Chapter 7

EVALUATION OF ALTERNATIVE MEASURES.

TABLE

EXHIBITS

DRAFT

Chapter 7

EVALUATION OF ALTERNATIVE MEASURES

The detailed analysis of airspace interactions between Sea-Tac and Boeing Field described in Chapter 6 demonstrated that aircraft delays and associated costs are expected to increase rapidly from 1990 to the year 2000 and beyond because of the airspace interactions. This chapter examines alternative measures that could alleviate the effects of the airspace interactions.

It could be argued that, because the significant aircraft delays are not expected probably before 1990, no action is required at this time. However, a simple solution to reducing future delays is not readily available. All of the measures identified will require a series of decisions and commitments by various agencies and public and private interests to achieve implementation. Such a process may take until 1990, when implementation will be needed.

The measures to reduce aircraft delays may be grouped as follows:

- Improved ATC Technology. The 1982 National Airspace System Plan includes a program of improved ATC technology that in concept, could result in modifications of ATC rules and procedures that could increase capacity (and hence reduce delays).

- Airport Facility Improvements. Capacity may be increased by adding runways to an existing airport or by building a new airport to relieve other overcrowded airports.

- Demand Management. Delay may be reduced if some of the demand for use of the airports is shifted from peak to off-peak hours by imposing quotas or differential pricing for airport use according to the time of day.

It is possible that a combination of measures may be required to alleviate or eliminate the airspace interactions between Sea-Tac and Boeing Field. A combination of measures is referred to in this report as a "program." A preliminary description of several of these measures is presented in this chapter.

IMPROVED ATC TECHNOLOGY

Improved ATC technology may lead to new ATC rules and procedures that permit reduced separations between aircraft and new instrument approach procedures.

Reduced Aircraft Separations

Runway capacity is influenced by the aircraft separation standards used by air traffic controllers in sequencing aircraft. Aircraft separation standards were originally established for safety reasons--to avoid aircraft colliding. However, in recent years, many aircraft separation standards have been increased to take into account the need for an aircraft following another aircraft "in trail" to remain clear of the wake vortices generated

by the preceding aircraft. The wake vortices, which are more severe behind heavier aircraft, require greater separation between aircraft than would be needed if the vortices were not present.

For the purposes of wake turbulence separation, the FAA currently classifies aircraft as heavy, large, and small. These categories are defined in Chapter 4, page 4-19. Minimum IFR in-trail spacing is 3 nautical miles except as follows:

1. Small behind large - 4 nautical miles

2. Small behind heavy - 6 nautical miles (at runway threshold)

3. Large behind heavy - 5 nautical miles

4. Heavy behind heavy - 4 nautical miles

These currently applicable separation standards are assumed in the baseline ATC scenario discussed in Chapter 6.

As demonstrated in Chapter 6, reducing separations between aircraft has a potential for significantly increasing airfield and airspace capacity and reducing aircraft delays. Delay values shown in Chapter 6 for the optimistic ATC scenario indicate the potential delay savings to be realized from reduced separations. However, reduced aircraft separations, to the extent assumed in the optimistic ATC scenario, can be achieved only if the wake vortex problem associated with large and heavy aircraft is solved. There

are several research and development programs called for in the National Airspace System Plan aimed at minimizing the effects of aircraft wake vortices. These programs are briefly described in Appendix G.

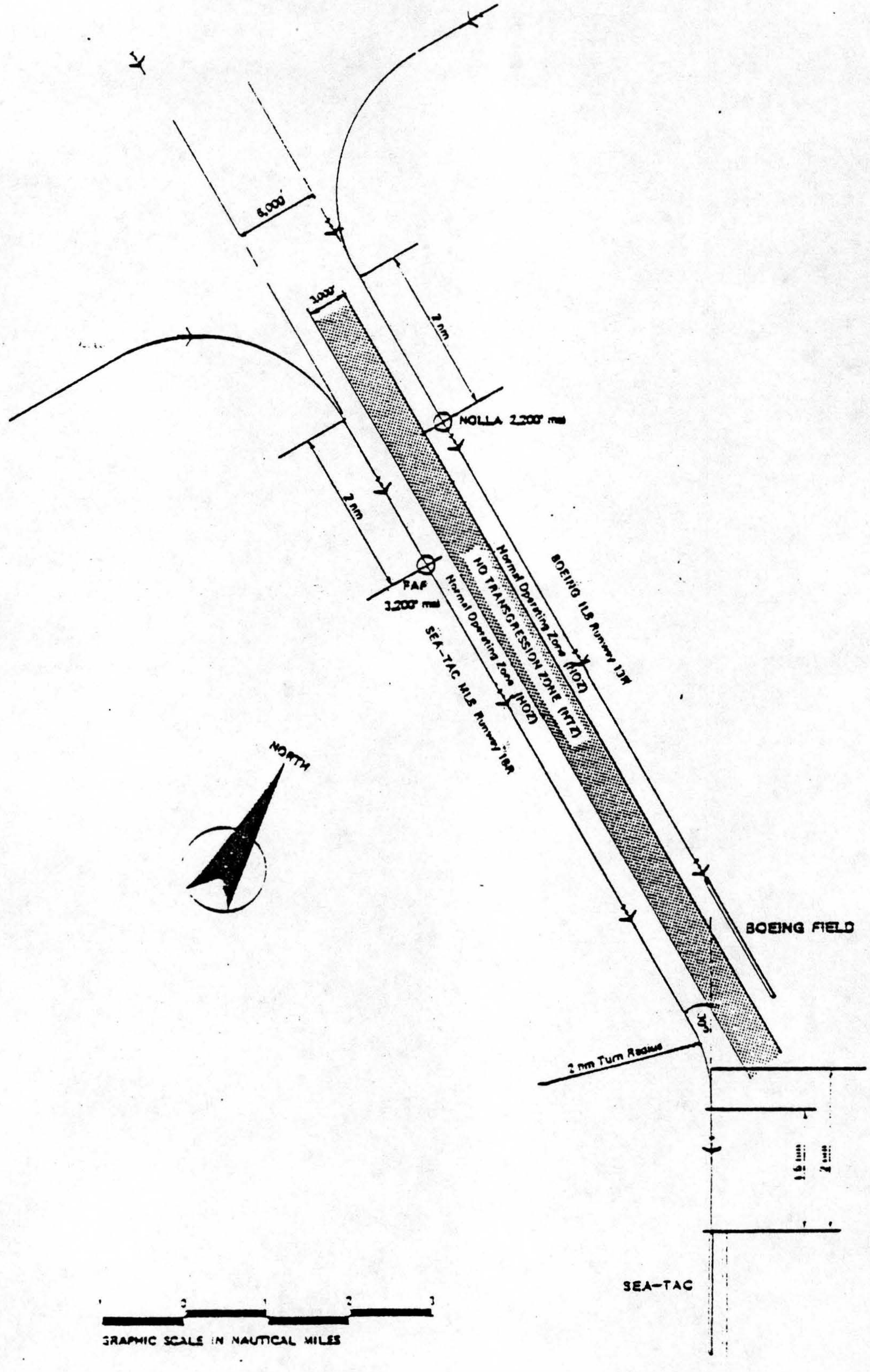
Potential Instrument Approach Using MLS at Sea-Tac

As noted earlier, the principal airspace interaction between Sea-Tac and Boeing Field is due to the closeness of the airports and the resulting proximity of the instrument approaches to Runway 16R at Sea-Tac and Runway 13R at Boeing Field for a south flow operation in IFR conditions.

