each alternative action and its impact on capacity. Additional studies will be needed to assess environmental, socioeconomic, or political issues associated with these actions.

This report has established benchmarks for development based upon traffic levels and not upon any definitive time schedule, since actual growth can vary year to year from projections. As a result, the report should retain its validity until the highest traffic level is attained regardless of the actual dates paralleling the development.

A Baseline benchmark of 281,000 aircraft operations (takeoffs and landings) was established based on the annual traffic level for 1993. Two future traffic levels, Future 1 and Future 2, were established at 386,000, and 491,000 annual aircraft operations respectively, based on Capacity Team consensus of potential traffic growth at Portland International. If no improvements are made at PDX, annual delay levels and delay costs are expected to increase from an estimated 5,670 hours and $6.8 million at the Baseline activity level to 40,938 hours and $49.1 million by the Future 1 demand level and 201,837 hours and $242.2 million by Future 2.

The Capacity Team studied various proposals with the potential for increasing capacity and reducing delays at PDX. The improvements evaluated by the Capacity Team are delineated in Figure 2 and described in some detail in Section 2, Capacity Enhancement Alternatives.

Objectives

The major goal of the Capacity Team was to identify and evaluate proposals to increase airport capacity, improve airport efficiency, and reduce aircraft delays. In achieving this objective, the Capacity Team:

- Assessed the current airport capacity.
- Examined the causes of delay associated with the airfield, the immediate airspace, and the apron and gate-area operations.
- Evaluated capacity and delay benefits of alternative air traffic control (ATC) procedures, navigational improvements, airfield development, and operational improvements.

Scope

The Capacity Team limited its analyses to aircraft activity within the terminal area airspace and on the airfield. They considered the operational benefits of the proposed airfield improvements, but did not address environmental, socioeconomic, or political issues regarding airport development. These issues need to be addressed in future airport planning studies, and the data generated by the Capacity Team can be used in such studies.

Methodology

The Capacity Team, which included representatives from the FAA, the Port of Portland, and various aviation industry groups (see Appendix A), met periodically for review and coordination. The Capacity Team members considered suggested capacity improvement alternatives proposed by the FAA's Office of System Capacity, the FAA's Technical Center, the FAA's Regional Aviation Capacity Program Manager, the Port of Portland, and other members of the team. Alternatives that were considered practicable were developed into experiments that could be tested by simulation modeling. The Capacity Team validated the data used as input for the simulation modeling and analysis and reviewed the interpretation of the simulation results. The data, assumptions, alternatives, and experiments were continually reevaluated, and modified where necessary, as the study progressed. A primary goal of the study was to develop a set of recommendations for capacity enhancement, complete with planning and implementation time horizons.

Initial work consisted of gathering data and formulating assumptions required for the capacity and delay analysis and modeling. Where possible, assumptions were based on actual field observations at PDX. Proposed improvements were analyzed in relation to current and future demands with the help of an FAA computer model, the Airport and Airspace Simulation Model (SIMMOD). Appendix B briefly explains the model.

The simulation models considered air traffic control procedures, airfield improvements, and traffic demands. Airfield configurations were prepared from present and proposed airport layout plans. Various configurations were evaluated to assess the benefit of projected improvements. Air traffic control procedures and system improvements determined the aircraft separations to be used for the simulations under both visual flight rules (VFR) and instrument flight rules (IFR).

Aircraft fleet mix and schedule assumptions were derived from *Official Airline Guide* data, historical data, and Capacity Team inputs. Aircraft volume, mix, and peaking characteristics were considered for each of the three different demand levels (Baseline, Future 1, and Future 2). From this, annual delay estimates were determined based on implementing various improvements. These estimates took into account historic variations in runway configuration, weather, and demand. The annual delay estimates for each configuration were then compared to identify delay reductions resulting from the improvements. Following the evaluation, the Capacity Team developed a plan of recommended alternatives for consideration.

SECTION 2

CAPACITY ENHANCEMENT ALTERNATIVES

The capacity enhancement alternatives are categorized and discussed under the following headings:

- Airfield Improvements.
- Operational Improvements.

