Capacity Analysis and Facility Requirements

Introduction

The capacity analysis for Paine Field is composed of two distinct elements: the ability of airport facilities to accommodate existing and projected aircraft operations (airfield capacity) and the ability of airport facilities to accommodate existing and projected ground vehicle operations (airport access capacity). The capacity of an airfield is primarily a function of the major aircraft traffic surfaces (runways and taxiways) that composes the facility and the configuration of those surfaces, but it is also related to, and considered in conjunction with, wind coverage, airspace utilization, and the availability and type of navigational aids. Airport access capacity is a function of the existing and/or future vehicular roadways located in the vicinity of the airport and their interface with the various airport specific access roads.

The capacity of the existing airfield and access facilities is analyzed with respect to the ability of each to accommodate current and forecast demand. This analysis aids in the identification of possible deficiencies in the present and/or future airport physical plant.

Airfield Capacity Methodology

This section addresses the evaluation method used to determine the capability of the airside facilities to accommodate aviation operational demand. Evaluation of this capability is expressed in terms of potential excesses and deficiencies in capacity. The methodology utilized for the measurement of airfield capacity in this study is described in FAA Advisory Circular 150/5060-5, *Airport Capacity and Delay*. From this methodology, airfield capacity is defined in the following terms:

- *Hourly Capacity of Runways:* The maximum number of aircraft that can be accommodated under conditions of continuous demand during a one-hour period.

- *Annual Service Volume (ASV):* A reasonable estimate of an airport's annual capacity (i.e., the level of annual aircraft operations that will result in an average annual aircraft delay of approximately one to four minutes).

The capacity of an airport's airside facilities is a function of several factors. These include the layout of the airfield, local environmental conditions, specific characteristics of local aviation demand, and air traffic control requirements. The relationship of these factors and their cumulative impact on airfield capacity is examined in the following paragraphs.

Airfield Layout

The layout or "design" of the airfield refers to the arrangement and interaction of the airfield components, which include the runway system, taxiways, and ramp entrances. As previously described, Paine Field is operated around three runways. Runway 16R/34L is the primary runway served by an east side full-length parallel taxiway (Taxiway A). Runway 16L/34R, the secondary parallel runway, is served by two full-length parallel taxiways, Taxiway F on the east side and Taxiway G on the west side. Runway 11/29, the crosswind runway, is served by a full-length northeast side parallel taxiway (Taxiway D) and an additional partial parallel taxiway (Taxiway C). This runway system is served by several runway exit taxiways and connector taxiways designed to minimize aircraft runway occupancy times, thus increasing the capacity of the runway system.

In general, the airport's existing landside facilities are well distributed around airport property, with the exception of the west side, which is primarily undeveloped. Located on the northeast portion of airport property, east of Airport Road, is the BOMARC Business Park complex. The Boeing Company aircraft assembly facility is located immediately north and east of the airport. The airport's administration offices, general aviation hangar and apron areas, the airport air traffic control tower, fuel storage facilities, facilities associated with Everett Community College, and the Museum of Flight are located on the north central portion of the airfield. Goodrich Inc. and the ARFF facilities are located on the southern portion of airport property, while general aviation facilities encompass the central and eastern portions of the airport. Each of these facilities is well situated to efficiently utilize the existing taxiway system.

Environmental Conditions

Climatological conditions specific to the location of an airport not only influence the layout of the airfield, but also impact the utilization of the runway system. Variations in the weather resulting in limited cloud ceilings and reduced visibility typically lower airfield capacity, while changes in wind direction and velocity typically dictate runway usage and also influence runway capacity.

Paine Field and the Puget Sound area exhibit a weather phenomenon known as the Puget Sound Convergence Zone. When the eastward flow of air from the Pacific Ocean meets the Olympic Mountains, it does one of two things, travels over the mountains or around the mountains. The path of least resistance in this case is around the mountains. Thus, airflow in the Sound occurs from both the north and the south producing large amounts of rainfall. When Paine Field experiences airflow from the north, Seattle may be experiencing just the opposite with airflow from the south. This phenomenon at times can play havoc on the local air traffic control system with two different flows of traffic into and out of airports thirty miles apart.

Ceiling and Visibility. FAA Advisory Circular 150/5060-5, *Airport Capacity and Delay*, describes three categories of ceiling and visibility minimums for use in both capacity and delay calculations. Visual Flight Rules (VFR) conditions occur whenever the cloud ceiling is at least 1,000 feet above ground level and the visibility is at least three statute miles. Instrument Flight Rules (IFR) conditions occur when the reported cloud ceiling is at least 500 feet, but less than 1,000 feet and/or visibility is at least one statute mile, but less than three statute miles. Poor Visibility and Ceiling (PVC) conditions exist whenever the cloud ceiling is less than 500 feet and/or the visibility is less than one statute mile.

However, meteorological data obtained for Paine Field from the National Climatic Data Center for use in this study, has been categorized in more specific terms:

- VFR conditions - ceiling equal to or greater than 1,000 feet above ground level and visibility equal to or greater than 3 statute miles. These conditions occur at the airport approximately 89.1% of the time annually.
- VFR minimums to Category I ILS minimums - ceiling less than 1,000 feet and/or visibility less than 3 statute miles, but ceiling equal to or greater than 200 feet and visibility equal to or greater than ½ statute mile. These conditions occur at the airport approximately 8.9% of the time annually.
- Below minimums - ceiling less than 200 feet and/or visibility less than ½ statute mile. These conditions occur at the airport approximately 2% of the time annually.

Therefore, in consideration of the airport's existing approach instrumentation (i.e., the precision instrument approach to Runway 16R/34L and historical meteorological records), the airport can be expected to experience VFR conditions approximately 89.1% of the time, IFR conditions approximately 8.9% of the time, and below minimums approximately 2% of the time.

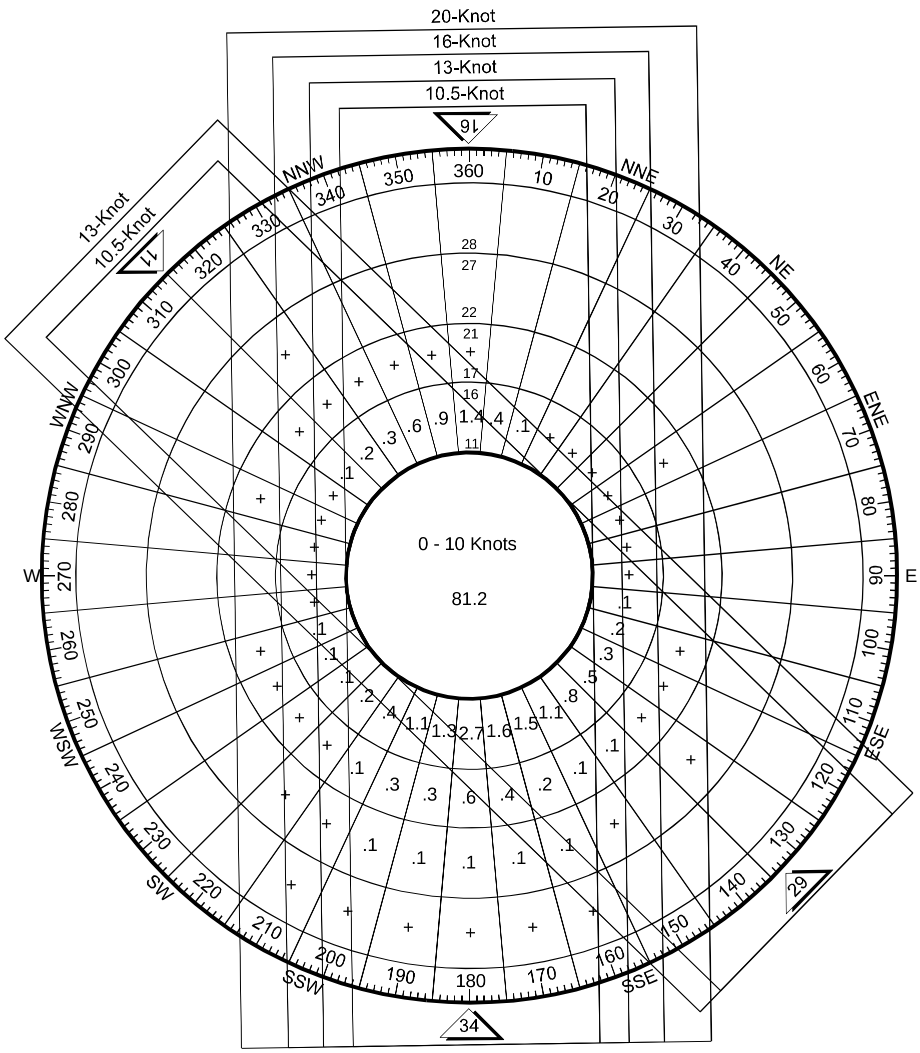
Wind Coverage. Surface wind conditions (i.e., direction and speed) generally determine the desired alignment and configuration of the runway system. Runways, which are not oriented to take advantage of prevailing winds, will restrict the capacity of the airport.