To alleviate the airspace interaction between the two airports in the south flow condition, a new type of dual independent instrument approach procedure would be required. Such a procedure, illustrated in Exhibit 7-1, would utilize a microwave landing system (MLS).

The procedure is described in the following paragraphs. It is emphasized that the procedure is conceptual in nature, and would not be permissible under current ATC rules. The feasibility of such a procedure is subject to (1) FAA review, testing, and modification of ATC rules; (2) provision of new avionics in aircraft; and (3) acceptance by pilots.

The initial portion of the final approach segment to Sea-Tac's Runway 16R would parallel Boeing Field's Runway 13 extended centerline, 6,000 feet to the southwest. A 30° turn would then be made (2 nautical mile radius) to a 1.5 nautical mile straight-in final approach. Pilots would have to execute



SOURCE: Peat, Marwick, Mitchell & Co.

Exhibit 7-1

Airspace Study

Sea-Tac International Airport
King County International Airport

POTENTIAL INSTRUMENT APPROACH TO SEA–TAC

the turning portion of the final approach at 2 nautical miles as shown. The approach procedure to Boeing Field would be similar to today's ILS approach to Runway 13R.

The 6,000-foot spacing between approach centerlines would permit a 3,000-foot no-transgression zone (NTZ) and 1,500-foot normal operating zones (NOZ). Current requirements for independent ILS approaches for straight-in landings to parallel runways are 4,300-foot minimum spacing between runway centerlines, a 2,000-foot NTZ and 1,150-foot NOZs. Separate monitor controllers would be required, as for independent parallel approaches under current ATC rules. The natural vertical separation between the two airports would permit normal turn-ons to final approach.

A microwave landing system (MLS) would be necessary to provide continuous guidance for the approach to Sea-Tac. The MLS allows aircraft to follow any of several curving or segmented approach paths to the runway, thereby easing some of the constraints imposed by the present instrument landing system (ILS). The ILS, which has been the standard at U.S. airports since 1941, guides aircraft along a straight path at a fixed slope of about 3° extending five to seven miles from the runway threshold. All aircraft approaching the airport must merge to follow this path in single file, spaced at intervals dictated by separation minima and the need to avoid wake vortex.

Because MLS uses a scanning beam, rather than a fixed beam like ILS, it allows aircraft to fly any of several approach angles and to approach along curved paths that intersect the alignment of the runway at any selected

point. MLS also may provide precision guidance for departures and missed approaches, a feature of particular importance when traffic patterns of closely located airports conflict.

The reductions in aircraft delays expected in the year 2000 if a new dual independent instrument approach procedure with an MLS were installed at Sea-Tac were estimated by using the Peat Marwick airspace simulation model. In the analysis, the optimistic ATC scenario for a south flow operation during IFR conditions was assumed. It was also assumed that all aircraft using Sea-Tac were equipped with avionics necessary to use the curved MLS approach. The analysis showed that peak hour delays for the optimistic ATC scenario were reduced to about 4 minutes per aircraft (from about 18 minutes per aircraft)--the same level of delay that would be experienced at Sea-Tac if Sea-Tac and Boeing Field had no airspace interactions. Appendix H presents more information about this analysis.

There are several factors that will affect the installation and use of MLS. The FAA has designated MLS as the precision approach guidance system to replace ILS over the next 20 years; an MLS is programmed by FAA for Sea-Tac for 1990. In addition, the FAA's transition plan stipulates that no ILS will be removed until all of the ILS-equipped airports have operational MLS and at least 60% of the equipped aircraft routinely using the ILS/MLS runway are MLS-equipped. Therefore, up to 40% of the regular users of a given airport could still have to use the ILS precision approach guidance system, or not operate at the airport if functioning ILS equipment were removed.

Because of the cost of MLS avionics, there is likely to be continued resistance to MLS from aircraft operators; they will probably oppose the decommissioning of ILS at specific sites and be reluctant to purchase MLS equipment.

In addition, the United States is committed, by an agreement with the International Civil Aviation Organization, to retain ILS service at international gateway airports through 1995. There are 75 such airports at present, including Sea-Tac. The retention of ILS service at Sea-Tac may cause some users to further delay purchasing MLS equipment because the installed ILS equipment will still be usable until at least 1995.

Unless virtually all aircraft use the MLS approach, the delay reduction benefits cited above will not be realized.

It should also be stressed that an instrument approach procedure using an MLS would require new ATC rules and procedures and would require much testing before being accepted by pilots and controllers.

Thus, although a new dual independent instrument approach procedure using an MLS would remove the airspace interaction between Sea-Tac and Boeing Field for a south flow operation, there are several considerations that have to be taken into account before such a new procedure could be implemented. Alleviating or eliminating the airspace interactions between Sea-Tac and Boeing Field by providing a new instrument approach to Sea-Tac would require:

- Installation of MLS serving Runway 16R at Sea-Tac

- Installation of necessary cockpit avionics in most aircraft using Sea-Tac

- Research and demonstration, together with controller and pilot acceptance of independent instrument approach procedures to nonparallel runways

- Development of procedures by airline and other aircraft operators to ensure flight stabilization on "short" final approach segment