Figure 1 shows the current layout of the airport, plus the airfield improvements considered by the Capacity Team.

Figure 2 lists the capacity enhancement alternatives evaluated by the Capacity Team and presents the estimated annual delay savings benefits for selected improvements. The annual savings are given for the Baseline, Future 1, and Future 2 activity levels which correspond to annual aircraft operations of 281,000, 386,000, and 491,000 respectively.

Figure 4 presents the recommended action and suggested time frame for each capacity enhancement alternative considered by the Capacity Team.

Figure 4. Capacity Enhancement Alternatives Studied and Recommended Actions

Alternatives Airfield Improvements	Action	Time Frame	Responsible Agency
1. Improve Exit Taxiways on Runway 10L/28R	Recommended	Baseline	Port
2. Build New Exit Taxiways for Runway 10R/28L	Recommended	Baseline	Port
3. Build Taxiway Exits B-3 & B-4 (with enlarged fillets) North of Runway 10R/28L	Recommended	Baseline	Port
4. Build a N/S Taxiway Connecting East Ends of Parallel Runways	Recommended	Future 2	Port
5. Build Penalty Boxes	Further Study	Future 1	Port
6. Build Departure Pads on the Ends of Runways 10R/28L, 28R	Recommended	Future 1	Port
Operational Improvements			
7. Staggered CAT I Instrument Approaches			
A. 1.5 NM Stagger, ILS Runway 10L (East Flow)	Completed	1996	FAA
B. 1.5 NM Stagger, MLS Runway 28L (West Flow)	Completed	1996	FAA
C. 1.5 NM Stagger ILS Capability Runway 28L (West Flow)	Recommended	Baseline	FAA/Port
8. Simultaneous (Independent) CAT I Approaches to All Parallel Runways	Recommended	Baseline	FAA
9. Immediate North Divergent Turn for Turbo Props in Both Flow Directions	Recommended	Baseline	FAA/Port
10. Immediate Divergent Turns for All Aircraft	Recommended	Future 2	FAA/Port
11. Peak Period Use of Runway 3 for Arrivals by Small Cargo Aircraft	Recommended	Future 1	Port

Airfield Improvements

1. Improve Exit Taxiways on Runway 10L/28R.

Improving Exit A-2 could reduce the arrival runway occupancy times. Exit A-2 would help ensure a runway occupancy time (ROT) of less than 50 seconds, thereby permitting the minimum arrival-to-arrival in-trail IFR separation to remain at 2.5 NM. On a runway with mixed operations, a departure can be released as soon as an arrival exits the runway. Therefore, reducing the arrival runway occupancy time would enable a departure to take off sooner. Extending Taxiway A to Runway 3/21 would allow greater flexibility in sequencing departures to Runway 10L.

The estimated 1996 project cost for Exit A-2 is $700,000.

The estimated 1996 project cost for Taxiway A is $1,000,000.

2. Build New Exit Taxiways for Runway 10R/28L.

Adding exits would ensure a ROT of less than 50 seconds. Construction of Exits C-2 and C-5 would permit cargo and military aircraft bound for the south side of the airport to exit Runway 10R/28L sooner than is presently possible, thus minimizing runway occupancy time and potentially increasing runway capacity.

The estimated 1996 project cost for Exit C-2 is $3,800,000.

The estimated 1996 project cost for Exit C-5 is $2,800,000.

3. Build Taxiway Exits B-3 & B-4 (with enlarged fillets) North of Runway 10R/28L.

The addition of B-3, at an acute angle and approximately 5,500 feet from the threshold of 28L, would aid large jets in gaining easier/quicker access to Taxiway E, thereby ensuring arrival runway occupancy times of less than 50 seconds.

Constructing B-4, at an acute angle and approximately 5,500 feet from the threshold of 10R would permit commuter and narrow body aircraft easy access to the ramp and Taxiway B. By helping ensure runway occupancy times of less than 50 seconds, the new exit would permit the continued use of the 2.5 NM minimum IFR in-trail separation on final approach.