Wind conditions affect all airplanes in varying degrees; however, the ability to land and takeoff in crosswind conditions varies according to pilot proficiency and aircraft type. Generally, the smaller the aircraft, the more it is affected by the crosswind component.

To determine wind velocity and direction at Paine Field, wind data to construct the all weather wind rose was obtained for the period 1991-2000 from observations taken at the airport. There were approximately 51,068 observations available for analysis during this ten-year period. The allowable crosswind component is dependent upon the Airport Reference Code (ARC) for the type of aircraft which utilize the airport on a regular basis. According to the existing Airport Layout Plan, the current Airport Reference Code (ARC) for Runway 16R/34L is D-V.

In consideration of the ARC D-V classification, these standards specify that the 20-knot crosswind component be utilized for analysis. In addition, it is known that the airport will continue to also serve small single and twin-engine aircraft for which the 10.5-knot crosswind component is considered maximum; therefore, the 20-knot and 10.5-knot crosswind components should be analyzed for this airport. The following illustration, entitled *ALL WEATHER WIND ROSE: 20-, 16-, 13- & 10.5-KNOT CROSSWIND COMPONENTS*, illustrates the all weather wind coverage provided at Paine Field. For comparison purposes, the 13- and 16-knot crosswind components have also been included.

Figure C1
ALL WEATHER WIND ROSE: 20-, 16-, 13- & 10.5-KNOT CROSSWIND COMPONENTS
Paine Field Master Plan Update



Source: National Oceanic and Atmospheric Administration, National Climatic Data Center
Station # 72793 – Paine Field, Snohomish County, Everett, WA. Period of Record – 1991-2000. Total Observations: 51,068.

The desirable wind coverage for an airport's runway system is 95%. This means that the runway orientation and configuration should be developed so that the maximum crosswind component is not exceeded more than 5% of the time annually. The following table, entitled *ALL WEATHER WIND COVERAGE SUMMARY*, quantifies the wind coverage offered by the airport's existing runway system, including the coverage for each runway end. Based on the all weather wind analysis for Paine Field, utilizing the FAA Airport Design Software supplied with AC 150/5300-13, the existing runway configuration provides 100.0% wind coverage for the 20-knot crosswind component, 99.99% wind coverage for the 16-knot crosswind component, 99.98% wind coverage for the 13-knot crosswind component, and 99.95% for the 10.5-knot crosswind component. Therefore, no additional runways are required from a *wind coverage* standpoint.

Table C1
ALL WEATHER WIND COVERAGE SUMMARY
Paine Field Master Plan Update

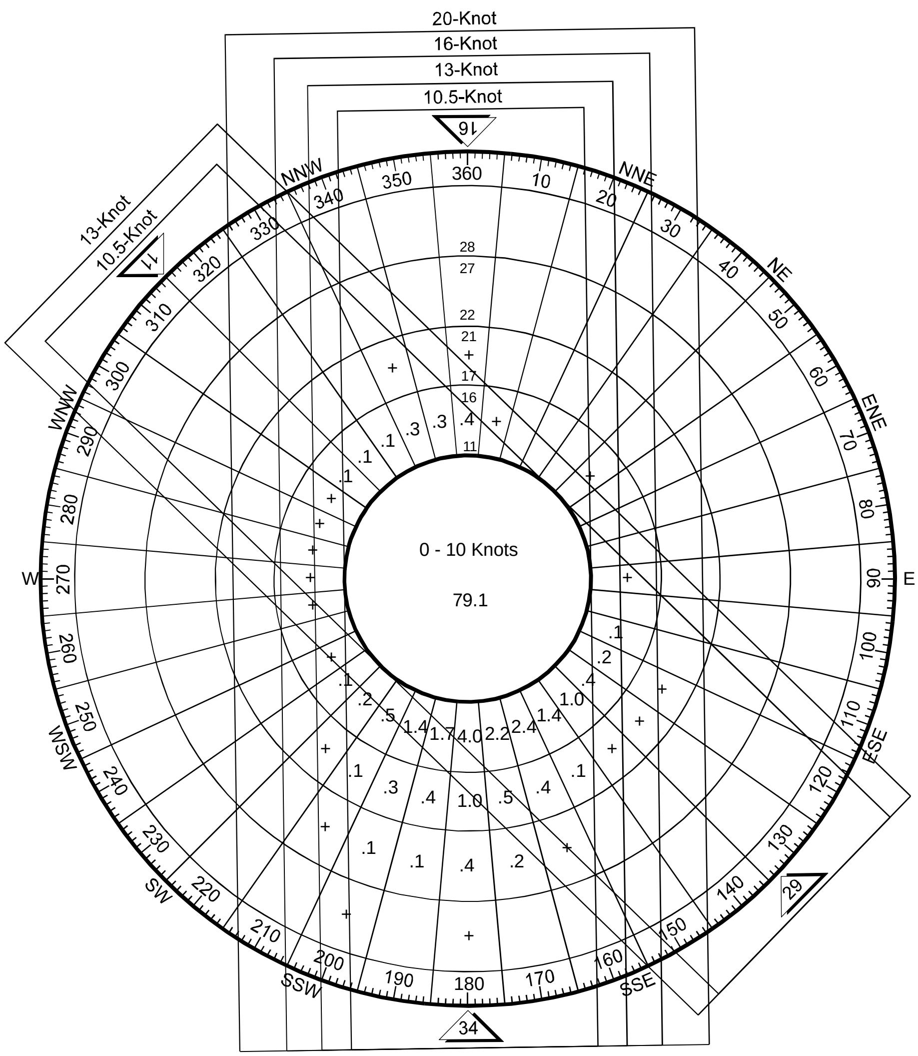
Runway Designation	20-Knot Crosswind Component	10.5-Knot Crosswind Component
Runway 16/34	99.99%	98.62%
Runway 16	74.80%	73.53%
Runway 34	65.63%	65.20%
Runway 11/29	99.83%	93.35%
Runway 11	77.09%	71.53%
Runway 29	65.98%	63.96%
Combined	100.0%	99.95%

Source: Wind analysis tabulation provided by Barnard Dunkelberg & Company utilizing the FAA Airport Design Software supplied with AC 150/5300-13.

It should be noted these statistics indicate that Runway 11/29 is rarely needed to provide crosswind coverage at Paine Field. There are, however, several other considerations that should be analyzed. These include the benefits provided by having a crosswind practice runway at an airport like Paine Field that is a center for flight training and the operational flexibility provided by having a 4,500-foot runway available for use if one of the other runways is temporarily closed for any reason.

The airport is served by a precision ILS and a VOR or GPS-B approach. In an effort to evaluate the effectiveness of these approaches, an Instrument Flight Rules (IFR) wind rose has been constructed. The following illustration and table quantify the wind coverage offered by each runway end.

Figure C2
IFR WEATHER WIND ROSE: 20-, 16-, 13- & 10.5-KNOT CROSSWIND COMPONENTS
Paine Field Master Plan Update



Source: National Oceanic and Atmospheric Administration, National Climatic Data Center
Station # 72793 – Paine Field, Snohomish County, Everett, WA. Period of Record – 1991-2000. Total Observations: 51,068.

Table C2
IFR WIND COVERAGE SUMMARY
Paine Field Master Plan Update

Runway Designation	Wind Coverage Provided Under IFR Conditions (1) 20-Knot Maximum Crosswind	Wind Coverage Provided Under IFR Conditions (1) 10.5-Knot Maximum Crosswind
Runway 16/34	100.00%	98.95%
Runway 16	85.35%	84.37%
Runway 34	50.48%	50.20%
Runway 11/29	99.75%	92.22%
Runway 11	87.50%	80.17%
Runway 29	55.46%	54.11%
Combined	100.0%	99.92%

Source: Wind analysis tabulation provided by Barnard Dunkelberg & Company utilizing the FAA Airport Design Software supplied with AC 150/5300-13.
(1) Ceiling of less than 1,000 feet, but equal to or greater than 200 feet and/or visibility less than 3 statute miles, but equal to or greater than ½ statute mile.

From this IFR wind coverage summary, it can be determined that Runway 16 provides better wind coverage for each crosswind component, which is where the existing precision instrument approach is located. However, additional analysis of a 34L precision approach will be undertaken to address future noise levels, as well as the alleviation of "head-to-head" flight operations. The information provided by this analysis will be incorporated into the formulation of various future airside development alternatives and the ultimate development recommendations for the airport.

Characteristics of Demand

Certain site-specific characteristics related to aviation use and aircraft fleet makeup impact the capacity of the airfield. These characteristics include runway use, aircraft mix, percent arrivals, touch-and-go operations, and exit taxiways.

Aircraft Mix. The capacity of a runway is dependent on the type and size of the aircraft that utilize the facility. Aircraft are categorized into four classes: Classes A and B consist of small single engine and twin-engine aircraft (both prop and jet), weighing 12,500 pounds or less, which are representative of the general aviation fleet. Class C and D aircraft are large jet and propeller aircraft typical of those utilized by the airline industry and the military. Aircraft mix is defined as the relative percentage of operations conducted by each of these four classes of aircraft. In consideration of the forecasts presented in the previous chapter, an aircraft mix table has been generated. The following table, entitled *AIRCRAFT CLASS MIX FORECAST, 2000-2021,* presents the projected operational mix for the selected forecasts.