- FAA modification of ATC rules and procedures

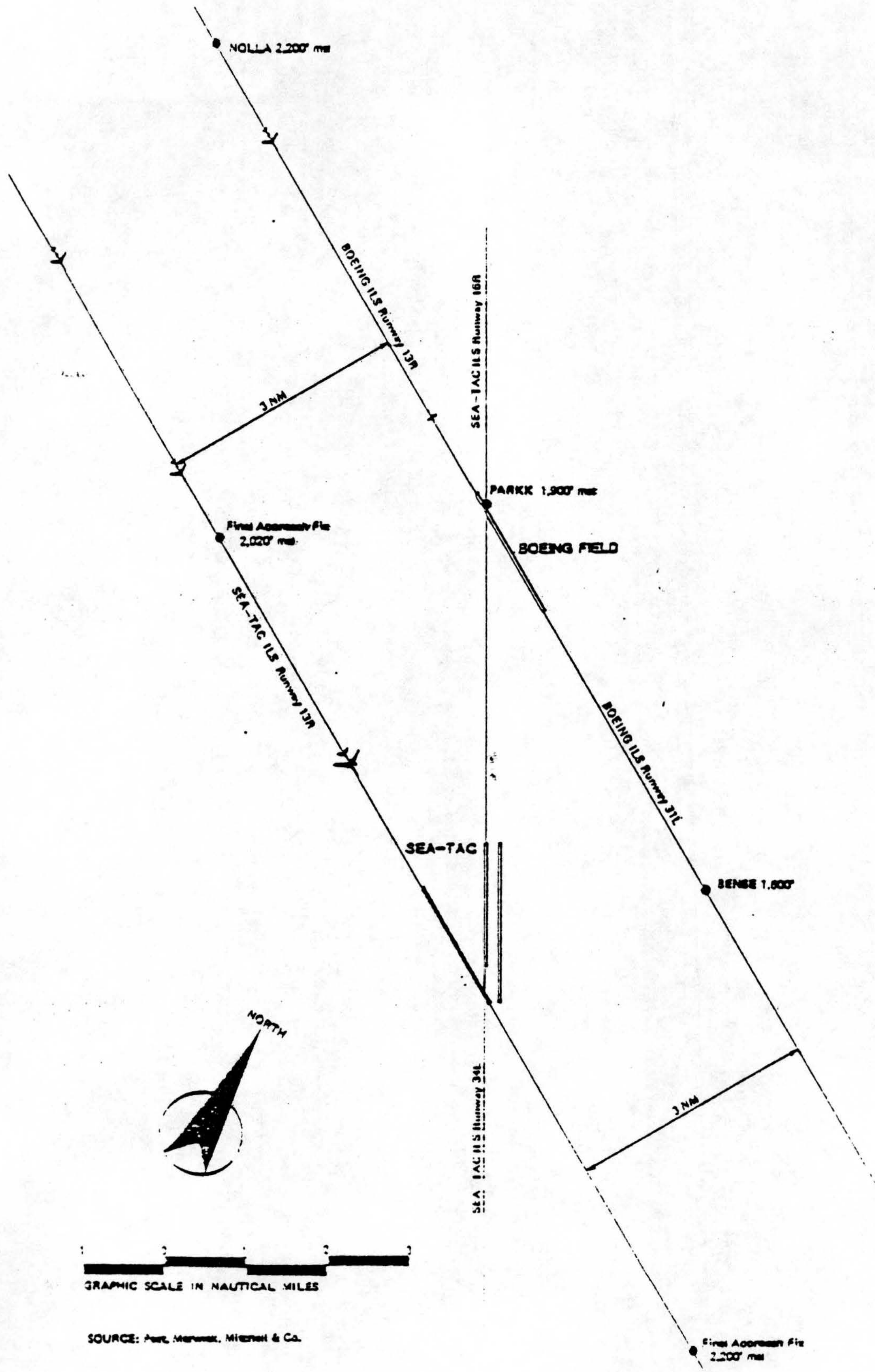
- Completion of environmental assessment and related processing

AIRPORT FACILITY IMPROVEMENTS

Measures that increase system capacity include adding runways to an existing airport or using reliever airports together with the addition of necessary airfield improvements or navigational aids.

New Runway at Sea-Tac

A fully instrumented Runway 13-31 at Sea-Tac would permit simultaneous independent approaches for a south flow in IFR conditions to both Sea-Tac and Boeing Field under existing ATC rules and procedures, as illustrated in Exhibit 7-2. Site constraints at Sea-Tac would limit such a runway to a length of about 5,000 feet, and consequently the runway would only be



SOURCE: Peat, Marwick, Mitchell & Co.

Exhibit 7-2

Airspace Study

Sea-Tac International Airport

King County International Airport

POTENTIAL RUNWAY 13–31 AT SEA–TAC

Peat, Marwick, Mitchell & Co. September 1982

suitable for commuter and general aviation aircraft. Most of the airline (jet) aircraft, would continue to use Runway 16R. Nonetheless, the new runway would result in decreased use of the instrument approach to Runway 16R during IFR conditions. Therefore, the delays caused by interaction with Boeing Field traffic would be reduced.

The practicality of a new runway at Sea-Tac is questionable: (1) the length of the runway limits its use to a minority of aircraft using Sea-Tac; (2) providing the navigational aids necessary for an instrument approach to Runway 13 would be difficult because of the dramatic drop-off in the ground elevations to the northwest; (3) the runway may require the relocation of existing facilities such as the fuel storage tanks, which are currently adjacent to the threshold of Runway 34R, and (4) the runway would result in new areas around the airport being exposed to aircraft noise.

Reliever Airports

In metropolitan areas where there is congestion at the primary air carrier airport and excess capacity at surrounding airports, the diversion of general aviation traffic can be effective in improving the use of airfield and airspace capacity in the whole region. In this case, an airport would be needed to accommodate general aviation traffic that otherwise would use Boeing Field or Sea-Tac during IFR conditions.

Ideally, the reliever airport should be located so that there are no airspace conflicts between the reliever airports and the primary airport(s). Also, the secondary reliever airport would have to have instrument landing

capability and be conveniently located. Further, although voluntary relocation would be desirable, additional incentives may be required, such as increased landing fees at Sea-Tac and Boeing Field.

Existing airports in the vicinity of Sea-Tac and Boeing Field that may have potential as reliever airports include Snohomish County Airport (Paine Field), Kitsap County Airport, and Renton Municipal Airport. Paine Field and Kitsap County Airport both have instrument landing capability for a south flow operation but are located more than 25 miles from Boeing Field. Renton Municipal Airport, conveniently located only about 4 miles east of Boeing Field, does not currently have instrument landing capability for a south flow operation.

Before any airport is targeted as a secondary reliever airport to Sea-Tac and Boeing Field, careful analysis of the capability of that airport to receive additional aircraft operations during IFR conditions is essential. It is possible that an airport that may be designated as a secondary reliever airport would require additional airfield facilities, new navigational aids, or more basing facilities including aircraft servicing, repair, and maintenance.

In view of the administrative and financial implications of designating existing airports as secondary reliever facilities, it is likely that coordination at a regional level may be required to effect the use of the airports in the desired manner.