The estimated 1996 project cost for Exit B-3 is $2,300,000.

The estimated 1996 project cost for Exit B-4 is $2,300,000.

4. Build a North/South Taxiway Connecting East Ends of Parallel Runways.

This new taxiway would provide PDX with a second crossfield taxiway between Runways 10R/28L and 10L/28R. It would reduce taxi times for arrivals and departures. The taxiway would also provide a more direct route for aircraft taxiing between the north and south apron edge taxiways.

In the East Flow, the taxiway would primarily benefit aircraft arriving on Runway 10L destined for terminal gates located on Concourses A, B, and C, and, in the future, the East Terminal. In the West Flow, with the existing noise restrictions, the taxiway would give controllers more flexibility in departing aircraft.

With the existing noise restrictions, and with or without the additional ILS approaches, the primary benefit of the North/South Taxiway would significantly increase flexibility in moving aircraft on the ground and greatly improve traffic flow.

The estimated 1996 cost is $56,000,000.

Combined Savings of Alternatives 4 and 10.

With or without the additional ILS approaches, the primary benefit of the North/South Taxiway and divergent turns would be in the West Flow. Northbound departures from Concourses A, B, and C, as well as the future East Terminal, could depart on 28R independent of southbound departures on 28L.

Without 7A and without 7C.

The North/South Taxiway and divergent turns would provide a significant benefit to PDX even without the additional ILS approaches.

Annual delay savings would be 684 hours or $0.8 million at the Baseline activity level; 4,977 hours or $6.0 million at Future 1; and 45,200 hours or $54.2 million at Future 2.

The combined annual delay savings of 4 and 10 over improvement 10 would be 0 at the Baseline activity level; 959 hours or $1.2 million at Future 1; and 10,111 hours or $12.1 million at Future 2.

With 7A and 7C.

With the additional ILS approaches, the North/South Taxiway and divergent turns would provide greater benefits to PDX.

Annual delay savings would be 2,515 hours or $3.0 million at the Baseline activity level; 30,081 hours or $36.1 million at Future 1; and 149,015 hours or $178.8 million at Future 2.

The combined annual delay savings of improvements 4, 10, 7A, and 7C over the combined savings of improvements 10, 7A, and 7C would be 190 hours or $0.2 million at the Baseline activity level; 1,140 hours or $1.4 million at Future 1; and 16,196 hours or $19.4 million at Future 2.

5. Build Penalty Boxes.

Constructing a holding area for arrivals waiting for gate space would relieve congestion near the terminal area, and would allow more efficient taxiway utilization. A site will need to be determined.

6. Build Departure Pads on the Ends of Runways 10R/28L, 28R.

This project would improve the flow of ground traffic and reduce taxi interference and delays. Expanding the staging area would enable controllers to sequence successive departures more efficiently by allowing departing aircraft to bypass aircraft in the departure queue.

The estimated 1996 cost for 10R is $2,600,000.

The estimated 1996 cost for 28L is $3,200,000.

The estimated 1996 cost for 28R is $2,300,000.

Operational Improvements

7. Staggered CAT I Instrument Approaches.

Currently CAT I approaches are only allowed on Runways 10R and 28R. In VFR 2 and IFR weather conditions, CAT I approaches are needed on Runways 10L and 28L to allow staggered dependent approaches in order to reduce delay.

A. 1.5 NM Stagger, ILS Runway 10L (East Flow).

An ILS on 10L could be used for staggered dependent CAT I approaches in IFR 1 and independent straight-in approaches in VFR 2. The ILS was installed and was commissioned on June 20, 1996.

Annual delay savings would be 1,111 hours or $1.3 million at the Baseline activity level; 16,952 hours or $20.3 million at Future 1; and 65,457 hours or $78.5 million at Future 2.

B. 1.5 NM Stagger, MLS Runway 28L (West Flow).

Few aircraft are equipped to utilize an MLS approach. An MLS on 28L could be used by Horizon DH8 and D328 aircraft in VFR 2 and IFR 1. Capacity would be gained by reducing competition for one runway, while also reducing arrival taxi times. Approximately 64 daily arrivals at each demand level could perform an MLS approach to Runway 28L. The MLS was installed and commissioned on September 12, 1996.