Table C3
AIRCRAFT CLASS MIX FORECAST, 2000-2021
Paine Field Master Plan Update

	VFR Conditions			IFR Conditions		
Year	**Class A & B**	**Class C**	**Class D**	**Class A & B**	**Class C**	**Class D**
2000 (1)	93.4%	5.0%	1.6%	80.0%	13.0%	7.0%
2006	90.0%	7.5%	2.5%	80.0%	13.0%	7.0%
2011	90.0%	7.5%	2.5%	80.0%	13.0%	7.0%
2016	90.0%	7.5%	2.5%	80.0%	13.0%	7.0%
2021	90.0%	7.5%	2.5%	80.0%	13.0%	7.0%

Class A - Small Single Engine, < 12,500 pounds
Class B - Small Twin-Engine, < 12,500 pounds
Class C - 12,500 - 300,000 pounds
Class D - > 300,000 pounds
(1) Existing percentage breakdown was estimated by Barnard Dunkelberg & Company (BD&Co.)

Percent Arrivals. Runway capacity is also significantly influenced by the percentage of all operations that are arrivals. Because aircraft on final approach are typically given absolute priority over departures, higher percentages of arrivals during peak periods of operations reduce the Annual Service Volume (ASV). The operations mix occurring on the runway system at Paine Field reflects a general balance of arrivals to departures; therefore, it was assumed in the capacity calculations that arrivals equal departures during the peak period.

Touch-And-Go Operations. A touch-and-go operation refers to an aircraft maneuver in which the aircraft performs a normal landing touchdown followed by an immediate takeoff, without stopping or taxiing clear of the runway. These operations are normally associated with training activity and are included in local operations figures when reported by an air traffic control tower. According to FAA *Form 5010*, touch-and-go operations are estimated to represent 50% of the total annual operations being conducted at the airport. It is anticipated that the level of flight training will increase through the planning period; however, the airport will continue to be a center for both business related itinerant and general aviation operations. Therefore, the percentage of touch-and-go operations is expected to increase to 60% by the end of the planning period. It should be noted that a high percentage of instrument operations occurring at the airport are conducting training flights during VFR weather conditions. Approximately 50%-70% of these instrument operations break off their final approach to a go-around "missed" approach, which are subsequently counted as an arrival and a departure by FAA air traffic control.

Runway Use. The use configuration of the runway system is defined by the number, location, and orientation of the active runway(s) and relates to the distribution and frequency of aircraft operations to those facilities. Both the prevailing winds in the region and the existing runway facility at Paine Field combine to dictate the utilization of the existing runway system. According to airport management observations, Runway 16R/34L is the primary use runway. It is estimated that approximately 53% (50% 16R, 50% 34L) of the airport's operations are conducted utilizing this runway, while 43% (50% 16L, 50% 34R) of the airport's operations are conducted on Runway 16L/34R, and the remaining 4% (75% 29, 25% 11) of the airport's operations are conducted on Runway 11/29. Additionally, it is of interest to note that Runway 16R/34L operates (is open) on a 24 hour basis while Runways 16L/34R and 11/29 are designated VFR runways operating (are open) only from 7 a.m. to 9 p.m., when the FAA airport Air Traffic Control Tower is open.

Exit Taxiways. The capacity of a runway system is greatly influenced by the ability of an aircraft to exit the runway as quickly and safely as possible. Therefore, the quantity and design of the exit taxiways can directly influence aircraft runway occupancy time and the capacity of the runway system.

Due to the location of the existing exit taxiways serving the runway system at Paine Field, the number of available exit taxiways for use in the capacity calculation is adequate. Based upon the mix index of aircraft operating at the airport under VFR conditions, the capacity analysis, as described in the FAA Advisory Circular 150/5060-5, *Airport Capacity and Delay*, gives credit to only those runway exit taxiways located between 3,000 and 5,500 feet from the landing threshold. Therefore, landings to Runway 16R and Runway 34L each received an exit rating of two, with four being the maximum and no credit given for an exit within 750 feet of another exit. Runway 16L/34R and Runway 11/29, which primarily serve small aircraft, each receive an exit rating of one or two. It does not appear that the runway system would benefit from the construction of additional taxiways. However, the future location of all taxiway improvements (if any) will be evaluated in conjunction with the formulation of airside development alternatives.

Air Traffic Control Rules

The FAA specifies separation criteria and operational procedures for aircraft in the vicinity of an airport contingent upon aircraft size, availability of radar, sequencing of operations and noise abatement procedures, both advisory and/or regulatory, which may be in effect at the airport. The impact of air traffic control on runway capacity is most influenced by aircraft separation requirements dictated by the mix of aircraft utilizing the airport. Presently, there are no special air traffic control rules in effect at Paine Field that significantly impact operational capacity; however, it should be noted that when operating on the crosswind runway (Runway 11/29) there is currently a Land and Hold Short Operation (LAHSO) procedure, which is inclusive of the appropriate markings, lighting, and signage. It should be noted the Paine Field Air Traffic Control Tower does not operate on a twenty-four hour schedule.

Peak Period Operations

An additional element of assessing airport usage and determining various requirements necessitated by capacity and demand considerations is the determination of peak period activities. Actual ATCT records for 2000, along with statistics regarding operations at airports with similar activity and operational characteristics, have been utilized to formulate peak period forecasts. The projection of peak period operational activity is depicted in the following table, entitled *PEAK PERIOD AIRCRAFT OPERATIONS, 2000-2021*. The Peak Month Aircraft Operations in 2000 was determined by an examination of air traffic control tower records and that percentage has been used to estimate peak month operations throughout the planning period. The Average Day of the Peak Month was estimated by dividing the peak month operations by 31. Peak Hour/Average Day Ratio was established by examining operations at other airports with similar activity and operational characteristics, as well as utilizing typical ratios provided in FAA AC 150/5070-6A, *Airport Master Plans*. While peak period, as previously mentioned, is an average, and due to the geography of Paine Field - exhibiting bursts of good weather followed by bursts of bad weather, it is of interest to note that Paine Field recently experienced peak hours of 120 operations.

Table C4
PEAK PERIOD AIRCRAFT OPERATIONS, 2000-2021
Paine Field Master Plan Update

Year	Annual Aircraft Operations	Peak Month Aircraft Operations	Average Day of Peak Month	Peak Hour/ Average Day Ratio	Average Peak Hour Aircraft Operations
2000	213,291	21,329	688	9.0%	62
2006	290,235	29,024	936	8.5%	80
2011	310,980	31,098	1,003	8.3%	83
2016	334,204	33,420	1,078	8.0%	86
2021	359,176	35,918	1,159	7.8%	90

Source: BD&Co. Forecast Based on Methodology From FAA AC 150/5070-6A, *Airport Master Plans* and FAA AC 150/5060-5, *Airport Capacity and Delay*.

Airfield Capacity Analysis

As previously described, determination of capacity figures for Paine Field will utilize the throughput method of calculation, described in the FAA Advisory Circular 150/5060-5, *Airport Capacity and Delay*. These formulae, applying information generated from preceding analyses, illustrate capacity and demand in terms of the following results:

- Hourly Capacity of Runways
- Annual Service Volume (ASV)

The following capacity computations provide assistance in evaluating the ability of the existing airport facilities, both airside and landside, to accommodate forecast demand.

Hourly Runway Capacity

Calculations of hourly runway capacity begin with an evaluation of each possible runway-use configuration at the airport. With consideration of the airport's aircraft mix index, annual percentage of touch-and-go operations, existing IFR operating conditions and taxiway exit rating, an hourly capacity was calculated. For all runway use configurations, the airport's average VFR hourly capacity was determined to be approximately 202 operations, which compares to an IFR hourly capacity of approximately 78 operations.

Annual Service Volume

After determining the hourly capacity for each potential runway use configuration, a weighted hourly capacity of the entire airport can be calculated. The weighted hourly capacity takes into consideration not only the aircraft mix index, but also the percent utilization of each possible runway use configuration. The weighted hourly capacity for Paine Field for 2000 was determined to be approximately 92 operations per hour. This weighted hourly capacity can then be used in calculating the ASV for the airport. The ASV is calculated using the following formula:

$$ASV = C_W \times D \times H$$

C_W weighted hourly capacity
D ratio of annual demand to average daily demand
H ratio of average daily demand to average peak hour demand

In consideration of the existing runway configuration, runway utilization patterns and 2000 operation counts (i.e., 213,291), Paine Field has been determined to have a daily demand ratio (D) of 310 operations and an hourly demand ratio (H) of 11.1 operations, and thus, an ASV of approximately 316,218 operations.