Thus alleviating the effects of the airspace interactions between Sea-Tac and Boeing Field by a system of reliever airports would require:

- Determination of local market/airport site relationships

- Identification of airports that (a) have the capability to accommodate additional IFR operations, or (b) could have the capability if certain improvements in facilities or services provided were made

- Public agency sponsor and financing for additional facilities as needed

- Identification of regional agency responsible for coordinating airport activities

- Environmental review process

DEMAND MANAGEMENT

Delay can be expected whenever traffic demand approaches or exceeds the airport or airspace capacity. When traffic occurs in bunches or peaks, there may be delays even though the total number of aircraft using the airport or the airspace is less than the rated capacity for that peak time period. Some amount of delay arises every time two aircraft are scheduled to use a runway or the same segment of airspace at the same time. The

probability of simultaneous arrivals increases rapidly as traffic levels approach the rated capacity, so that average delay for aircraft increases rapidly as traffic levels approach capacity.

By the year 2000, demand during peak periods at Sea-Tac for a south flow operation and IFR conditions will be at or exceeding the capacity of the airspace available for Sea-Tac's operations. Because of the interaction between Sea-Tac and Boeing Field, every arrival at Boeing Field will preclude an arrival at Sea-Tac. As a result, demand is expected to exceed available airfield and airspace capacity at Sea-Tac for several hours during a south flow when IFR conditions occur. From 5 p.m. to 6 p.m., the peak for combined Sea-Tac and Boeing Field traffic, forecast demand in IFR conditions for the year 2000 is 52 operations (33 arrivals, 19 departures) at Sea-Tac and 44 operations (26 arrivals, 18 departures) at Boeing Field. These demand levels result in an effective demand at Sea-Tac for a south flow of 52 + 26 = 78 operations per hour. Sea-Tac capacity under these conditions is 48 operations per hour under the baseline ATC scenario and 65 operations per hour under the optimistic ATC scenario.

Various "demand management" concepts have been considered at various locations to limit peak demands. These concepts are discussed in the following paragraphs.

IFR Quotas

Demand can be limited by setting a quota on the number of operations that can take place during peak periods in IFR conditions. The quota can be placed on total operations, or a certain number of operations can be allocated to different classes of users in IFR conditions. No quota will be necessary in VFR conditions. It would be necessary to consider demand levels in IFR conditions at both Sea-Tac and Boeing Field together when setting a quota because of the airspace interactions. For example, if it were desired to maintain aircraft delays at current levels, it would be necessary to establish a combined quota for Sea-Tac and Boeing Field at about 70 operations per hour during IFR conditions. This quota can be compared to the forecast of demand in the year 2000 at Sea-Tac and Boeing Field of 96 operations per hour. Thus, if all airline traffic were to be accommodated at Sea-Tac, this quota would essentially preclude any arrivals at Boeing Field during the quota period. Other quotas would yield correspondingly different average delays in IFR conditions.

Before the air traffic controllers' strike in 1981, "high density quotas" on IFR operations had been in effect at 4 airports since 1977 (Chicago O'Hare International Airport, J. F. Kennedy International Airport, LaGuardia Airport and Washington National Airport). Representatives of the air carriers were allowed to meet as scheduling committees (with antitrust immunity) to negotiate how many quota "slots" at these airports would be allocated to each carrier. General aviation aircraft IFR operations were accommodated using a reservation system. A similar quota system for Sea-Tac and Boeing Field could be developed.

Thus, alleviating the airspace interactions between Sea-Tac and Boeing Field by imposing a quota system on operations at those airports would require:

- Establishment of IFR quota limits and procedures
- Federal agency action to establish IFR quotas and cooperative methods for allocating slots among airlines and other aircraft operators
- Federal agency ruling concerning rights of airport access and interstate commerce
- Appropriate operating agreements by the Port of Seattle and King County on limitations to use of facilities

IFR Peak Period Surcharge

Demand in IFR conditions might also be limited by increasing user fees during peak periods to discourage traffic. Most airports now charge a landing fee based on the weight of the aircraft. This fee schedule is designed to recover construction and operating costs of the airfield facilities. However, when the use of an airport is nearing capacity in IFR conditions, it is conceivable that landing fees could be increased by a fixed amount per aircraft that would cause a reduction in operations. This method would allow users who value access to the airport at peak times in IFR conditions to pay for their preference; those who do not wish to pay the high fee would use the airport at other times, or perhaps use an airport

without the IFR peak period surcharge. Revenues raised from the surcharge could be used to offset airfield facility costs, similar to landing fee revenues today.

General aviation users are expected to be more sensitive than the airlines to a landing fee surcharge. The 1968 decision of the Port Authority of New York and New Jersey to increase minimum landing fees from $5 to $25 during peak hours brought about an immediate decline of about 30% in general aviation operations during peak hours at its three carrier airports and a noticeable decline in aircraft delays. In 1979, a $50 surcharge added to peak hour landing fees at Kennedy and LaGuardia resulted in a further decrease in general aviation traffic at these airports. However, some general aviation users (primarily high performance turbojet aircraft used for corporate travel) are often willing to absorb a fairly large increase in fees in order to use specific airports during peak hours.

Because the primary airspace interaction between Sea-Tac and Boeing Field only occurs in a south flow during IFR conditions, it may be possible to impose a peak hour surcharge that is effective only during the occurrence of those particular conditions.

Thus, alleviating the airspace interaction between Sea-Tac and Boeing Field by imposing a peak hour surcharge in IFR conditions would require:

- A practical method of determining the amount of surcharge to effect the desired reduction of IFR peak demand

- A practical means for collecting the surcharge
- Federal agency ruling concerning rights of airport access and interstate commerce
- Appropriate operating agreements between the Port of Seattle and King County
- Possible modification of existing airport/airline use agreements

Cooperative Rescheduling of Flights

Because airlines provide scheduled service at times as close as possible to the desires of the traveling public, it is unrealistic to assume that the airlines would voluntarily reschedule flights to off-peak times. Also, cooperative rescheduling of general aviation flights would be impractical.

EVALUATION OF MEASURES

The seven individual measures that have been described were evaluated in terms of (a) effect on airfield and airspace capacity, (b) effect on aircraft delay, (c) cost of implementation, and (d) feasibility of implementation. Table 7-1 summarizes the evaluation of these measures.