Annual delay savings would be 269 hours or $0.3 million at the Baseline activity level; 4,706 hours or $5.6 million at Future 1; and 9,775 hours or $11.7 million at Future 2.

Combined Savings of 7A and 7B.

The combined annual delay savings of improvements 7A and 7B would be 1,380 hours or $1.6 million at the Baseline activity level; 21,658 hours or $25.9 million at Future 1; and 75,232 hours or $90.2 million at Future 2.

C. 1.5 NM Stagger, ILS Capability Runway 28L (West Flow).

If new technology could provide CAT I ILS capability on 28L, then any type of aircraft could land on 28L in VFR 2 and IFR 1.

Full CAT I ILS capability on Runway 28L would reduce arrival delay and arrival taxi time.

Annual delay savings would be 530 hours or $0.6 million at the Baseline activity level; 7,971 hours or $9.6 million at Future 1; and 32,273 hours or $38.7 million at Future 2.

This represents a savings over improvement 7B of 261 hours or $0.3 million at the Baseline activity level; 3,265 hours or $4.0 million at Future 1; and 22,498 hours or $27.0 million at Future 2.

Combined Savings of 7A and 7C:

The combined annual delay savings of improvements 7A and 7C would be 1,641 hours or $1.9 million at the Baseline activity level; 24,923 hours or $29.9 million at Future 1; and 97,730 hours or $117.2 million at Future 2.

8. Simultaneous (Independent) CAT I Approaches to All Parallel Runways.

The runway spacing at PDX is 3,100 feet. In order to allow simultaneous independent IFR approaches at this time, a rule change would be required. Simultaneous independent approaches to the parallel runways would allow flexibility to use both runways independently, increase capacity, and reduce delay.

Annual delay savings would be 1,753 hours or $2.1 million at the Baseline activity level; 25,334 hours or $30.4 million at Future 1; and 98,647 hours or $118.4 million at Future 2.

Savings of Improvement 8 over the Combined Savings of Improvements 7A and 7C.

The annual delay savings of improvements 8 over the combined savings of improvements 7A and 7C would be 112 hours or $0.1 million at the Baseline activity level; 411 hours or $0.5 million at Future 1; and 917 hours or $1.1 million at Future 2.

Note: Departure noise restrictions would limit the incremental benefit of independent approaches over staggered approaches at Future 2. With independent approaches, the resulting departure demand would be more peaked and cause more departure delay. Relaxing departure noise restrictions would reduce departure delay and increase annual delay savings.

9. Immediate North Divergent Turn for Turbo Props in Both Flow Directions.

Current noise abatement procedures allow for immediate south divergent turns. The implementation of immediate north divergent turns would allow the tower to depart aircraft more efficiently. North and south divergent turns would allow the tower controller to fan turbo prop departures in a manner that would expedite departure situations. Due to the current fleet mix at Portland, there is a large number of aircraft that would be able to take advantage of this new rule. Any increase in departure rate improves efficiency for the entire airport. Departures leaving sooner reduce the number of aircraft waiting for takeoff and subsequent taxiway congestion.

Annual delay savings would be 487 hours or $0.6 million at the Baseline activity level; 3,596 hours or $4.3 million at Future 1; and 32,897 hours or $39.5 million at Future 2.

10. Immediate Divergent Turns for all Aircraft.

Current noise abatement restrictions place all heavy and large turbojet departures on a single departure route regardless of the departing runway or destination. This forces the tower controller to wait for the required IFR separation before departing successive jet aircraft. After implementation of this procedure the tower would be able to fan all aircraft using the divergent turn rule. This would streamline the departure procedures, facilitate the tower controller's job, reduce departure delays and allow for the most expeditious departure scenario at Portland.

Annual delay savings would be 684 hours or $0.8 million at the Baseline activity level; 4,018 hours or $4.8 million at Future 1; and 35,089 hours or $42.1 million at Future 2.

