Chapter 6

DETAILED ANALYSIS OF AIRSPACE INTERACTIONS

TABLES

EXHIBITS

DRAFT

Chapter 6

DETAILED ANALYSIS OF AIRSPACE INTERACTIONS

During the first phase of this study a preliminary assessment was made of the effects of airspace interactions in the Seattle area on airfield capacities and aircraft delays at Seattle-Tacoma International Airport (Sea-Tac) and King County International Airport (Boeing Field). The assessment, which was made using capacity and delay handbook techniques and an annual delay aggregation model, showed that high levels of aircraft delays and associated costs attributable to airspace interactions are projected to occur between 1990 and the year 2000.

On the basis of the findings of this preliminary assessment, the Port of Seattle and King County decided to continue into the second phase of the study. The first task in the second phase involves a detailed analysis of the airspace interactions, the results of which are presented in this chapter. Later in the second phase, alternatives and potential actions to mitigate the delays attributable to airspace interactions will be identified, described, and evaluated.

MODELS USED

Airspace interactions between Sea-Tac and Boeing Field were analyzed in detail by using a computerized parallel runway capacity model and the annual delay aggregation model with specific data for Sea-Tac and Boeing Field.

Key inputs to the runway capacity model include:

- Runway configuration and use patterns
- Arrival separations
- Departure separations
- Runway occupancy times
- Aircraft mix
- Approach velocities

The output from the model is the hourly capacity of the runway configuration under consideration.

Key inputs to the annual delay aggregation model include:

- Annual demand
- Hourly, daily, and monthly variations in traffic
- Ceiling and visibility conditions
- Runway capacities

The outputs from the model are total annual aircraft delay, average annual aircraft delay, and peak hour delays for the average day of the peak month.

An airspace/airfield computer simulation model is being set up to assist in the evaluation of alternatives to mitigate the delays attributable to airspace interactions. The model, which provides extremely detailed information on aircraft operations, may be used to evaluate possible changes in air traffic control procedures or new navigational aids, such as a microwave landing system. Key inputs to the model are the same as those for the runway capacity model and the following:

- A network of links and nodes representing the airspace system (including the respective airfields)
- A detailed schedule of aircraft demand

The outputs from the model include information on aircraft flow rates, average aircraft delays, and aircraft travel times.

CAPACITY AND DELAY CALCULATIONS

Hourly and annual airfield capacity and aircraft delays were calculated for Sea-Tac and Boeing Field for two air traffic control (ATC) scenarios. The first ATC scenario assumes a continuation of current procedures and aircraft separation standards through the year 2000, and may be considered a worst case representation of the ATC system, that is, no improvement over today. This scenario will be referred to in this report as "the baseline ATC scenario." The second ATC scenario assumes that aircraft separation standards will be reduced for certain aircraft in 1990 and the year 2000, particularly in IFR conditions.* The second ATC scenario (hereinafter

*Source: Report No. FAA-EM-78-8A, "Parameters of Future ATC Systems Relating to Airport Capacity/Delay," June 1978.

referred to as "the optimistic ATC scenario") is an optimistic representation of the ATC system which assumes major breakthroughs in technology. The achievement of these reduced separations will depend to a large extent on the success of the research programs included in the FAA's National Airspace System Plan (such as programs on the detection and alleviation of the wake vortices that are generated by large and heavy aircraft).

It should be noted that differences between capacity values estimated in the preliminary assessment of airspace interactions and those presented herein are due to different assumptions of aircraft separations in the respective analyses. In the preliminary assessment, capacities were estimated using an "in between" set of aircraft separations for the years 1990 and 2000--in anticipation of some form of improvement in the ATC system over today's conditions.

Hourly Runway Capacity

Using the parallel runway capacity model, hourly runway capacities for Sea-Tac and Boeing Field were estimated for the two ATC scenarios. These capacities are shown in Table 6-1, together with the peak hour demand for the years 1980, 1985, 1990, and 2000. In VFR conditions under the baseline ATC scenario, the hourly capacity of Sea-Tac is expected to decrease from 77 operations in 1980 to 72 operations by the year 2000. However, under the optimistic ATC scenario, the hourly capacity of Sea-Tac is expected to increase to 81 operations by the year 2000. The capacities under either scenario exceed forecasts of VFR peak hour demand through the year 2000.