Conditions that are involved with the determination of the weighted hourly capacity and the daily demand are not forecast to change significantly in the future, and those numbers will remain fairly constant through the planning period. The hourly ratio, as specified in the formula, is the inverse of the daily operations that occur during the peak hour. In other words, as operations increase, the peak periods tend to spread out, increasing the hourly ratio (H). As the hourly ratio increases, the ASV will increase. Capacity information contained in the previous 1995 MP indicated that a Paine Field runway configuration accommodates an ASV of 305,000 annual operations. However, general planning guidelines suggest that the ASV for Paine Field could be as much as 367,000 annual operations per year. Based on the aircraft fleet mix currently utilizing Paine Field, this ASV seems appropriate through the planning period.

Table C5
AIRFIELD CAPACITY FORECAST SUMMARY, 2000-2021
Paine Field Master Plan Update

Year	Annual Operations	Design Hour Operations	Annual Service Volume (ASV)
2000	213,291 (1)	62	316,000
2006	290,235	80	333,000
2011	310,980	83	344,000
2016	334,204	86	351,000
2021	359,176	90	367,000

(1) Actual operations count for the airport.

Ground Access Capacity

The capacity of the landside access system is a function of the maximum number of vehicles that can be accommodated by a particular ground access facility. Therefore, the focus of the roadway capacity assessment is on the service provided between the various airport facilities and the regional highway system (SR 526 and Interstate 5). Because Paine Field is located within a densely populated area, the existing airport access roadway system is impacted not only by the direct users of the airport, but also by the background traffic associated with the surrounding residential, commercial, and industrial development in the vicinity of the airport.

The capacity of roadways providing access to the airport is based on the *Highway Capacity Manual,* published by the Transportation Research Board, Special Report 209, 1985. It is normally preferred that a roadway operate below capacity to provide reasonable flow and minimize delay to the vehicles using it. The *Highway Capacity Manual* defines different operating conditions, known as levels-of-service. The levels-of-service are functions of the volume and composition of the traffic and the speeds attained. Six levels-of-service have been established, designated by the letters A-F, providing for best to worst service in terms of driver satisfaction. Level-of-service F defines a road operating beyond its maximum capacity; traffic is typically almost at a standstill causing major delays to road users. Level-of-service A is defined as a road with free flow operational characteristics at average travel speeds. Vehicles on a level-of-service A roadway are completely unimpeded in their ability to maneuver within the traffic stream. A level-of-service C, represented by stable traffic flow and minimal delays, is generally the preferred level of service on a road system such as in the vicinity of Paine Field. Average hourly volumes of airport service roadways of typical facilities at level-of-service C and D are summarized in the following table.

Table C6
GROUND ACCESS FACILITY VOLUME
Paine Field Master Plan Update

Facility Type	Average Hourly Volume (1) (Vehicle/Hour/Lane) (2)
Main-access and feeder freeways (controlled access, no signalization)	1,000-1,600
Ramp to and from main-access freeways, single lane	900-1,200
Principal arterial (some cross streets, two-way traffic)	900-1,600
Main-access road (signalized intersections)	700-1,000
Service road	600-1,200

Source: Measuring Airport Landside Capacity, Transportation Research Board, 1987
(1) Highway level-of-service C and D
(2) Passenger-car equivalents

It should be noted that the roadway capacity analysis for Paine Field takes into consideration the forecast of passenger enplanements and aviation activity. The roadway capacity analysis does not take into consideration additional traffic demands that might be generated by new industrial or commercial activity on the airport. The effects of any new industrial/commercial demand cannot be analyzed until employment numbers are quantified; therefore, as a part of the feasibility analysis for any new major employer on the airport, the impact on the landside access system must be considered.

The major roadways associated with Paine Field include: Airport Road, Holly Drive, 100th St. S.W., 112th St. S.W., SR 99 (Pacific Highway), Beverly Park Road, SR 525 (Mukilteo Speedway), 121st St. S.W., and Minuteman Drive.

- Airport Road is currently classified as an arterial roadway operated as a seven-lane facility north of 100th St. S.W. and six lanes south of 100th St. S.W., including two peak hour HOV (High Occupancy Vehicle) lanes. Airport Road runs northwest to southeast, between SR 526 and 128th St. S.W. While it is a major access route into the Boeing Plant and carries a large volume of the peak hour Boeing trips, it does provide access to the non-Boeing portions of the Paine Field property, as well as other industrial and commercial businesses along the route.

- Holly Drive is a two-lane collector arterial roadway, which is an extension of Beverly Park Road and extends to the northeast.
- 100th St. S.W. provides a link between the commercial area around Evergreen Way and Airport Road. It also provides one of the main access points into Paine Field. This road has two lanes and has curbs, gutters, and sidewalks about 1/3 of its length.
- 112th St. S.W. is a two-lane minor arterial providing a link between Beverly Park Road and SR 527 in the Silver Lake Area, east of I-5. Snohomish County plans to widen this portion of the street to five lanes including bike lanes, curb, gutter, and sidewalk.
- SR 99 (Evergreen Way) is a state route running between Northern Pierce County, through King County and into Everett. This highway also provides connections to other regional and state routes, which include I-5, SR 525, and SR 526. SR 99 has been classified as a principal arterial. The basic cross section is five (5) lanes with intermittent sidewalks. The City of Everett plans to improve SR 99 between 112th St. S.W. and Airport Road. The improvement will widen SR 99 to provide three lanes in each direction.
- Beverly Park Road is classified as a collector arterial and connects 52nd Ave. W to SR 525 and Holly Drive. A portion of the network abuts the city of Mukilteo, which includes two lanes, one shoulder, and no sidewalks. There is a narrow pedestrian and bicycle pathway separated from the shoulder in the vicinity of Fairmount Elementary School. Bike lanes along this route are provided southwest of the SR525 intersection. Snohomish County has plans to improve this road to five lanes with curbs and sidewalks in 2004/05.
- SR 525 (Mukilteo Speedway) connects the I-5/I-405 interchange to the Mukilteo Ferry Terminal. It is classified as a two-lane principal arterial; however, a WSDOT project to widen this roadway to four lanes began in early 2001 and will continue for two years.
- 121st S.W., classified as a collector arterial, connects Beverly Park Road to SR 525. The City of Mukilteo plans to improve this street by realigning 121st St. S.W. to create a four-leg intersection with Harbour Pointe Boulevard and SR 525.
- Minuteman Drive is currently a two-lane internal Snohomish County/Paine Field roadway providing access into the airport's industrial park and hangar areas. Minuteman Drive is an extension of 106th St. S.W.; however, it is not a dedicated public right-of-way. This roadway will be widened to three lanes with curbs and a sidewalk in 2001.

Based on the adopted forecast, peak hour trips into and out of the airport on the west leg of Airport Road/100th Street S.W. intersection, due to passenger activity, will represent an insignificant increase in the overall traffic volumes. While the airport entrance roadway is adequate to accommodate this increase, traffic entering and leaving the airport will be affected by the level-of-service at the Airport Road/100th Street S.W. intersection, which will likely operate in the level-of-service D or E range during the system peak hour. Currently, The Boeing Co. shift change creates a peak period hour between the hours of 2:30 p.m. and 4:00 p.m.

On Airport Road, north of the intersection with 100th St. S.W., the increase in traffic due to forecast passenger activity at Paine Field as a percentage of projected background traffic will be, as previously mentioned, a very insignificant amount of the total traffic traversing this roadway.

According to Snohomish County Public Works, Airport Road was recently reconstructed to create a seven-lane section with a center turn lane, two through lanes, and a peak hour HOV lane in each direction. This improvement also included the addition of bike lanes, curbs, gutters, and sidewalks on both sides of the road. In terms of traffic volume relative to roadway capacity, the ultimate configuration of Airport Road should be adequate.

A transportation study for a new Airport Road Transfer Station (ARTS), published by W&H Pacific, February 23, 2001, states that the new ARTS would create minimal impacts on the operation of the street network. The proposed facility is located on the southeast corner of Paine Field, adjacent to Airport Road, and will be accessed by driveways off Minuteman Drive. As part of the study, ten street networks were identified in the project. Current levels-of-service for these street segments range from B, good, to F, total failure. Total failure exists at Beverly Park Road/SR 525 during the weekday a.m. and the p.m., at Airport Road/SR 99 during the p.m., which coexists with the Boeing Plant shift change between 2:00 p.m. and 4:00 p.m. and the weekends, and at SR 99/112th Street S.W. on the weekends. According to Snohomish County Code, Title 26B, new developments must meet requirements to mitigate impacts on the transportation system. Currently, there are a number of projects on the books, which are committed to by the county to bring the new facility into compliance: Beverly Park Road from Airport Road to SR 525, 112th St. S.W. from SR 99 to 3rd Ave. W., Airport Road from SR 99 to 94th, 112th St. S.W. from Beverly Park to Airport Road. These improvements will provide levels-of-service of E or better.

Capacity Summary

This section has analyzed the capacity of existing facilities at Paine Field. Both adequate airfield and ground access facilities are critical components in the ability of the airport as a whole to efficiently serve the public. Capacity deficiencies that cause delays associated within one area will often be reflected in the ability or inability of the entire facility to function properly.