Table 7-1

SUMMARY OF MEASURES TO ALLEVIATE AIRSPACE INTERACTIONS

Measure	Effect on capacity	Effect on delay	Implementation			Comments
			Capital Cost	Feasibility	Primary responsibility	
Improved ATC Technology						
Reduced aircraft separations	Increase	Reduce	Unknown	Low in near term	FAA	Requires successful wake vortex research, FAA and industry acceptance, and new rules and procedures. May require additional exit taxiway(s).
Potential instrument approach using MLS to Sea-Tac	Increase	Reduce	Unknown	Low in near term	FAA	Requires installation of MLS, cockpit avionics, FAA and industry acceptance, and new rules and procedures.
Airport Facility Improvements						
Potential new runway at Sea-Tac	Increase	Reduce	High	Low	Port	Severe site constraints make feasibility extremely doubtful.
Reliever airports	None[a]	Reduce	Unknown	Moderate	Port/County/ other airport operators	Depends on local market/airport site relationships.
Demand Management						
IFR Quotas[b]	None[a]	Reduce	Low	Moderate	FAA/Port/ County	Requires federal agency approval and operating agreements between the Port of Seattle and King County.
IFR peak period surcharge[b]	None[a]	Reduce	Low	Low in near term	Port/County/ FAA	Requires federal agency approval and operating agreements between the Port of Seattle and King County. Effective amount of surcharge needs to be determined. May require amendment of existing airline use agreements at Sea-Tac.
Cooperative rescheduling of flights	None[a]	Reduce	Unknown	Very low	Airlines	Airline economics virtually preclude voluntary rescheduling.

a. No change in capacity unless significant changes in aircraft mix result.
b. Would need to be applied to Sea-Tac and Boeing Field simultaneously.

Source: Peat, Marwick, Mitchell & Co.

Effect on Airfield and Airspace Capacity

As shown in Table 7-1, only three of the measures have potential for increasing airfield and airspace capacity: reduced aircraft separations, the MLS approach at Sea-Tac, and a new runway at Sea-Tac. Of the three measures, reduced aircraft separations would provide the greatest increase in airfield and airspace capacity. As shown on Table 6-1, the capacity of Sea-Tac in IFR conditions increases from 48 operations per hour under the baseline ATC scenario to 65 operations per hour under the optimistic ATC scenario (which assumes reduced aircraft separations).

The MLS approach to Sea-Tac does not increase the capacity of Sea-Tac significantly--perhaps by only 1 or 2 operations per hour. The primary benefit of this measure is that it allows the capacity of Sea-Tac to be fully realized because of the elimination of the interaction with Boeing Field arrivals.

A new fully instrumented Runway 13-31 at Sea-Tac would provide a small increase in capacity--perhaps 2 or 3 operations per hour--if operated so that small aircraft (on Runway 13) are segregated from the large and heavy aircraft (on Runway 16R). Again, the primary benefit of this measure is that it reduces the use of the instrument approach to Runway 16R during IFR conditions and hence reduces the interaction with Boeing Field arrivals.

Effect on Aircraft Delay

All of the measures listed in Table 7-1, if implemented, would result in reduced aircraft delays at Sea-Tac. Of these measures, reduced aircraft separations would provide for the greatest reduction in aircraft delays. It should be noted that the estimates of delay reductions are based on the assumption that aircraft separations would be decreased in accordance with the optimistic scenario described in Chapter 6. However, if assumed decreases in separations are only partially achieved, smaller delay reductions would result. For example, the FAA is considering reclassifying certain heavy aircraft to the large classification on the basis of wake turbulence data. This reclassification would effectively reduce separation standards for these specific aircraft and may be of limited benefit in reducing delays in the near term.

As shown in Table 6-2, total annual delays at Sea-Tac in the year 2000 are reduced from 1,199,000 minutes under the baseline ATC scenario to 252,000 minutes under the optimistic ATC scenario (which assumes reduced separations)--a savings of about 947,000 minutes of delay annually. A similar savings in aircraft delays may be obtained with the MLS approach to Sea-Tac, which in essence removes the airspace interaction between Sea-Tac and Boeing Field for a south flow. As shown in Table 6-4, the effect of assuming no interaction between the airports for the baseline ATC scenario in the year 2000 is a reduction in aircraft delay at Sea-Tac of 887,000 minutes.

The extent of the delay reductions from all of the remaining measures depends on the number of aircraft that are removed from the interacting ILS approaches to Sea-Tac and Boeing Field during IFR conditions in a south flow. For

example, a new fully instrumented Runway 13-31 at Sea-Tac may result in 6 to 8 arrivals in the small aircraft class that would not have to use the instrument approach to Runway 16R at Sea-Tac, hence alleviating the airspace interaction and reducing aircraft delays. Similarly, the level of an IFR quota at Sea-Tac and Boeing Field would determine the reduction in aircraft delays.

Cost of Implementation

By necessity, the following discussion on the capital cost of implementing these measures has to be qualitative--sufficient information is not available to assess the costs quantitatively. Further, the cost of implementing four of the measures is unknown. For example, the reduced aircraft separations and the MLS approach to Sea-Tac measures involve research and development programs as well as the installation of sophisticated avionic equipment in aircraft--the details of which are not yet defined. The reliever airports measure may involve only the use of a demand management technique in order achieve aircraft use of an airport other than Sea-Tac or Boeing Field. Thus, if the existing airport to which the traffic is diverted does not require significant facility improvements, the cost of implementing the measure could be relatively low. However, if the existing airport to which the traffic diverted requires extensive facility improvements, the costs of implementing the measure could be high. Obviously, the costs to the airlines of rescheduling flights is unknown.

The cost of building a new runway at Sea-Tac approximately 5,000 feet long would include construction as well as associated costs of providing navigational aids to permit an instrument approach, relocation costs of existing facilities, etc. The costs of this measure would be high relative to the other measures.

The costs of implementing IFR quotas and a peak period surcharge are relatively low because these measures do not involve significant capital investments.

Feasibility of Implementation

The feasibility of the reduced aircraft separation measure is dependent to a large extent on the success of research programs aimed at minimizing the effects of wake vortices. These programs face many technical obstacles and problems of acceptance by controllers and pilots. Several of these programs have been under way for many years without success; some are not active at present. Therefore, the outlook for significant near-term benefits is not promising, and there is no assurance that such benefits will be realized, even over the long term.

The feasibility of the potential instrument approach using MLS at Sea-Tac is totally dependent on the success of FAA's program to replace ILS with MLS. The anticipated resistance to MLS from aircraft operators, because of the cost of the MLS avionics, and the ICAO agreement that will require the retention of ILS at Sea-Tac until at least 1995, make it unlikely that an MLS approach to Sea-Tac will be feasible in the next 10 to 15 years. In

addition, the development of a dual independent approach concept described previously would require even more research, testing, and demonstration. Hence this measure is rated low in the near term.

The feasibility of a new runway at Sea-Tac is rated low because of the site constraints that would limit its length to 5,000 feet (and hence limit its utility), and because of its potentially high cost.

The feasibility of the reliever airports measure, which is rated moderate, is dependent on the availability of airports in the vicinity of Sea-Tac and Boeing Field to provide instrument approach capability in a less congested environment. As noted earlier, there are airports that have either the convenience of location or the instrument approach capability, but not both.