This represents a savings over improvement 9 of 197 hours or $0.2 million at the Baseline activity level; 422 hours or $0.5 million at Future 1; and 2,192 hours or $2.6 million at Future 2.

11. Peak Period Use of Runway 3 for Arrivals by Small Cargo Aircraft.

The fleet mix at Portland provides us with a large number of small cargo aircraft (box-haulers) returning to Portland between 5:00 PM and 6:30 PM. These arrivals are scheduled flights that fly daily, Monday through Friday. The box-haulers are classed in SOIR (Simultaneous Operations on Intersecting Runways) Group 2. Their classification allows them to land on Runway 3 and hold short of Runway 10R/28L, when the runways are dry and there is no tailwind component.

In VFR 1, box-haulers (approximately 15 per day) could land on Runway 3 independent of all other aircraft arriving and departing on the parallel runways. This would reduce both arrival and departure delays. It would also increase the hourly arrival capacity (or departure capacity) by the corresponding number of box-haulers landing on Runway 3.

Approximately half of the box-haulers park on the south side of the airport. Future plans call for all cargo operators to park on the south side of the airport near Runway 3.

Annual delay savings would be 84 hours or $0.1 million at the Baseline activity level; 679 hours or $0.8 million at Future 1; and 2,342 hours or $2.8 million at Future 2.

SECTION 3

SUMMARY OF TECHNICAL STUDIES

Overview

The Portland International Airport Capacity Team evaluated the efficiency of the existing airfield and the proposed future configurations. A brief description of the computer model and methodology used can be found in Appendix B. Certain standard inputs were used to reflect the operating environment at PDX. Details can be found in the data packages produced by the FAA's Technical Center during the study. The potential benefits of various improvements were determined by examining airfield capacity, airfield demand, and average aircraft delays.

Figure 5 shows airfield weather conditions and runway utilization used for simulation. Figure 6 depicts historical runway utilization and weather conditions. Figure 7 shows the aircraft approach speeds used for simulation. Figure 8 depicts the daily fleet mix by aircraft class for the aircraft operating at PDX at each of the three demand levels.

Figure 9 illustrates the hourly profile of daily demand for the Baseline activity level. For comparison, it also includes a curve that depicts the profile of daily operations for the Future 1 and Future 2 activity levels.

Figure 10 illustrates the average-day, peak-month demand levels for PDX for each of the three annual activity levels used in the study. Figure 11 depicts the annual operations for each activity level by aircraft category.

The average direct aircraft operating cost for PDX is $1,200 per hour in 1994 dollars. These figures represent the costs for operating the aircraft and include such items as fuel, maintenance, and crew costs, but they do not consider lost passenger time, disruption to airline schedules, or any other intangible factor.

Daily operations corresponding to an average day in the peak month were used for each of the forecast periods. The Airport and Airspace Simulation Model (SIMMOD) was used to determine aircraft delays during peak periods. Delays were calculated for current and future conditions. Daily delays were annualized to measure the potential economic benefits of the proposed improvements. The annualized delays provided a basis for comparing the benefits of the proposed changes. The benefits associated with various runway use strategies were also identified. The cost of a particular improvement was measured against its annual delay savings. This comparison indicated which improvements would be the most effective.

For expected increases in demand, a combination of improvements can be implemented to allow airfield capacity to increase while aircraft delays are minimized.

Figure 5. Runway Utilization — Simulated

Weather	VFR 1	VFR 2	IFR 1	
Minima:	Visual	<VFR 1 & ≥IFR 1	CAT 1	All Weather
Ceiling:	3,500 ft.	2,000 ft.	200 ft.	
Visibility:	10 miles	5 miles	0.5 miles	
East Flow (10s)	35.3%	9.2%	7.8%	52.3%
West Flow (28s)	39.1%	5.0%	3.6%	47.7%
Total	74.4%	14.2%	11.4%	100.0%

Note: The Team agreed that only VFR 1, VFR 2, and IFR 1 conditions would be used for simulations due to the nature of the list of proposed improvements. Figure 5 presents the information used in modeling.