In IFR conditions under the baseline ATC scenario, the hourly capacity of Sea-Tac is expected to decrease from 55 operations in 1980 to 48 operations in the year 2000. Under the optimistic ATC scenario, the hourly capacity of Sea-Tac is expected to increase to 65 operations by the year 2000. Peak hour demand in the year 2000 is forecast to be 55 operations per hour, thus exceeding the capacity of Sea-Tac in IFR conditions under the baseline ATC scenario.

Because the major differences between the two ATC scenarios occur in IFR conditions and relate primarily to large and heavy aircraft, the hourly capacity of Boeing Field in VFR conditions is the same under both ATC scenarios, that is, the hourly capacity is expected to decrease from 210 operations in 1980 to 199 operations by the year 2000. Peak hour demand in VFR conditions is expected to increase from 198 operations in 1980 to 227 operations by the year 2000. Thus, demand at Boeing Field is expected to exceed the capacity in VFR conditions sometime between 1985 and 1990.

In IFR conditions under the baseline ATC scenario, hourly capacity at Boeing Field is expected to decrease from 54 operations in 1980 to 51 operations by the year 2000. However, under the optimistic ATC scenario, the hourly capacity of Boeing Field is expected to increase to 63 operations by the year 2000. Peak hour demand at Boeing Field during IFR conditions is expected to increase from 28 to 44 operations during the study period. The capacities under both scenarios exceed forecasts of IFR peak hour demand through the year 2000.

Table 6-1

ESTIMATED HOURLY RUNWAY CAPACITIES
AND PEAK HOUR* DEMANDS
(number of aircraft operations per hour)

	VFR capacity			IFR capacity		
	Baseline ATC scenario	Optimistic ATC scenario	VFR demand	Baseline ATC scenario	Optimistic ATC scenario	IFR demand
Sea-Tac International Airport						
1980	77	77	54	55	55	51
1985	74	74	54	55	55	51
1990	75	80	55	53	64	52
2000	72	81	59	48	65	[55]
King County International Airport (Boeing Field)						
1980	210	210	198	54	54	28
1985	210	210	203	54	54	31
1990	203	203	[213]	51	55	36
2000	199	199	[227]	51	63	44

Note: See text for definition of scenarios. Boxed numbers indicate that demand exceeds capacity.

*Average day, peak month.

Source: Peat, Marwick, Mitchell & Co.

Average Annual Aircraft Delays

Table 6-2 and Exhibit 6-1 present estimates of average annual aircraft delays for Sea-Tac and Boeing Field for the two ATC scenarios obtained by using the annual delay aggregation model. Annual delays were computed for Sea-Tac and Boeing Field on the basis of combinations of aircraft mixes, weather conditions, runway configurations, operating strategies for runway use, annual demand, and airspace interactions between these two airports. These delays are averages for every aircraft operation that takes place in the year shown.

For the 213,604 total annual operations occurring at Sea-Tac in 1980, the average annual delay to aircraft was estimated to be just over half a minute (0.6 minute). However, by the year 2000, annual delays at Sea-Tac are expected to increase to 4.6 minutes per aircraft under the baseline ATC scenario and to 1.0 minute per aircraft by the year 2000 under the optimistic ATC scenario. For comparison purposes, as was mentioned in the previous chapter, PMM&Co. estimates of average annual delays at other U.S. airports, made as part of FAA Improvement Task Force Delay Studies in recent years, are as follows: Hartsfield Atlanta International, 4.5 minutes (1978); Denver Stapleton International, 2.9 minutes (1978); John F. Kennedy International (New York), 5.8 minutes (1978); Lambert-St. Louis International, 0.9 minutes (1979); and San Francisco International, 2.1 minutes (1977).

At Boeing Field, annual delays are expected to increase from 0.6 minute per aircraft in 1980 to about 2.5 minutes per aircraft in the year 2000 under both ATC scenarios.

Table 6-2

AVERAGE ANNUAL AIRCRAFT DELAYS

	Annual demand (aircraft operations)	Total annual delay (minutes)		Average annual delay (minutes)	
		Baseline ATC scenario	Optimistic ATC scenario	Baseline ATC scenario	Optimistic ATC scenario
Sea-Tac International Airport					
1980	213,604	128,000	128,000	0.6	0.6
1985	205,780	123,000	123,000	0.6	0.6
1990	220,600	239,000	126,000	1.1	0.6
2000	260,820	1,199,000	252,000	4.6	1.0
King County International Airport (Boeing Field)					
1980	410,853	245,000	245,000	0.6	0.6
1985	424,000	311,000	311,000	0.7	0.7
1990	445,000	504,000	492,000	1.1	1.1
2000	488,500	1,360,000	1,216,000	2.8	2.5

Note: See text for definition of scenarios.