IFR quota systems have been in effect at several high activity U.S. airports since 1977 and have been demonstrated to work, although not without certain difficulties at times. In this situation, however, there is the complicating factor that a quota system would be necessary for a combined Sea-Tac and Boeing Field operation. Therefore, the feasibility of this measure is rated moderate.

The feasibility of an IFR peak period surcharge is dependent on establishing an "effective" value for the surcharge and determining a practical method for collection. Although similar measures have been used at other airports, current airline use agreements may preclude the imposition of such a surcharge at Sea-Tac. Hence, the feasibility of this measure is rated low in the near term.

Cooperative rescheduling of flights to off-peak times is precluded by airline economics and the overall impracticality of the measure. Hence, the feasibility of this measure is rated very low.

SUMMARY

Airspace interactions between Sea-Tac and Boeing Field are expected to cause significant levels of aircraft delays by the early 1990s. These delays are projected to increase very rapidly through the 1990s and beyond.

As described previously, the interactions are most critical during IFR conditions and when the two airports are operated in a south flow configuration. IFR south flow conditions occur about 7% of the time. The interactions also are important during IFR conditions and when the airports are operated in a north flow configuration. IFR north flow conditions occur about 2% of the time.

Significance of Delays to Aircraft Operators

The projected delays will become increasingly important to aircraft operators and their passengers because delays will disrupt operations and schedules and result in substantial increases in operating costs.

For example, in IFR south flow conditions, average peak hour delays to aircraft using Sea-Tac under the baseline ATC scenario are expected to increase dramatically from about 11 minutes in 1980 to about 19 minutes in 1990 and to more than 60 minutes in the year 2000. At Boeing Field, average

peak hour delays are expected to exceed 15 minutes by the year 2000. As noted in Chapter 5, the airspace interactions between Boeing Field and Sea-Tac are sensitive to demand levels at both airports. For example, although IFR peak hour demand at Sea-Tac is projected to increase about 2% by 1990 and 7% by the year 2000 (compared to 1980), peak hour delays (south flow) are projected to increase 75% and 500% by those years, respectively.

The cost of aircraft delays caused by airspace interactions is expected to be high. Total delay costs to the airlines alone caused by the interactions are expected to be about $2 million in 1990 and about $19 million annually by the year 2000 (for the baseline ATC scenario). Aggregate delay costs to the corporate and other general aviation aircraft operators will be less because of the lower aircraft operating costs of these aircraft. Nonetheless, the operators of these aircraft are also expected to be concerned about the costs of their delays.

Significance of Delays to Others

The negative effects of the interactions and resulting delays are not limited solely to aircraft operators and their passengers. Sea-Tac and Boeing Field play vital and distinct roles in serving aviation in the metropolitan area. The Port of Seattle and King County have made major investments in these airports.

Ultimately, the magnitude and cost of delays could be so high that they become a negative influence on the level of airline service at Sea-Tac and the service provided to business aircraft at Boeing Field. Thus, to the

extent that new airline service at Sea-Tac and the accommodation of business aircraft at Boeing Field are considered integral to the economic growth of the region, the constraining effects of airspace interactions in the future will become increasingly important to the Port of Seattle and King County.

Also, aircraft delays of the magnitude estimated in this study imply a major increase in the workload of the FAA air traffic control system associated with the two airports.

Summary of Measures and Programs

A wide variety of measures to reduce delay have been considered in this chapter under the broad categories of (1) Improved ATC Technology, (2) Airport Facility Improvements, and (3) Demand Management. As discussed previously, no individual measure can be counted on to alleviate future aircraft delays and some are more feasible than others. Two measures have been removed from further consideration because of inadequate prospects for implementation (new runway at Sea-Tac, cooperative rescheduling of flights). A combination of individual measures--a program--may be required to alleviate or eliminate the airspace interactions between Sea-Tac and Boeing Field.

The measures involving future ATC technology (reduced aircraft spacing, and a potential instrument approach using MLS to Sea-Tac) could provide the necessary capacity to meet demands through the year 2000. However, the outlook for significant reductions in aircraft separations or in developing a new instrument approach at Sea-Tac using MLS is not bright. There is no reliable means of predicting if and when these measures will be available.

Therefore, the other measures such as reliever airports, IFR quotas, and peak period surcharges need to be explored further so that one or more are available for implementation, either individually, partially, or in combination as part of a program, when required in the future. For example, the use of reliever airports without some form of incentive (such as a quota or peak period surcharge) is unlikely to have a significant effect on alleviating or eliminating the airspace interaction. Thus, a program that would eventually lead to the development of reliever airports (with instrument landing capability and in a convenient location) and some form of demand management at Sea-Tac and Boeing Field may prove effective. It it likely that such a program would involve coordination of airport activities at a regional level. The long lead time associated with implementing these measures and programs shows that certain preliminary steps should begin in the near future.

Appendix G

DEVELOPMENT PROGRAMS CONCERNING WAKE TURBULENCE

FAA development programs concerning wake turbulence detection and alleviation include: vortex advisory system (VAS), wake vortex avoidance system (WVAS), aerodynamic alleviation, the use of Doppler radar for wake detection, and the use of microwave landing systems (MLS) for multiple approach and glide paths.

1. Vortex Advisory System (VAS). The VAS is a predictive concept based on the observation that current separation standards may be overly conservative much of the time, because certain wind conditions cause vortices to dissipate or move out of the flight path of a following aircraft within a short time. A test system at Chicago O'Hare International Airport has proved technically workable, but has not been found operationally acceptable by users. An industry task force is recommending that the FAA reactivate its program for developing a usable VAS system.

2. Wake Vortex Avoidance System (WVAS). The WVAS concept uses meteorological and sensor data to detect, track, and predict vortex motion and decay. Conceptually, the WVAS would give the controller automated spacing requirements for specific aircraft that would provide positive vortex avoidance. In February 1977, a Transportation Systems Center report* concluded that, with a

---

*"Aircraft Wake Vortices: A State of the Art Review of the United States R&D Program."

system meeting the design goals of WVAS, 3-mile separation between aircraft of any type could be used safely 99% of the time and that a WVAS could allow down to 2-mile separation 86% of the time.

Although considerable time has been spent in efforts to develop a WVAS, all that presently exists is the system concept. Considerable development is necessary to determine the operational feasibility and safety of the system.

3. Vortex Alleviation Through Aircraft Design. Wind tunnel and flight test programs indicate that it is possible to reduce the adverse effects of wake vortices by a limited amount through aerodynamic design. Some disadvantages result--such as increased fuel usage* and noise--and these must be considered in contrast to the benefits of reduced in-trail final approach spacing.