Figure 6. Runway Utilization — Historical

Weather	VFR 1	VFR 2	IFR 1	IFR 2	IFR 3	
Minima:	Visual	<VFR 1 & ≥IFR 1	CAT 1	CAT II	CAT II	All Weather
Ceiling:	3,500 ft.	2,000 ft.	200 ft.	100 ft.		
Visibility:	10 miles	5 miles	0.5 miles	0.25 miles	0.125 miles	
East Flow (10s)	34.7%	9.1%	7.7%	0.6%	1.1%	53.2%
West Flow (28s)	38.4%	4.9%	3.5%	0.0%	0.0%	46.8%
Total	73.1%	14.0%	11.2%	0.6%	1.1%	100.0%

Note: Figure 6 depicts historical PDX data tabulated from 10 years of Surface Airways Hourly Data (TD-1440) for 1/1/79 through 12/31/88, from the National Climatic Data Center, Asheville, NC.

Figure 7. Aircraft Approach Speeds

Aircraft Class	Aircraft Types	VFR/IFR (knots)
Small	Small single or twin engine props	110
Medium	Business jets and commuter props (e.g., DH7, DH8, SWM)	130
Large	Large jets, except 757 (e.g., air carrier jets — B727, F28)	140
B757	Boeing 757	140
Heavy	Heavy Aircraft	155

Figure 8. Aircraft Daily Fleet Mix by Aircraft Class

Aircraft Class	Aircraft Types	Baseline (281,000)	Future 1 (386,000)	Future 2 (491,000)
Small	Small single or twin engine props	166 (18.9%)	182 (15.1%)	198 (12.9%)
Medium	Business jets and commuter props (e.g., DH7, DH8, SWM)	310 (35.3%)	440 (36.5%)	570 (37.2%)
Large	Large jets, except 757 (e.g., air carrier jets — B727, F28)	334 (38.0%)	482 (40.0%)	630 (41.1%)
B757	Boeing 757	34 (3.9%)	51 (4.2%)	68 (4.4%)
Heavy	Heavy Aircraft	34 (3.9%)	51 (4.2%)	68 (4.4%)
Total Daily Number of Operations		**878**	**1,206**	**1,534**

Note: Aircraft classifications are based on FAA separation standards prior to August 17, 1996.

Figure 9. Profile of Daily Demand — Hourly Distribution

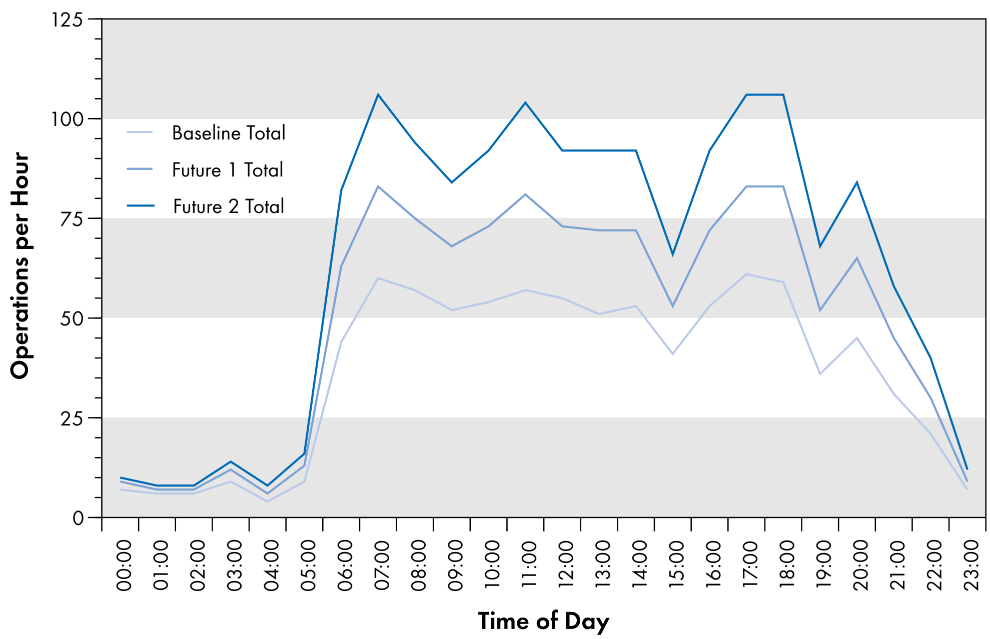
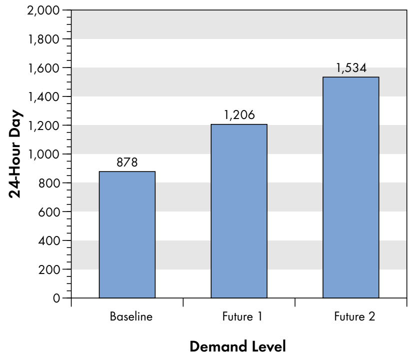