Source: Peat, Marwick, Mitchell & Co.

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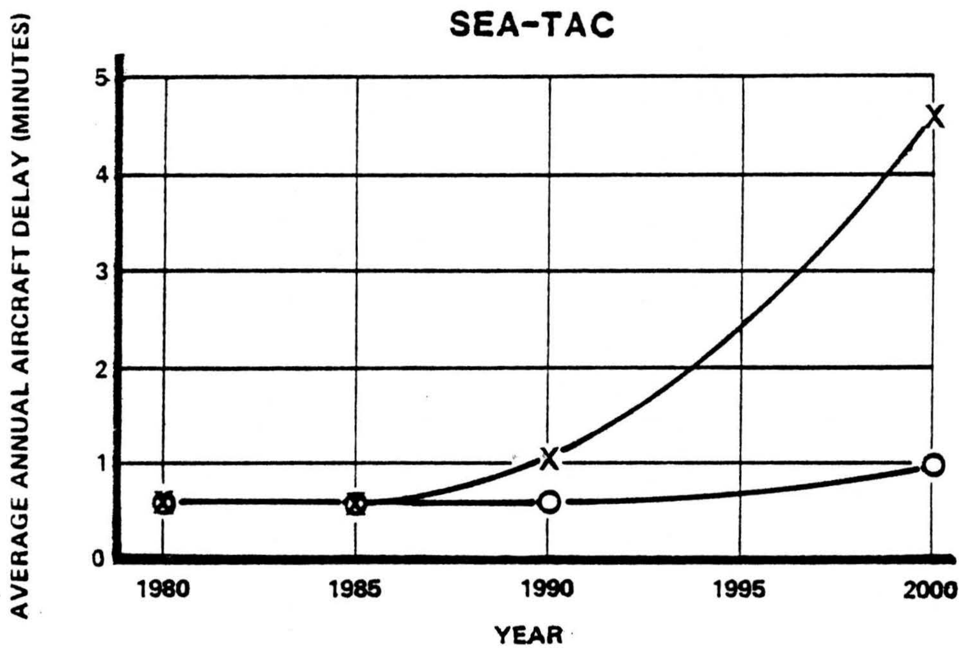

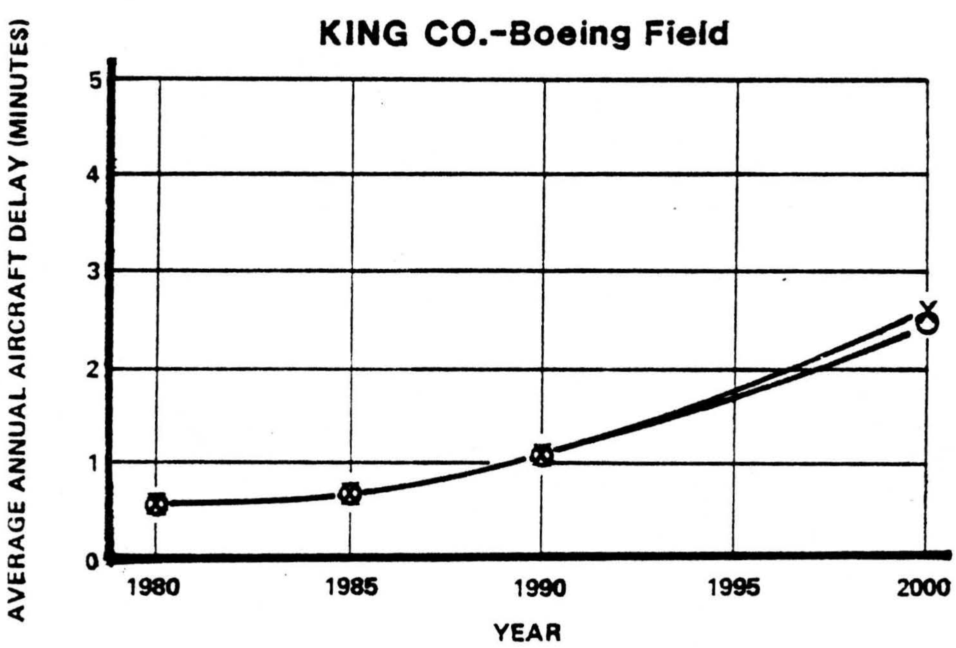

Source: Peat, Marwick, Mitchell & Co.