Research is continuing in this area by the FAA, NASA, and the industry, but according to the FAA, "these efforts have not reached the stage where either the airframe manufacturers or the users feel implementable wake vortex alleviation systems are achievable."**

---

*Increased fuel usage is estimated to cost $4.50 per aircraft per landing. Source: "New Engineering and Policy Initiatives," Volume 1, March 1, 1979; DOG-FA77 WA-400J, Department of Transportation, FAA.

**"Operating Procedures of Aircraft and Airports Likely to Impact Their Compatibility." Paper presented by Mr. A. Adil, FAA, for Transportation Research Board, January 20, 1982.

4. Use of Doppler Radar to Detect Vortices. The FAA tested the performance of the National Oceanic and Atmospheric Administrations (NOAA) FM-CW Doppler weather radar system to detect wake vortex related echos from large aircraft landing at Denver Stapleton International Airport. According to the FAA, the results of this effort will be available this fall. If detection of vortices on the final approach course becomes operationally feasible and practical, it may become possible for controllers to safely reduce longitudinal spacing from current requirements under certain conditions. It appears that the potential benefits of this concept offer sufficient promise to justify further investigation and study; however, significant near-term capacity benefits are unlikely.

5. Use of MLS to Avoid Wake Vortices. The microwave landing system (MLS) can provide multiple approach and glide paths, whereas the present instrument landing system (ILS) provides only straight-line guidance along a single path. Higher glide paths could enable the "following" aircraft to fly above the path of the lead aircraft and therefore not be adversely affected by the lead aircraft's wake vortices. Similarly, different approach paths for following aircraft may provide some benefits, especially if the lead (and heavier) aircraft is downwind. The potential for capacity increase is limited by the number of aircraft that can use high-angle glide paths and by the numbers of small, large, and heavy aircraft in the aircraft mix. Also, multiple approach paths

may be constrained by noise and other environmental considerations, aircraft performance, obstructions, airspace and other operational restrictions, and air traffic demand patterns.

Further, any potential benefits will be long term, because the FAA's MLS transition plan* is to be carried out over the next 20 years. Also, the United States is committed (by an agreement with the International Civil Aviation Organization) to retain ILS service at international gateway airports through 1995. General aviation aircraft operators, who potentially could provide the greatest benefits in system capacity if their aircraft are MLS-equipped (and if wake turbulence separations can be reduced), may be reluctant to purchase MLS equipment (at a cost of $5,000 or more per aircraft) as long as ILS is available.

---

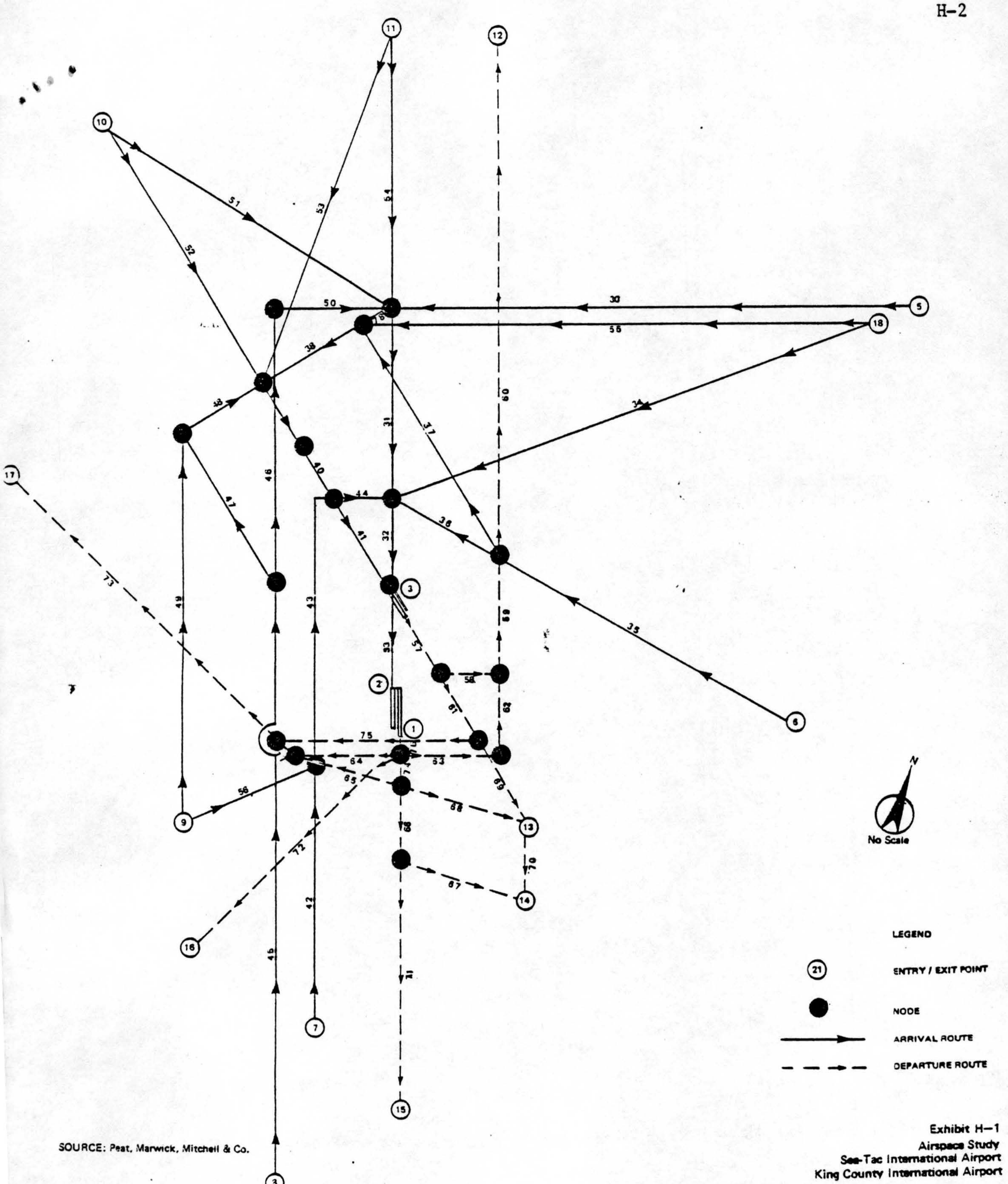
*Microwave Landing System Transition Plan, APO-81-1, FAA, May 1981.