The following Facility Requirements section will delineate the various facilities required to properly accommodate future demand. That information, in addition to the capacity analysis, will provide the basis for formulating the alternative development scenarios for the airport and will ensure that the new recommended development plan can adequately accommodate the long-term aviation development requirements.

Facility Requirements

In efforts to identify future demand at the airport for those facilities required to adequately serve future needs, it is necessary to translate the forecast aviation activity into specific types and quantities. This section addresses the actual physical facilities and/or improvements to existing facilities needed to safely and efficiently accommodate the projected demand that will be placed on the airport. This section consists of two separate analyses: those requirements dealing with *airside* facilities and those dealing with *landside* facilities.

Airfield Requirements

The analysis of airfield requirements focuses on the determination of needed facilities and spatial considerations related to the actual operation of aircraft on the airport. This evaluation includes the delineation of airfield dimensional criteria, the establishment of design parameters for the runway and taxiway system, and an identification of airfield instrumentation and lighting needs.

Airfield Dimensional Criteria

The types of aircraft that currently operate at Paine Field and those that are projected to utilize the facility in the future have an impact on the planning and design of airport facilities. This knowledge assists in the selection of FAA specified design standards for the airport, which include runway/taxiway dimensional requirements; runway length; and runway, taxiway, and apron strength. These standards apply to the "Design Aircraft", which either currently utilizes the airport or which is projected to utilize the airport in the future. Certain areas at the airport are intended for use by large and small aircraft (e.g., Runway 16R/34L and supporting taxiway system, the Boeing Company Ramp, the Terminal Ramp, and Goodrich Inc.), while other areas are intended for use by small aircraft only (Runway 16L/34R and Runway 11/29, along with their supporting taxiway systems and general aviation ramps).

Because various areas on the airport are intended for use by aircraft with widely varying physical and operational characteristics, they can be designed with different criteria. The portion of the airport that is utilized by large and small aircraft accommodates a substantial number of large transport jet aircraft. These large transport aircraft operations are primarily related to Boeing Company and Goodrich Inc. manufacturing and maintenance activities at Paine Field. The largest aircraft that currently utilizes Paine Field on a regular basis (more than 500 landings or takeoffs per year) is the B-747-400. The B-747-400 sets the parameter for wingspan and approach speed, with a wingspan of 213 feet and an approach speed of 154 knots. The areas on the airport which are only utilized by smaller aircraft (Runway 16L/34R and Runway 11/29) accommodate primarily general aviation aircraft under 12,500 pounds, with approach speeds less than 121 knots, and wingspans less than 49 feet (e.g., the Beech King Air B100).

According to FAA Advisory Circular 150/5300-13, *Airport Design*, the first step in defining an airport's design geometry is to determine its Airport Reference Code (ARC). An airport that accommodates aircraft with an approach speed as great as 141 knots, but less than 166 knots and with wingspans as great as 171 feet, but less than 214 feet, should be designed utilizing ARC D-V dimensional criteria, and those aircraft with an approach speed as great as 91 knots, but less than 121 knots and with wingspans up to 49 feet, should be designated utilizing ARC B-1 criteria. The previously mentioned aircraft is the Design Aircraft for dimensional criteria only (i.e., runway/taxiway separation, runway/taxiway safety areas, aircraft parking separation, etc.), and is not intended to be used to dictate runway length requirements, although it may be used as a guide in the process of determining runway length. Additionally, if the development of Boeing's B-747X aircraft comes to fruition, it would be classified with an ARC of D-VI. However, the new aircraft would likely produce less than 500 operations per year (FAA threshold for design criteria).

The dimensional criteria illustrated in the following tables, entitled *ARC D-V DIMENSIONAL STANDARDS FOR RUNWAY 16R/34L (In Feet)* and *ARC B-I (small aircraft only) DIMENSIONAL STANDARDS FOR RUNWAYS 16L/34R AND 11/29 (In Feet)* are dimensions required for those portions of the airport utilized by both large and small aircraft.

Table C7
ARC D-V DIMENSIONAL STANDARDS FOR RUNWAY 16R/34L (in Feet)
Paine Field Master Plan Update

Item	Approach Visibility Minimums Lower Than ¾ - Statute Mile[1]	Existing Dimension
Runway Width	150	150
Runway Centerline to Taxiway Centerline	400	540
Runway Centerline to A/C Parking	500	500+
Runway Centerline to BRL	---	745
Runway Centerline to Holdline	286	286
Runway Safety Area Width	500	500
Runway Safety Area Length Beyond Runway End		
Runway 16R	1,000	1,000
Runway 34L	1,000	1,000
Runway Object Free Area Width	800	800
Runway Object Free Area Length Beyond Runway End		
Runway 16R	1,000	1,000
Runway 34L	1,000	1,000
Runway Blast Pad Width		
Runway 16R	220	220
Runway 34L	220	220
Runway Blast Pad Length		
Runway 16R	400	400
Runway 34L	400	400
Runway Shoulder Width	35	35

Source: AC 150/5300-13, Federal Aviation Administration.
Runway Safety Area (SA): An area adjacent to the runway, which is capable of supporting the occasional passage of aircraft without causing structural damage under dry conditions.
Runway Object Free Area (OFA): A two dimensional ground area centered on the runway centerline which is clear of objects, except for objects that need to be located in the OFA for air navigation or aircraft ground maneuvering purposes.
Building Restriction Line (BRL): The BRL encompasses the runway protection zones (RPZ), the runway object free area, the runway visibility zone, NAVAID critical areas, areas required for terminal instrument procedures, and areas required for airport traffic control tower clear line of sight.
Bold type dimensions reflect a deficiency in standards.
[1] Existing airport approach visibility minimums is ½ statute mile.

Table C7 (Continued)
ARC D-V DIMENSIONAL STANDARDS FOR RUNWAY 16R/34L (in Feet)
Paine Field Master Plan Update

Item	Approach Visibility Minimums Lower Than ¾ - Statute Mile[1]	Existing Dimension
Taxiway Shoulder Width	35	35
Taxiway Width		
Taxiway Alpha	75	75
Taxiway Alpha-A	75	100
Taxiway Alpha-1	75	100
Taxiway Alpha-2	75	**50**
Taxiway Alpha-3	75	**50**
Taxiway Alpha-4	75	75
Taxiway Alpha-5	75	150
Taxiway Alpha-6	75	100
Taxiway Alpha-7	75	75
Taxiway Alpha-8	75	100
Taxiway Alpha-9	75	100
Taxiway Safety Area Width	214	214
Taxiway Object Free Area Width	320	320

Source: AC 150/5300-13, Federal Aviation Administration.
Bold type dimensions reflect a deficiency in standards.
[1] Existing airport approach visibility minimums is ½ statute mile.

Table C8
ARC B-I (Small Aircraft Only) DIMENSIONAL STANDARDS FOR RUNWAY 16L/34R and 11/29 (in Feet)
Paine Field Master Plan Update

Item	Approach Visibility Minimums Not Lower Than ¾ - Statute Mile[1]	Existing Dimension
Runway Width		
Runway 16L/34R	60	75
Runway 11/29	60	75
Runway Centerline to Taxiway Centerline		
Runway 16L/34R	150	150
Runway 11/29	150	150
Runway Centerline to A/C Parking		
Runway 16L/34R	125	250
Runway 11/29	125	250
Runway Centerline to BRL		
Runway 16L/34R	---	200
Runway 11/29	---	200
Runway Safety Area Width	120	120
Runway Safety Area Length Beyond Runway End		
Runway 16L	240	240
Runway 34R	240	240
Runway 11	240	240
Runway 29	240	240
Runway Object Free Area Width	250	250
Runway Object Free Area Length Beyond Runway End		
Runway 16L	240	240
Runway 34R	240	240
Runway 11	240	240
Runway 29	240	240

Source: AC 150/5300-13, Federal Aviation Administration.
Runway Safety Area (SA): An area adjacent to the runway, which is capable of supporting the occasional passage of aircraft without causing structural damage under dry conditions.
Runway Object Free Area (OFA): A two dimensional ground area centered on the runway centerline, which is clear of objects, except for objects that need to be located in the OFA for air navigation or aircraft ground maneuvering purposes.
Building Restriction Line (BRL): The BRL encompasses the runway protection zones (RPZ), the runway object free area, the runway visibility zone, NAVAID critical areas, areas required for terminal instrument procedures, and areas required for airport traffic control tower clear line of sight.
[1] Existing runway approach visibility minimums.

Table C8 (Continued)
ARC B-I (Small Aircraft Only) DIMENSIONAL STANDARDS FOR RUNWAY 16L/34R and 11/29 (in Feet)
Paine Field Master Plan Update

Item	Approach Visibility Minimums Not Lower Than ½ - Statute Mile[1]	Existing Dimension
Runway Blast Pad Width	80	N.D.
Runway Blast Pad Length	60	N.D.
Runway Shoulder Width	10	N.D.
Taxiway Width		
Taxiway Charlie	25	40
Taxiway Delta	25	40
Taxiway Foxtrot	25	40
Taxiway Golf	25	40
Taxiway Safety Area Width	49	49
Taxiway Object Free Area Width	89	89

Source: AC 150/5300-13, Federal Aviation Administration.
[1] Existing airport approach visibility minimums.
N.D. – Not Designated.