X Baseline ATC Scenario

O Optimistic ATC Scenario

Note: See Text for Definition of Scenarios.

Exhibit 6-1

Airspace Study
Sea-Tac International Airport
King County International Airport

AVERAGE ANNUAL AIRCRAFT DELAYS

Peat, Marwick, Mitchell & Co. July 1982

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Of considerable importance are the aircraft delays that occur during peak hours, particularly during IFR weather conditions, when the effects of the airspace interaction between Sea-Tac and Boeing Field are felt. Table 6-3 presents aircraft delays during the peak hour for the average day of the peak month in VFR conditions (90.6% occurrence), IFR north flow conditions (2.4% occurrence), and IFR south flow conditions (7.0% occurrence).

As shown, average peak hour delays at Sea-Tac in VFR conditions range from 1.9 minutes per aircraft in 1980 to 3.4 minutes per aircraft in the year 2000 under the baseline ATC scenario. Peak hour delays in VFR conditions are estimated to be slightly less under the optimistic ATC scenario in 1990 and the year 2000.

In IFR conditions, peak hour delays are estimated to increase rapidly over the study period under the baseline ATC scenario because of the conflicting trends of reduced capacity and increasing demands. In IFR conditions for a north flow operation, peak hour delays are estimated to triple, from 4.8 minutes per aircraft in 1980 to 18.7 minutes per aircraft by the year 2000. In IFR conditions for a south flow operation, the situation is even worse: average delays are estimated to increase from 11.0 minutes per aircraft in 1980 to more than an hour per aircraft by the year 2000. When delay levels reach such proportions, air carrier service at Sea-Tac will deteriorate as airlines consider diverting or canceling flights. The increases in delays at Sea-Tac by the year 2000 under the optimistic ATC scenario are much lower; the worst delay is about 18 minutes per aircraft for an IFR south flow operation.

Table 6-3

PEAK HOUR AIRCRAFT DELAYS

	Average peak hour delays* (minutes per aircraft)		
	VFR	IFR north flow	IFR south flow
Baseline ATC scenario			
Sea-Tac International Airport			
1980	1.9	4.8	11.0
1985	1.8	3.4	10.7
1990	2.3	8.8	19.4
2000	3.4	18.7	60+
King County International Airport (Boeing Field)			
1980	4.1	0.3	0.3
1985	5.0	0.4	0.4
1990	6.7	0.9	0.9
2000	14.2	1.4	15.5
Optimistic ATC scenario			
Sea-Tac International Airport			
1980	1.9	4.8	11.0
1985	1.8	3.4	10.7
1990	1.8	3.8	10.0
2000	3.0	4.8	17.9
King County International Airport (Boeing Field)			
1980	4.1	0.3	0.3
1985	5.0	0.4	0.4
1990	6.7	0.9	0.9
2000	13.8	1.2	1.2

Note: See text for definition of scenarios.

*Average day, peak month.

Source: Peat, Marwick, Mitchell & Co.

At Boeing Field, peak hour delays are typically greatest in VFR conditions because of the higher demand levels relative to capacity. Delays are estimated to increase from about 4 minutes per aircraft in 1980 to about 14 minutes per aircraft by the year 2000 for both ATC scenarios. Delays in IFR conditions at Boeing Field under the baseline ATC scenario will not become significant until after 1990 when in a south flow of traffic, average peak hour delays are estimated to increase to more than 15 minutes per aircraft. On the other hand, under the optimistic ATC scenario, peak hour delays in IFR conditions at Boeing Field by the year 2000 are expected to be about 1 minute.

EFFECTS OF AIRSPACE INTERACTIONS

As described in Chapters 4 and 5, the proximity of Sea-Tac and Boeing Field results in airspace interactions, particularly for a south flow operation when IFR arrival flight paths converge and for a north flow operation when Sea-Tac IFR departures are held for Boeing Field IFR arrivals. Delay model runs were performed to estimate the effects of these interactions on Sea-Tac and Boeing Field aircraft operations using the capacities derived from the parallel runway capacity model.