Figure 10. Airfield Demand Levels



	Annual Operations	24-Hour Day	Equivalent Days
Baseline	281,000	878	320
Future 1	386,000	1,206	320
Future 2	491,000	1,534	320

Note: The number of equivalent days for Baseline, Future 1, and Future 2 are determined by dividing the number of annual operations by the number of daily operations.

Figure 11. Annual Operations by Aircraft Category

	Air Carrier, Air Taxi, Commuter	General Aviation	Military	Total
Baseline	210,000 (75%)	58,600 (21%)	12,400 (4%)	281,000 (100%)
Future 1	315,000 (82%)	58,600 (15%)	12,400 (3%)	386,000 (100%)
Future 2	420,000 (86%)	58,600 (12%)	12,400 (<3%)	491,000 (100%)

Airfield Capacity

The PDX Capacity Team defined airfield capacity to be the maximum number of aircraft operations (landings or takeoffs) that can take place in a given time. The following conditions were considered:

- Airspace constraints.
- Ceiling and visibility conditions.
- Runway layout and use.
- Aircraft mix.
- Percent arrival demand.

Figure 9 illustrates the hourly profile of daily demand for the Baseline activity level of 281,000 operations per year, the Future 1 activity level of 386,000 operations per year, and the Future 2 activity level of 491,000 operations per year.

Figure 12 presents the airfield capacities for PDX. These values were developed for the east and west flow runway configurations, under VFR 1, VFR 2, and IFR 1 conditions, with a 50/50 split of arrivals and departures and balanced hourly flow rates. The capacities were based on PDX 1996 acceptance rates and Future 2 SIMMOD flow rates.

A comparison of the information contained in Figures 9 and 12 reveals that:

- The IFR 1 arrival capacity for the Basecase, 31 arrivals, is exceeded during two hours of the day at the Baseline activity level.
- The IFR 1 arrival capacity for the Basecase is exceeded during nine hours of the day at the Future 1 activity level.
- The IFR 1 arrival capacity for the staggered ILS capability on either 10L or 28L, improvement 7A or improvement 7C, is exceeded during one hour of the day at the Future 1 activity level.

Figure 12. Airfield Capacity — 50/50 Split and Balanced Hourly Flow Rates

Baseline: 2.5 NM In-Trail IFR Spacing		
VFR 1	56 Arrivals	56 Departures
VFR 2 (with sidestep to 10L or 28R)	40 Arrivals	40 Departures
IFR 1 (with single arrival stream)	31 Arrivals	31 Departures

Improvements 7A and 7C — 1.5 NM Stagger, with 10L and 28L ILS Capability		
VFR 1	56 Arrivals	56 Departures
VFR 2 (no sidestep to 10L or 28R)	47 Arrivals	47 Departures
IFR 1 (with 2 arrival streams, staggered)	46 Arrivals	46 Departures

Note: East Flow: Arrivals = 10R, 10L; Departures = 10R, 10L
West Flow Arrivals = 28R, 28L; Departures = 28R, 28L

Aircraft Delays

Aircraft delay is defined as the time above the unimpeded travel time for an aircraft to move from its origin to its destination. Aircraft delay results from interference from other aircraft competing for the use of the same facilities.