Appendix H

SIMULATION OF POTENTIAL INSTRUMENT APPROACH AT SEA-TAC

Peat Marwick's airspace simulation model was applied to demonstrate the difference in aircraft delays that might be expected from implementing a potential dual independent instrument approach procedure to Runway 13R at Boeing Field and Runway 16R at Sea-Tac using a microwave landing system (MLS), as described in Chapter 7. For comparison, two model runs were made; one assuming a new instrument approach procedure using an MLS, the other assuming the existing straight-in instrument landing system (ILS) approaches. The model was run for five hours from 3 p.m. to 8 p.m., using the year 2000 projected level of demand for Sea-Tac and Boeing Field under the optimistic ATC scenario. Exhibit H-1 shows the basic network representation of the airspace near Sea-Tac and Boeing Field for a south flow operation under current operating procedures with an ILS approach to Runway 16R at Sea-Tac. This formed the basis for a similar network, shown in Exhibit H-2, which reflects the new instrument approach to Runway 16R at Sea-Tac with an MLS approach.

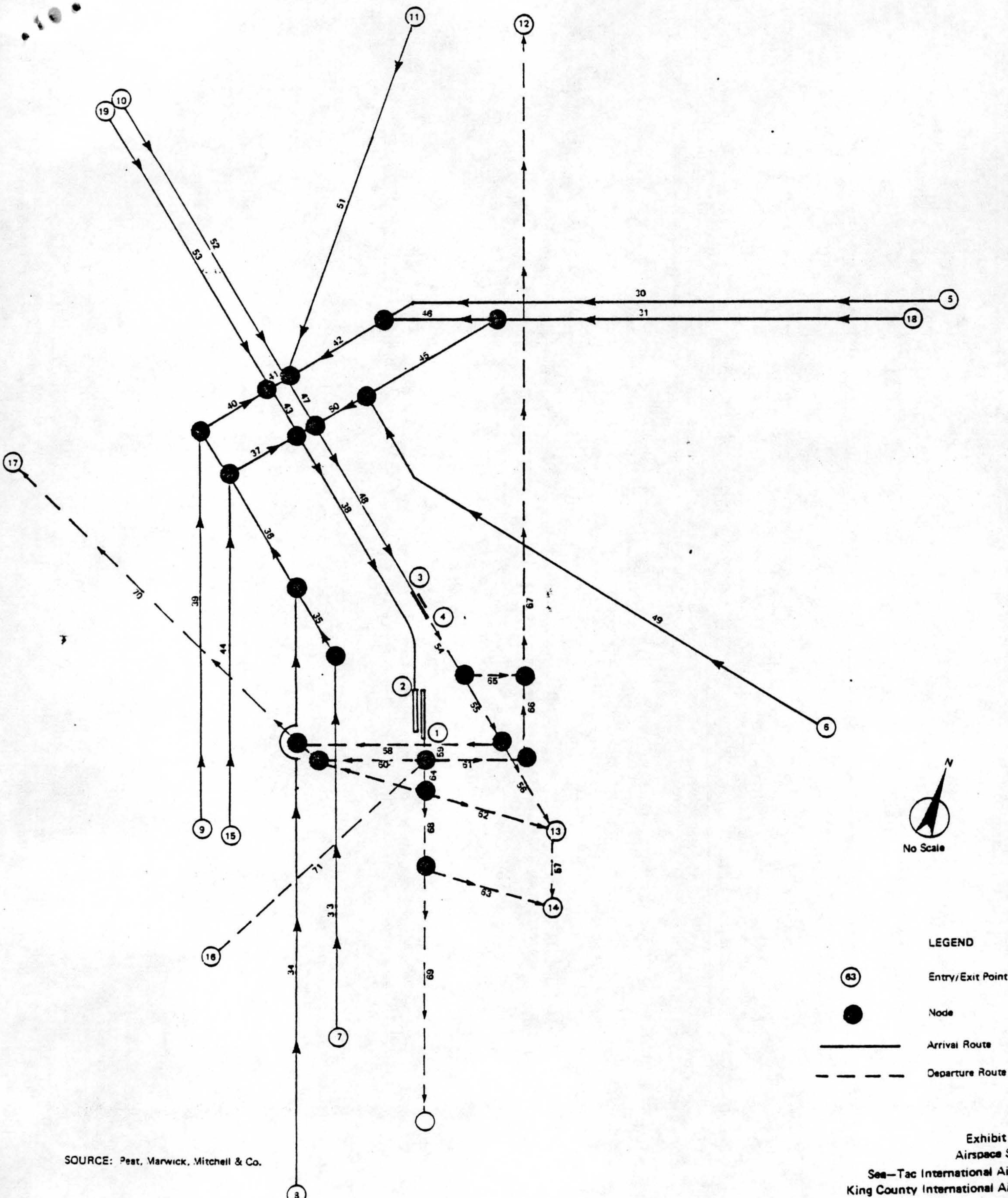
The results of the model runs, which are summarized in Table H-1, show that aircraft delays are reduced dramatically by assuming the new instrument approach procedure. Peak hour delays were reduced from about 18 minutes per aircraft for the ILS approach to about 4 minutes per aircraft assuming the MLS approach. Thus, with the new procedure, aircraft delays may be reduced to a level equivalent to assuming no interaction between Sea-Tac and Boeing Field (see Table 6-5).



SOURCE: Peat, Marwick, Mitchell & Co.

Exhibit H–1
Airspace Study
Sea-Tac International Airport
King County International Airport
AIRSPACE NETWORK – ILS APPROACH TO SEA–TAC
Peat, Marwick, Mitchell & Co. September 1982

WORKING DRAFT
FOR DISCUSSION PURPOSES ONLY



SOURCE: Peat, Marwick, Mitchell & Co.

Exhibit H-2
Airspace Study
Sea-Tac International Airport
King County International Airport
AIRSPACE NETWORK – MLS APPROACH TO SEA-TAC
Peat, Marwick, Mitchell & Co. September 1982

Table H-1

RESULTS OF SIMULATION ANALYSIS OF POTENTIAL INSTRUMENT APPROACH (WITH MLS) TO SEA-TAC

	Demand (Operations)						Existing ILS Approaches		Dual Approach Using MLS	
	Sea-Tac			Boeing						
Hour	Arrival	Departure	Total	Arrival	Departure	Total	Flow rate* (operations)	Average delay* (minutes)	Flow rate* (operations)	Average delay* (minutes)
3:00-3:59 p.m.	18	19	37	19	10	29	37	5.1	37	1.3
4:00-4:59 p.m.	17	23	40	26	18	44	39	10.9	40	2.1
5:00-5:59 p.m.	33	19	52	19	13	32	46	14.2	52	3.7
6:00-6:59 p.m.	29	24	53	15	10	25	50	18.2	53	4.1
7:00-7:59 p.m.	28	22	50	11	5	16	54	16.4	50	3.1
8:00-8:59 p.m.	27	14	41	6	4	10	47	6.7	41	2.2

*Flow rates and aircraft delays are for Sea-Tac operations.

Source: Peat, Marwick, Mitchell & Co.