Table 6-4 shows the effects of the airspace interactions on total annual aircraft delays at both Sea-Tac and Boeing Field. The predominant effect is on aircraft at Sea-Tac. It is estimated that about 10,000 minutes of delay at Sea-Tac in 1980 were attributable to the airspace interactions. However, by the year 2000 under the baseline ATC scenario, the airspace interactions are estimated to result in 887,000 minutes of delay annually. On the basis

Table 6-4

EFFECTS OF AIRSPACE INTERACTIONS
ON ANNUAL AIRCRAFT DELAYS

	Annual delay (minutes)		
	With interaction	Assuming no interaction	Difference
Baseline ATC scenario			
Sea-Tac International Airport			
1980	128,000	118,000	10,000
1985	123,000	113,000	10,000
1990	239,000	144,000	95,000
2000	1,199,000	312,000	887,000
King County International Airport (Boeing Field)			
1980	245,000	245,000	0
1985	311,000	311,000	0
1990	504,000	504,000	0
2000	1,360,000	1,252,000	108,000
Optimistic ATC scenario			
Sea-Tac International Airport			
1980	128,000	118,000	10,000
1985	123,000	113,000	10,000
1990	126,000	118,000	8,000
2000	252,000	206,000	46,000
King County International Airport (Boeing Field)			
1980	245,000	245,000	0
1985	311,000	311,000	0
1990	492,000	492,000	0
2000	1,216,000	1,194,000	22,000

Note: See text for definition of scenarios.

Source: Peat, Marwick, Mitchell & Co.

of 1981 aircraft operating costs,* total airline aircraft delays translate into a delay cost of about $25 million annually by the year 2000. Approximately $19 million of the delay cost is attributable to airspace interactions as illustrated on Exhibit 6-2. Under the optimistic ATC scenario, the effects of the airspace interactions are dramatically reduced--to about 46,000 minutes of delay by the year 2000, or to a cost of about $1.0 million annually.

As shown in Table 6-4, the effects of the airspace interactions on Boeing Field operations are negligible until late in the study period (primarily because of the low levels of aircraft operations forecast in IFR conditions). About 108,000 minutes of aircraft delays are estimated to be attributable to the interactions by the year 2000 under the baseline ATC scenario, and 22,000 minutes of delay under the optimistic ATC scenario.

Table 6-5 shows the effects of the airspace interactions on peak hour delays for the average day, peak month at both Sea-Tac and Boeing Field. Again, the predominant effect is on Sea-Tac aircraft operations, particularly in IFR conditions for a south flow operation: average peak hour delays in 1980 under the baseline ATC scenario are increased by about 8 minutes per aircraft (from 3.0 minutes to 11.0 minutes). By the year 2000, it is estimated that the airspace interactions would cause peak hour delays in IFR conditions for a south flow operation to exceed 1 hour per aircraft (rather than 11.6 minutes per aircraft assuming no interaction). However, under the