As can be seen in the above tables, the runway/taxiway facilities at Paine Field are in compliance with a majority of the FAA specified dimensional criteria for the runway's existing approach visibility minimums, and for the lower than ¾-mile visibility minimums.

Runways

In consideration of the forecasts of future aviation activity, the adequacy of the runway system must be analyzed from several perspectives. These include runway orientation and airfield capacity, which were analyzed in the previous section, as well as runway length, pavement strength and runway visibility, which will be evaluated in the following text. The analysis of these various aspects pertaining to the runway system will provide a basis for recommendations of future improvements.

Runway Orientation. Paine Field currently operates with three runways, the primary Runway 16R/34L, the secondary Runway 16L/34R, and the crosswind Runway 11/29. As presented in a previous section, the existing runway configuration provides excellent wind coverage (i.e., 100%) for the 20- and 10.5-knot crosswind components; therefore, no additional runways are required from a *wind coverage* standpoint.

Airfield Capacity. The evaluation of airfield capacity, as presented in previous sections, indicates that the airport will not exceed the capacity of the existing runway/taxiway system before the end of the planning period.

Under existing operating conditions, the airport's Annual Service Volume (ASV) for the year 2021 was projected to be 367,000 operations. FAA planning standards indicate that when 60% of the ASV is reached (i.e., 220,200 operations), the airport should start planning ways to increase capacity and when 80% of ASV is reached (293,600 operations), construction of facilities to increase capacity should be initiated. These conditions should be monitored as *trends* and not just as one-time occurrences. This trend monitoring will provide lead-time in recognizing demand for facilities before the need occurs and will help to keep expenditures within budgetary constraints.

During 2000, aircraft operations at Paine Field totaled 213,291, which is below the 60% level of the ASV. In addition, 359,176 annual operations are forecast to occur at the airport by the end of the planning period, which is above the 60% level of the ASV. If regional passenger service is implemented at Paine Field, the forecasts indicate the airport could surpass 80% of its capacity by the end of the 20-year planning period.

Even before an airfield reaches capacity, it begins to experience certain amounts of delay in aircraft operations. As an airport's operations increase toward capacity, delay increases exponentially. These estimates of the annual service volume indicate that the airport will be approaching its capacity to accept aircraft operations if the forecasts of aviation activity are achieved. As stated previously, it should be kept in mind that these are only general estimates and, specific conditions (particularly those related to air traffic control, aircraft fleet mix, and approach capabilities) can significantly lower or raise an airport's ability to accept aircraft traffic. It appears that the physical layout of Paine Field has adequate capacity to accommodate the forecast number of aircraft operations; however, there is a potential for some capacity and delay problems in the future. The airport's development program will strive to maximize the airport's ability to accept aircraft operations within the constraints of its existing physical runway layout.

Runway Length. The determination of runway length requirements for Paine Field is based on several factors. These factors include:

- Airport elevation;
- Mean maximum daily temperature of the hottest month;
- Runway gradient;

- Critical aircraft type expected to use the airport; and,
- Stage length of the longest nonstop trip destination.

The runway length operational requirements for aircraft are greatly affected by elevation, temperature and runway gradient. The calculations for runway length requirements at Paine Field are based on an elevation of 609.65 feet AMSL, 73.0 degrees Fahrenheit NMT (Mean Normal Maximum Temperature), and a maximum difference in runway elevation at the centerline of 15 feet.

As can be seen in the following table, entitled *RUNWAY TAKE-OFF LENGTH REQUIREMENTS*, there are four runway lengths shown for small aircraft type runways (runways intended for use primarily by aircraft under 12,500 pounds). Each of these provides the proper length to accommodate a certain type of aircraft that will utilize the runway. The lengths range from 2,520 to 3,640 feet, while the runway length for small aircraft seating more than ten passengers is 4,090 feet.

There are four different lengths given for large aircraft under 60,000 pounds. The specified large aircraft runway lengths pertain to those general aviation aircraft, generally jet-powered, of 60,000 pounds or less maximum certificated take-off weight. The requirements of the large aircraft fleet range from 4,770 to 7,430 feet in length for the runway at Paine Field. Each of these lengths provides a runway sufficient to satisfy the operational requirements of a certain percentage of the fleet at a certain percentage of the useful load, (i.e., 75 percent of the fleet at 60 percent useful load). The useful load of an aircraft is defined as the difference between the maximum allowable structural gross weight and the operating weight empty. In other words, it is the load that can be carried by the aircraft composed of passengers, fuel, and cargo. Generally speaking, the following aircraft comprise seventy-five percent of the large aircraft fleet weighing less than 60,000 pounds: Learjets, Sabreliners, Gulfstreams, Citations, Falcons, Hawkers, and Westwinds.

The last row in the table refers to the critical large transport aircraft, the B-747-400 and the B-777-200/300. These calculations were obtained from Airplane Characteristics for Airport Planning, Boeing Commercial Airplane Group. Heavy gross weight take-offs are routinely programmed for these aircraft with delivery flights to all areas of the World - the Pacific Rim, Europe, Australia, South America, and Asia - from the Everett Boeing Plant.

Table C9
RUNWAY TAKE-OFF LENGTH REQUIREMENTS
Paine Field Master Plan Update

Runway Requirement	Runway Take-off Length (Feet) Dry Pavement	Runway Take-off Length (Feet) Wet Pavement
Small Aircraft with less than 10 seats		
75% of Small Aircraft	2,520	2,520
95% of Small Aircraft	3,040	3,040
100% of Small Aircraft	3,640	3,640
Small Aircraft with more than 10 seats	4,090	4,090
Large Aircraft less than 60,000 pounds		
75% of fleet/60% useful load	4,770	5,320
100% of fleet/60% useful load	6,030	6,760
75% of fleet/90% useful load	5,180	5,500
100% of fleet/90% useful load	7,430	7,430
Large Aircraft greater than 60,000 pounds		
B-747-400[2]	9,300	9,300[1]
B-777-200[3]	7,200	7,200[1]
B-777-300[4]	9,050	9,050[1]

Source: Runway Lengths Based on 606' AMSL, 73.0°F NMT and Maximum difference in runway end of 15 feet.
[1] Runway length calculations do not differentiate between dry and wet pavement conditions.
[2] 747-400 Airplane Characteristics for Airport Planning, Boeing Commercial Airplane Group, October 1994. Based on take-off runway length requirement – standard day + 27° F, CF6-80C2b1F engines (57,900 pounds thrust), a brake-release gross weight of 800,000 pounds, and an airport elevation of 606'.
[3] 777-200 (Baseline Model) Airplane Characteristics for Airport Planning, Boeing Commercial Airplane Group, May 1995. Based on take-off runway length requirement – standard day + 27° F, GE90-B3/-B4 engines (74,500 pounds thrust), a brake-release gross weight of 506,000 pounds, and an airport elevation of 606'.
[4] 777-300 (Baseline Model) Airplane Characteristics for Airport Planning, Boeing Commercial Airplane Group, August 1996. Based on take-off runway length requirement – standard day + 27° F, GE90-92B engines (90,000 pounds thrust), a brake-release gross weight of 580,000 pounds, and an airport elevation of 606'.

An important factor to note when considering the generalized large aircraft runway take-off length requirements presented in the table above is that the actual length necessary for a runway is a function of elevation, temperature, and aircraft stage length. As temperatures change on a daily basis, the runway length requirements change accordingly. The cooler the temperature, the shorter the runway necessary; therefore, for example, if an airport is designed to accommodate 75% of the fleet at 90% useful load, this does not mean that at certain times a larger business jet cannot use the airport or that aircraft cannot use it with heavier loadings than that represented by 90% of the maximum useful load.

According to the previous table, the length of the airport's primary runway is more than adequate to accommodate 100% of the large general aviation aircraft fleet at 90% useful load. However, the current runway length of 9,010 is 290 feet short in accommodating the fully loaded B-747-400 and 40 feet short of accommodating a fully loaded B-777-300. A delivery flight of these aircraft will infrequently require a longer runway than is provided at Paine Field and will subsequently have to utilize Boeing Field. As described by the Boeing Company and Goodrich Inc., any reduction in runway length will have an adverse effect on the aircraft's operational capabilities when operating at a maximum weight for delivery purposes.

These runway length requirements considered as a whole indicate that the runway length presently provided by Runway 16R/34L is adequate to accommodate the existing and forecast aircraft fleet under most operating conditions, thus a runway extension is not recommended. In consideration of the runway lengths provided by the general aviation runways at the airport, Runway 16L/34R can accommodate 95% of the small aircraft fleet with ten seats or less and Runway 11/29 can accommodate 100% of the small aircraft fleet including those with ten or more seats.

With this information as background, no runway extension projects are proposed for any of the runways at Paine Field.