The major factors influencing aircraft delays are:

- Ceiling and visibility conditions.
- Airfield and ATC system demand.
- Airfield physical characteristics.
- Air traffic control procedures.
- Aircraft operational characteristics.

Average delay in minutes per operation was generated by the Airport and Airspace Simulation Model (SIMMOD). A description of this model is included in Appendix B.

Conclusions

Based on the analysis completed during the study, the Capacity Team recommended the following capacity enhancement alternatives:

Alternatives	Future 1 Annual Delay Savings Millions of Dollars
• 1.5 NM Stagger, ILS Runway 10L (East Flow)	$20.3
• 1.5 NM Stagger, ILS Capability Runway 28L (West Flow)	$9.6
• Immediate North Divergent Turns for Turbo Props in Both Flow Directions	$4.3
• Peak Period Use of Runway 3 for Arrivals by Small Cargo Aircraft	$0.8
	Future 2 Annual Delay Savings Millions of Dollars
• Immediate Divergent Turns for all Aircraft	$42.1
• Build a N/S Taxiway Connecting East Ends of Parallel Runways (includes Improvements 7A, 7C, and 10)	$178.8

APPENDIX A

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APPENDIX B

COMPUTER MODEL AND METHODOLOGY

The Portland Capacity Team studied the effects of various improvements proposed to reduce delay and enhance capacity. The options were evaluated considering the anticipated increase in demand. The analysis was performed using computer modeling techniques. A brief description of the model and the methodology employed follows.

Computer Model

Airport and Airspace Simulation Model (SIMMOD)

SIMMOD is a fast-time, event-step model that simulates the real-world process by which aircraft fly through air traffic controlled en route and terminal airspace and arrive and depart at airports. SIMMOD traces the movement of individual aircraft as they travel through the gate, taxiway, runway, and airspace system, and detects potential violations of separations and operation procedures. It simulates the air traffic control actions required to resolve potential conflicts to insure that aircraft operate within procedural rules. Aircraft travel time, delay, and traffic statistics are computed and provided as model outputs. The model was calibrated for this study against field data collected at PDX to ensure it was site specific. Inputs for the simulation model were also derived from empirical field data. The model repeated each experiment 10 times using Monte Carlo sampling techniques to introduce system variability. The results were then averaged to produce output statistics.

Methodology

Model simulations included present and future air traffic control procedures, various airfield improvements, and traffic demands for different times. To assess the benefits of proposed airfield improvements, different airfield configurations were derived from present and projected airport layouts. The projected implementation time for air traffic control procedures and system improvements determined the aircraft separations used for IFR and VFR weather simulations.

For the delay analysis, agency specialists developed traffic demands based on the *Official Airline Guide*, historical data, and various forecasts. Aircraft volume, mix and peaking characteristics were developed for three demand periods: Baseline, Future 1, and Future 2. The estimated annual delays for the proposed improvement options were calculated from the experimental results. These estimates took into account the yearly variations in runway configurations, weather, and demand based on historical data.

The potential delay reductions for each improvement were assessed by comparing the annual delay estimates with the Basecase.

APPENDIX C

LIST OF ABBREVIATIONS

ARTCC .... Air Route Traffic Control Center
ASC .... Office of System Capacity, FAA
ATC .... Air Traffic Control
ATCT .... Airport Traffic Control Tower
CAT .... Category — of instrument landing system
FAA .... Federal Aviation Administration
GA .... General Aviation
GPS .... Global Positioning System
IFR .... Instrument Flight Rules
ILS .... Instrument Landing System
IMC .... Instrument Meteorological Conditions
LBS .... Pounds
MLS .... Microwave Landing System
NM .... Nautical Miles
PDX .... Portland International Airport
PRM .... Precision Runway Monitor
ROT .... Runway Occupancy Time
RVR .... Runway Visual Range
SIMMOD .... Airport and Airspace Simulation Model
SM .... Statute Miles
SMGCS .... Surface Movement Guidance and Control System
TRACON .... Terminal Radar Approach Control
VFR .... Visual Flight Rules
VHF .... Very High Frequency
VMC .... Visual Meteorological Conditions

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