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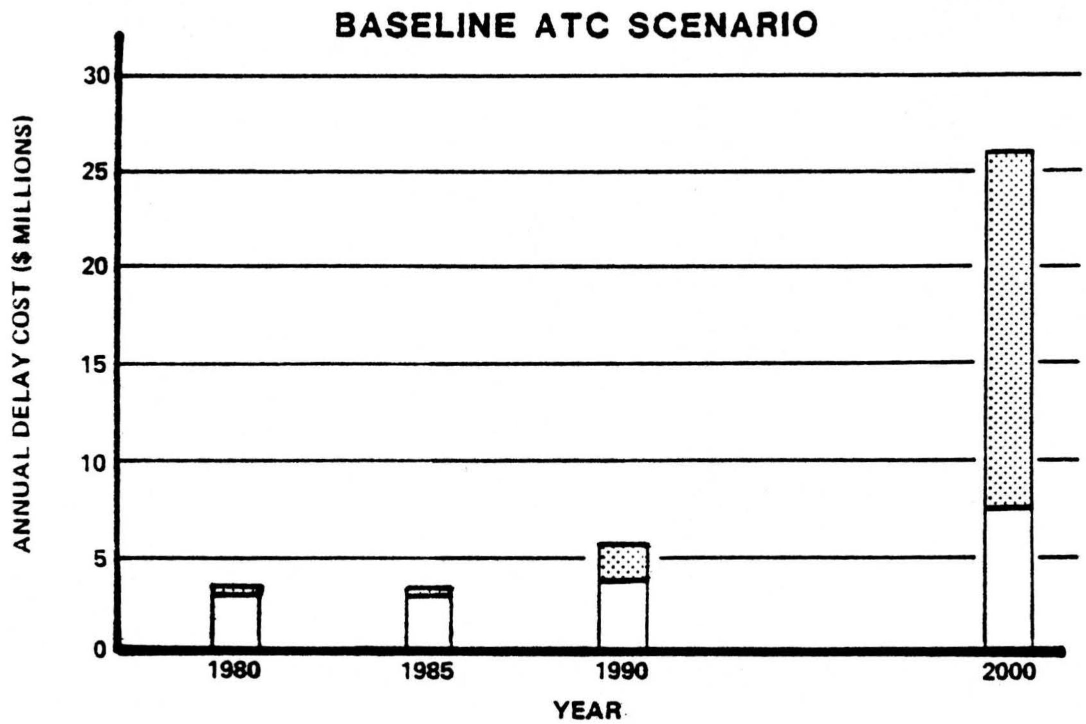
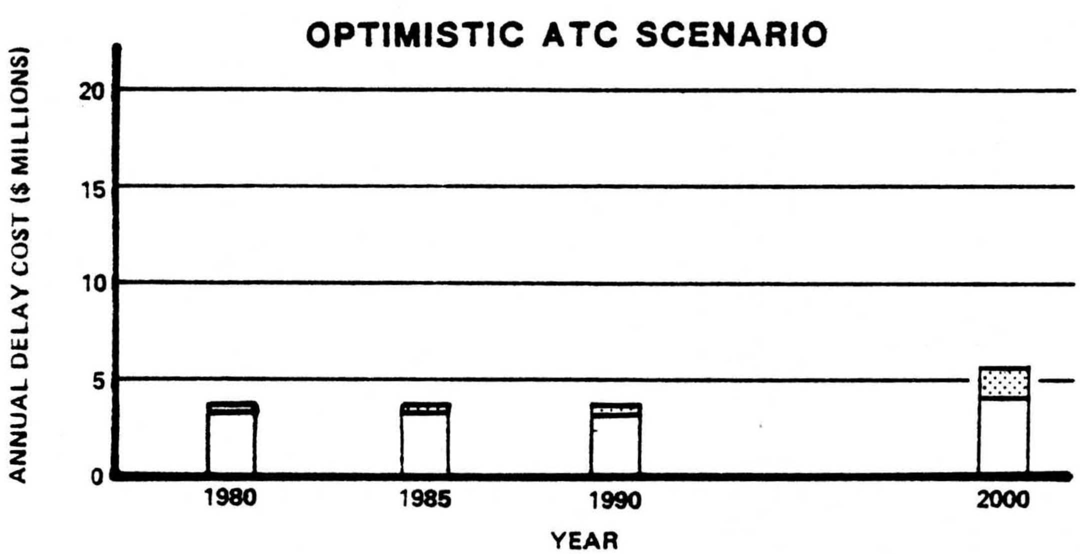
*On the basis of 1981 data, the weighted airline aircraft operating costs (essentially crew and fuel costs) for the Sea-Tac aircraft mix are approximately $24 per minute. During peak hours when most of the delays occur, airline traffic accounts for about 90% of the total operations.





Source: Peat, Marwick, Mitchell & Co.

Airspace Interaction Delay Cost

Other Delay Cost

Note: See Text for Definition of Scenarios.

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Exhibit 6-2

Airspace Study
Sea-Tac International Airport
King County International Airport

DELAY COSTS AT SEA-TAC

Peat, Marwick, Mitchell & Co. July 1982

Table 6-5

EFFECTS OF AIRSPACE INTERACTIONS ON
PEAK HOUR* AIRCRAFT DELAYS

	Average peak hour delays* (minutes per aircraft)					
	With interaction			Assuming no interaction		
	VFR	IFR north flow	IFR south flow	VFR	IFR north flow	IFR south flow
Baseline ATC scenario						
Sea-Tac International Airport						
1980	1.9	4.8	11.0	1.9	3.0	3.0
1985	1.8	3.4	10.7	1.8	2.9	2.9
1990	2.3	8.8	19.4	2.3	3.4	3.4
2000	3.4	18.7	60+	3.4	11.6	11.6
King County International Airport (Boeing Field)						
1980	4.1	0.3	0.3	4.1	0.3	0.3
1985	5.0	0.4	0.4	5.0	0.4	0.4
1990	6.7	0.9	0.9	6.7	0.9	0.9
2000	14.2	1.4	15.5	14.2	1.3	1.3
Optimistic ATC scenario						
Sea-Tac International Airport						
1980	1.9	4.9	11.0	1.9	3.0	3.0
1985	1.9	3.4	10.7	1.9	2.9	2.9
1990	1.8	3.8	10.0	1.8	3.1	3.1
2000	3.0	4.8	17.9	3.0	3.4	3.4
King County International Airport (Boeing Field)						
1980	4.1	0.4	0.4	4.1	0.4	0.4
1985	5.0	0.6	0.6	5.0	0.6	0.6
1990	6.7	0.9	0.9	6.7	0.9	0.9
2000	13.8	1.2	1.2	13.8	1.1	1.1

Note: See text for definition of scenarios.