Runway Pavement Strength. As identified in the *INVENTORY OF EXISTING CONDITIONS* chapter of this document, Runway 16R/34L is rated in good condition, with an existing gross weight bearing capacity of 100,000 pounds for single-wheel, 200,000 pounds for dual-wheel, 350,000 pounds for dual tandem-wheel, 722,000 pounds for dual tridem, and 830,000 pounds for double dual tandem-wheel main landing gear configuration aircraft. Runway 16L/34R is rated in good condition, with an existing gross weight bearing capacity of 12,500 for single-wheel main landing gear configuration aircraft. Runway 11/29 is also rated in good condition with an existing weight bearing capacity of 40,000-50,000 pounds for single-wheel and 55,000-75,000 pounds for dual-wheel main landing gear configuration aircraft. According to the existing and projected operational fleet mix, this pavement strength is adequate to accommodate both the commercial service aircraft and business jet fleet.

Assuming proper maintenance, these estimated design runway pavement strengths are adequate to accommodate present and forecast utilization (including infrequent use of Runway 16R/34L by aircraft up to 830,000 pounds). This does not take into consideration pavement rehabilitation or overlay projects required for upkeep and maintenance. Recently, the FAA funded a study, through the Washington State Department of Transportation (WSDOT), on airfield pavement within the state, including Paine Field. The report, produced by Pavement Consultants Inc., April 10, 2001, identified a large need for pavement maintenance on a recurrent basis. The report quantifies specific areas of the airport according to a pavement condition index (PCI).

Using each of the sections assigned a PCI, a pavement condition rating was assigned (PCR). This PCI index can range from a low of 0 to a high of 100 and the PCR can range from poor to excellent. Paine Field was found to have an overall average PCI of 77 and a PCR of very good for all pavements. Some of the primary distresses observed during the inspection include alligator cracking, block cracking, joint reflection cracking, swelling, joint seal damage, linear cracking, and corner spalling.

Runway Line of Sight. According to existing runway line-of-sight standards, any two points located five feet above the runway centerline must be mutually visible for the entire length of the runway. If the runway has a full-length parallel taxiway, the visibility requirement is reduced to a distance of one-half the runway length. While Paine Field does comply with the runway line-of-sight standards, due to the existence of Taxiway "Alpha", Runway 16R/34L demonstrates somewhat of an undulating profile, which can confuse automatic landing systems on some aircraft.

Taxiways

Taxiways are constructed primarily to enable the movement of aircraft between the various functional areas on the airport and the runway system. Some taxiways are necessary simply to provide access between aircraft parking aprons and runways, whereas other taxiways become necessary to provide more efficient and safer use of the airfield. As described earlier, the taxiway system at Paine Field generally meets the required standards.

Runway 16R/34L is served by a full-length parallel taxiway (Taxiway A) on its east side. This parallel taxiway is served by eleven easterly taxiway exits (including the intersection with Runway 11/29), as well as two westerly taxiway exits. The majority of Taxiway A has a runway centerline separation of 540 feet, with the northern end angling in toward the runway. At the threshold of Runway 16R, the separation between the runway centerline and the centerline of Taxiway A is 425 feet.

The crosswind runway, Runway 11/29, is equipped with a full-length parallel taxiway, Taxiway D, located on the northeast side of the runway. A partial parallel taxiway, Taxiway C, located on the northeast side of Taxiway D, extends 2,200 feet from the intersection of Taxiway A to the Central Ramp. Runway 11/29 is served with six northeasterly taxiway exits, as well as one southwesterly taxiway exit. There is a runway centerline separation of approximately 150 feet. The secondary parallel runway, Runway 16L/34R, is served by two full-length parallel taxiways, Taxiway F, on the east side, and Taxiway G, on the west side. Taxiway F is served with five taxiway exits and Taxiway G is served with six taxiway exits. Both taxiways are separated by 150 feet of centerline distance.

The taxiway system at Paine Field is well configured to provide good access between the runways and landside use areas (aprons, hangars, etc.). In addition, it is well configured to minimize runway occupancy times by providing properly located exit taxiways. Potential improvements will include providing access to new and/or expanded landside aviation use areas at the airport and a specific examination of the need for additional exit taxiways to improve the runway exit efficiency.

Development alternatives for the location of both additional exit taxiways and access taxiways are evaluated in the *CONCEPTS, ATERNATIVES AND DEVELOPMENT PLAN* chapter of this document. This evaluation will include providing access to the Goodrich Inc., Hangar 1 for aircraft as large as the B-747. Additionally, over the last ten years, the airport has improved the taxiway system by adding shoulders and removing obstructions within the object free area (OFA), as well as adding a perimeter roadway system to minimize the need for access of airport vehicles onto existing taxiways and/or shoulders.

Instrumentation and Lighting

Electronic landing aids, including instrument approach capabilities and associated equipment, airport lighting, and weather/airspace services, were detailed in the *INVENTORY OF EXISTING CONDITIONS* chapter of this document. The existing navigation aids at and around Paine Field include an ILS CAT I precision approach to Runway 16R, two non-precision approaches (NDB and GPS) to Runway 16R, one non-precision approach (GPS) to Runway 34L, and one circle-to-land approach (VOR or GPS-B).

Visual Landing Aids (lights). Presently, Runway 16R/34L at Paine Field is equipped with High Intensity Runway Lights (HIRL) edge lights and Runway Centerline Lights. The Runway 16R end is equipped with a Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights (MALSR) and a Precision Approach Path Indicator (PAPI) on the right side of the runway. Runway 34L is equipped with a Medium Intensity Approach Lighting System with Sequenced Flashers (MALSF) and a Precision Approach Path Indicator (PAPI) on the left side of the runway. Runways 16L/34R and 11/29 are both equipped with Medium Intensity Runway Lights (MIRL) edge lights. Runway 16R/34L is served with Runway End Identifier Lights (REILS) and Precision Approach Path Indicators (PAPI) on both ends, while Runway 11/29 is equipped with Vertical Approach Slope Indicator (VASI) lights on both ends. In conjunction with the examination of improved instrument approaches described above, improved airport lighting will also need to be evaluated. The type of airport lighting will be dependent on the type of instrument approach capabilities and will be examined in the next chapter.

Future Approaches. From the standpoint of wind direction during Instrument Meteorological Conditions, the existing straight-in approach capabilities to Runway 16R provide good coverage. However, to provide operational flexibility the potential to implement a precision instrument approach to Runway 34L and improved non-precision approach capabilities to Runway 16R should be considered. For long-term considerations, the ability to install a CAT II/III Precision Approach serving Runway 16L is being protected.

In the past, the airport has been served by straight-in non-precision approach capabilities to Runway 34L. With the relocation of the airport's VOR in 1992, straight-in VOR approach capabilities have not been re-established to Runway 34L or to Runway 16R. The re-establishment of these VOR approaches should remain a priority. As previously mentioned, 50%-70% of instrument approaches to Runway 16R/34L "break" off or perform a go-around operation. If wind conditions at Paine Field warrant or dictate a need for aircraft operations to fly to the north, departing aircraft would be in a "head-to-head" conflict with aircraft, which need to utilize the precision approach, landing south. The airport's "Noise Abatement Program" recommends that large aircraft, when departing north, fly a runway heading to the coast before initializing a bank to the east or west. Currently, if two aircraft are in a "head-to-head" conflict, the departing aircraft must quickly turn. Thus, full power aircraft must traverse over the city of Mukilteo or Everett. A further analysis of implementing a precision approach to Runway 34L will be conducted in the following chapters.

One issue which arose during the formulation of the facility requirements in the 1995 MP, was the potential need for published helicopter approaches to points on the airport other than the existing runway system. As of 1999, the existing helipad was decommissioned and will not need further analysis in this MP Update.

Within the near future, Global Positioning System (GPS) approaches are expected to be the FAA's standard approach technology. With GPS, the cost of establishing improved instrument approaches should be significantly reduced. Because of the expected continued use of sophisticated general aviation, air carrier, and corporate aircraft at Paine Field, the ability to implement improved instrument approaches will be analyzed in the next chapter.

Runway Protection Zones (RPZs). The function of the RPZ is to enhance the protection of people and property on the ground off the end of runways. This is achieved through airport control of the property within the RPZ area. This control can be exercised through either fee-simple ownership or the purchase of RPZ easement. The RPZ is trapezoidal in shape and centered about the extended runway centerline. Its inner boundary begins 200 feet beyond the end of the area usable for take-off or landing. The dimensions of the RPZ are functions of the type of aircraft, which regularly operate at the airport, in conjunction with the specified visibility minimums of the approach (if applicable).

In consideration of the existing instrument approach minimums and the type of aircraft each runway is designed to accommodate, the following table, entitled *RUNWAY PROTECTION ZONE DIMENSIONS*, lists existing RPZ dimensional requirements, along with the requirements for improved approach capabilities.

The airport currently owns the land areas associated with the RPZs for Runway 16L/34R and Runway 11/29, except for a small area on the southern end of the RPZ associated with Runway 34R and a portion of the 16L RPZ over county owned Airport Road, on which the airport owns avigation easements.