***Average day, peak month.**

Source: Peat, Marwick, Mitchell & Co.

optimistic ATC scenario, delays during the peak hour at Sea-Tac in the year 2000 for a south flow operation would be 17.9 minutes per aircraft (rather than 3.4 minutes per aircraft assuming no interaction).

At Boeing Field, aircraft delays due to the airspace interactions are significant toward the end of the study period: by the year 2000, peak hour delays in IFR conditions for a south flow operation under the baseline ATC scenario are estimated to be about 15 minutes per aircraft (rather than 1.3 minutes per aircraft assuming no interaction). Under the optimistic ATC scenario, peak hour delays at Boeing Field in IFR conditions are relatively insignificant.

Sensitivity of Delay Values

Aircraft delays are dependent on airspace and airfield capacity and on the magnitude and fluctuation of aircraft demand. For a given airspace/airfield system, increases in aircraft demand will result in increased aircraft delays. As demand levels approach capacity (be it on an hourly, daily, or annual basis), small increases in demand cause dramatic increases in delays.

Aircraft delays at Sea-Tac in IFR conditions are very dependent on the arrival demand levels at Boeing Field. To demonstrate the sensitivity of aircraft delays at Sea-Tac to Boeing Field arrival demand levels, runs of the annual delay model were made assuming changes in the forecast demand levels at both Sea-Tac and Boeing Field. The results of these model runs are summarized in Table 6-6. Baseline results, that is, results obtained from using the forecast levels of demand for the year 2000, are presented for comparison purposes.

Table 6-6

SENSITIVITY OF DELAY VALUES
Sea-Tac International Airport

		ANNUAL DELAY		PEAK HOUR DELAY* (minutes per aircraft)		
YEAR	DEMAND LEVEL	Total (minutes)	Average (minutes per aircraft)	VFR	IFR north flow	IFR south flow
Baseline ATC scenario						
2000	SEA forecast (260,820) BFI forecast (488,500)	1,199,000	4.6	3.4	60+	60+
2000	SEA forecast BFI forecast + 10%	1,292,000	5.0	3.4	60+	60+
2000	SEA forecast + 10% BFI forecast	1,730,000	6.0	4.4	60+	60+
2000	SEA forecast - 10% BFI forecast	782,000	3.0	2.8	13	30-40
Optimistic ATC scenario						
2000	SEA forecast (260,820) BFI forecast (488,500)	252,000	1.0	3.0	4.8	17.9
2000	SEA forecast BFI forecast + 10%	256,000	1.0	3.0	5.2	20.5
2000	SEA forecast + 10% BFI forecast	450,000	1.6	3.1	9.7	60+

Note: See text for definition of scenarios.

*Average day, peak month.

Source: Peat, Marwick, Mitchell & Co.

For aircraft operations under the baseline ATC scenario, Table 6-6 shows that a 10% increase in traffic at Boeing Field in the year 2000 results in an increase in the average annual delay from 4.6 minutes to 5.0 minutes per aircraft and that a 10% increase in traffic at Sea-Tac results in a delay increase from 4.6 minutes to 6.0 minutes per aircraft. The baseline ATC scenario, with a 10% increase in the demand forecast for Sea-Tac in the year 2000, may be considered a worst-case scenario. These levels of annual delays are equivalent to, or exceed, those that have been experienced in recent years at Chicago and Atlanta, the two busiest airports in the United States. In the event demand at Sea-Tac should be 10% less than that forecast for the year 2000, then under the baseline ATC scenario average annual delays are expected to be about 3.0 minutes per aircraft.

For aircraft operations under the optimistic ATC scenario, Table 6-6 shows that with a 10% increase in demand at Boeing Field, delays at Sea-Tac in the year 2000 during IFR conditions would be marginally increased. However, an increase of 10% in Sea-Tac demand in the year 2000 would result in an increase in annual delays from 1.0 to 1.6 minutes per aircraft, and peak hour delays during IFR conditions for a north flow operation would double from 4.8 minutes to 9.7 minutes per aircraft. Peak hour delays during IFR conditions for a south flow operation would more than triple, from 17.9 minutes to more than 1 hour per aircraft.

SUMMARY

1. Hourly Capacities. Airfield capacities and delays to aircraft were developed using computer models for two ATC scenarios. The baseline ATC scenario assumes a continuation of current procedures and aircraft separation standards through the year 2000. The optimistic ATC scenario assumes that aircraft separation standards will be reduced for certain aircraft in 1990 and the year 2000.

   Not accounting for airspace interactions, hourly capacity at Sea-Tac is expected to exceed hourly demand in VFR and IFR conditions through the forecast period under both ATC scenarios, except for IFR hourly demand in the year 2000 under the baseline ATC scenario. VFR hourly demand at Boeing Field is expected to exceed VFR hourly capacity by 1990, while IFR hourly capacity is expected to be sufficient to accommodate IFR hourly demand through the year 2000. It should be noted that delays can occur even when the demand averaged over 1 hour is less than the hourly capacity. Such delays occur because demand fluctuates within an hour, so that during small intervals of time, demand is greater than capacity.

2. Total Annual Delays. At Sea-Tac under the baseline ATC scenario, the total average annual aircraft delay per aircraft is expected to increase from just over half a minute (0.6 minute) in 1980 to 4.6 minutes by the year 2000. Of these delays, airspace interactions are estimated to account for less than 10% in 1980, but about 75% by the year 2000.

At Boeing Field, the total average annual aircraft delay per aircraft is expected to increase from just over half a minute (0.6 minute) in 1980 to approximately 2.6 minutes in the year 2000. Airspace interactions are not expected to contribute to these delays until after 1990.

At Sea-Tac under the optimistic ATC scenario, average annual aircraft delay is expected to increase to 1.0 minute per aircraft by the year 2000. However, the use of reduced aircraft separations for the optimistic ATC scenario will depend to a large extent on the success of research on the detection and alleviation of the wake vortices generated by large and heavy aircraft.

3. Sensitivity of Annual Delay Values. Sensitivity analyses show that delays under a worst-case scenario for the year 2000 (that is, baseline ATC scenario, current (1980) aircraft separations, combined with a traffic level 10% higher than forecast demand at Sea-Tac), average annual delays will reach 6.0 minutes per aircraft. With an optimistic scenario for the year 2000, (that is, optimistic ATC scenario and forecast demand), average annual aircraft delays will reach only 1.0 minute per aircraft.

4. Annual Delay Costs. At current (1980) levels of aircraft delays at Sea-Tac, delay costs are approximately $2.8 million per year, of which about $220,000 is attributable to the effects of the airspace interactions. However, by the year 2000 under the baseline ATC scenario,

these delay costs are expected to increase to about $25 million per year, and of this amount, $19 million per year will be attributable to airspace interactions. Under the baseline ATC scenario, delay costs attributable to the airspace interactions are reduced dramatically--to about $1 million per year by the year 2000.

5. Peak Hour Delays. Airspace interactions affect aircraft delays during IFR conditions, and the predominant effect occurs during a south flow operation. During IFR conditions and for a south flow operation, the arrival capacities at Sea-Tac and Boeing Field are reduced to little more than that of a single airport. At Sea-Tac, during these operating conditions, which occur approximately 7% of the year, and under the baseline ATC scenario, peak hour delays attributable to airspace interactions increased to about 11 minutes per aircraft in 1980 (from 3 minutes per aircraft assuming no interaction) and to over 1 hour per aircraft in the year 2000 (from 11.6 minutes per aircraft assuming no interaction). At Boeing Field during these conditions, peak hour delays attributable to airspace interactions are not expected to occur until after 1990.

Under the optimistic ATC scenario in IFR conditions and for a south flow operation, peak hour delays at Sea-Tac would be increased by 14.5 minutes per aircraft (from 3.4 minutes to 17.9 minutes per aircraft) in the year 2000 because of the airspace interactions. Peak hour delays at Boeing Field under the same conditions are relatively insignificant.

6. Boeing Field VFR Delays. Although not related to airspace interactions, an important finding of this analysis is that peak hour delays for the average day of the peak month in VFR conditions at Boeing Field are estimated to increase from about 4 minutes per aircraft in 1980 to almost 14 minutes per aircraft by the year 2000. The reason for this increase is that the forecast hourly demand at Boeing Field is expected to exceed available capacity.