Table C10
RUNWAY PROTECTION ZONE DIMENSIONS
Paine Field Master Plan Update

Item	**Width at Runway End (feet)**	**Width at Outer End (feet)**	**Length (feet)**
Existing RPZ Dimensions:			
Runway 16R	1,000	1,750	2,500
Runway 34L	1,000	1,510	1,700
Runway 16L	250	450	1,000
Runway 34R	250	450	1,000
Runway 11	250	450	1,000
Runway 29	250	450	1,000
Required RPZ Dimensions for Various Visibility Minimums:			
Not lower than 1-Mile,			
Small Aircraft Only	250	450	1,000
Approach Categories A & B	500	700	1,000
Not lower than 1-Mile,			
Approach Categories C & D	500	1,010	1,700
Not lower than 3/4-Mile, All Aircraft	1,000	1,510	1,700
Lower than 3/4-Mile, All Aircraft	1,000	1,750	2,500

Source: FAA Advisory Circular 150/5300-13, "Airport Design."

Please refer to the Appendix for policies and purpose for Runway Protection Zones gleaned from the *1997 Land Policy 97-02,* published by the FAA Seattle Airports District Office (ADO).

Future Lighting. Based on existing and future approach visibility minimums, it is recommended that the Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights (MALSR) on Runway 16R and the Medium Intensity Approach Lighting System with Sequenced Flashers (MALSF) on Runway 34L remain.

Glide path indicator lights are a system of lights that provide visual vertical approach slope guidance to aircraft during an approach to the runway. Precision approach path indicators (PAPIs) or Visual Approach Slope Indicators (VASIs) are designed for daytime and nighttime use during VFR (i.e., good weather) conditions. The PAPIs on Runways 16R/34L and 16L/34R are recommended to remain, while the VASIs associated with Runway 11/29 should be programmed to be supplanted with PAPIs.

Runway End Identifier Lights (REILs) are a system of lights that provide an approaching aircraft a rapid and positive identification of the approach end of the runway. At present, Runway 16L/34R is equipped with REILs. It is recommended that these be maintained. In the future, Runway 11/29 should be equipped with REILS.

In conjunction with its precision approach capabilities, the HIRL on Runway 16R/34L should be maintained, while the existing MIRL should remain for Runways 16L/34R and 11/29. In addition, Medium Intensity Taxiway Lighting (MITL) is presently in place on all taxiways at the airport except Taxilane E, Taxiway K-5, Taxiway K-6, and Taxilane H. MITL should be placed on all existing and new taxiways in the future.

Landside Requirements

Landside facilities are those facilities, which support the airside facilities, but are not actually a part of the aircraft operating surfaces. These consist of such facilities as terminal buildings, hangars, aprons, access roads, and support facilities. Following a detailed analysis of these facilities, current deficiencies can be noted in terms of accommodating both existing and future aviation needs at the airport.

Terminal Area Requirements

Components of the terminal area complex include the terminal building, gate/parking positions, apron area, vehicular access and auto parking. The following paragraphs identify the facilities required to meet the airport's needs through the planning period. Where noted, facility requirements have been utilized using the guidance of FAA Advisory Circular 150/5360-13, *Planning and Design Guidelines for Airport Terminal Facilities,* January, 1994 and *Measuring Airport Landside Capacity*, Transportation Research Board, 1987.

Passenger Terminal Building. Based on the previously presented forecast number of passenger enplanements, and using estimates of peak hour demand derived from those passenger enplanement forecasts, planning rules-of-thumb can be used to establish an ultimate square footage estimate for a passenger terminal building in consideration of predicted demand. These rules-of-thumb state that .08 to .12 square feet of space per annual enplanement is the average space requirement needed to sufficiently accommodate passengers. However, experience at small/non-hub airports indicates that this number could be as high as .21 square feet per annual enplanement. Using .08 as the basis for a calculation, a terminal area of 12,212 square feet is projected by the end of the planning period and using .21, a terminal area of 32,054 square feet is projected by the end of the planning period. The incremental ranges of square footage for the terminal building can be seen in the following table, *PASSENGER TERMINAL BUILDING SQUARE FOOTAGE REQUIREMENTS.*

Table C11
PASSENGER TERMINAL BUILDING SQUARE FOOTAGE REQUIREMENTS
Paine Field Master Plan Update

Year	Forecast Passenger Enplanements	.08 Square Feet Per Annual Enplanement	.21 Square Feet Per Annual Enplanement
2006	126,425	10,114	26,549
2011	136,621	10,929	28,690
2016	144,630	11,570	30,372
2021	152,640	12,212	32,054

Source: Barnard Dunkelberg & Co.
AC 150/5360-13: Planning and Design Guidelines for Airport Terminal Facilities.

*Gate/Parking Positions***.** The airport does not currently maintain a passenger terminal facility. According to guidelines from FAA Advisory Circular 150/5360-13, *Planning and Design Guidelines for Airport Terminal Facilities,* January 1994, estimates for the required number of aircraft parking positions were tabulated in consideration of the "Annual Utilization" method. It was projected that a total of three aircraft parking positions would be required at the airport by the end of the planning period, based on the previously presented enplanements and commercial service operational forecasts.

Terminal Area Vehicle Parking. There are three types of automobile parking typically located in the terminal area of the airport. These include public (passenger), rental car, and employee parking. Because of the absence of passenger activity at the airport, the demand for terminal parking facilities has been minimized. For long-range planning purposes, the provision of an appropriate area for passenger terminal parking is an important consideration.

FAA planning guidelines indicate that, at non-hub airports, one parking space should be provided for each 500 to 700 annual enplaned passengers. This guideline would indicate that parking for as many as 305 vehicles could be required by year 2021. Over half of the existing 450 parking spaces in the terminal area are required to accommodate existing tenants. The remainder available will need to be supplemented by converting the NE end of the Inner Terminal Ramp to auto parking as passenger parking demand grows.

Automobile access to the passenger terminal facilities is also an important consideration. The airport is the front door to the community for air travelers. Peak hour passenger demand is forecast to increase to 136 peak hour passengers by the end of the 20-year planning period. With this increase in the volume of passengers, it is likely there will be a significant impact related to the need to increase the efficiency and capacity of the existing roadway system serving the terminal area. Therefore, it will be important to take into consideration the configuration of the passenger terminal area and the access roadway. The terminal should be aesthetically pleasing, portraying a sense of arrival, while the access roadway system should be efficient, non-confusing, and have an ease of use for egress/ingress routing.

Table C12
PASSENGER TERMINAL FACILITY REQUIREMENTS, 2000-2021
Paine Field Master Plan Update

	2000[1]	2006	2011	2016	2021
Forecast Peak Hour Passengers	N/A	77	88	98	136
Gross Terminal Square Feet	1,600[2]	26,549	28,690	30,372	32,054
Gates/Aircraft Parking Positions	3	3	3	3	3
Automobile Parking Spaces[3]	450[4]	252	273	290	305
Peak Hour Passenger Automobiles In Peak Direction	N/A	64	73	82	114

Source: Barnard Dunkelberg & Co.
AC 150/5360-13: Planning and Design Guidelines for Airport Terminal Facilities.
[1] Actual.
[2] That Portion of Existing Terminal Building Which Could Easily Accommodate Passenger Facilities (Managers Office and Flightline Services)
[3] Required for passengers.
[4] North Lot, Main Lot, and South Lot In Terminal Area currently used by multiple tenants.
N/A Not Applicable Under Existing Conditions

Air Cargo Requirements

Historically, airmail and airfreight activity has occurred at Paine Field to a limited degree. These air cargo operations have been conducted at the airport with small air taxi type aircraft (prop aircraft with the capability of seating less than sixty passengers). This includes a scheduled mail route (by Methow Airlines), which transports mail from the regional postal facility in Everett to the San Juan Islands and a number of aircraft hauling checks (AMERIFLIGHT). Additionally, UPS did move its entire Seattle operation to Paine Field's South Ramp in early 2001 for several weeks when Boeing Field was closed for repair of damage sustained by an earthquake. As previously stated, the County's adoption of the 1978/79 Mediated Role Determination has discouraged air cargo operations from occurring at the airport. However, it is assumed that, if there is a demand for cargo operations at Paine Field, it is likely to be only temporary, and would be accommodated on the South Ramp until the cargo use area at SEA-TAC is re-established when (and if) the Port of Seattle moves forward with construction of the South Aviation Support Area (SASA) at SEA-TAC.

General Aviation Requirements

The number and type of projected general aviation operations and based aircraft can be converted into generalized projections of landside facility needs. The accompanying table illustrates the type of facilities and the number of units or acres needed for that facility to accommodate the potential demand for each development phase. As can be seen, the itinerant general aviation aircraft apron requirements are projected to increase from 657,693 $ft.^2$ (73,077 $yds.^2$) in the year 2006 to approximately 688,473 $ft.^2$ (76,497 $yds.^2$) by the year 2021, while based aircraft apron requirements are projected to increase from approximately 171,720 ft^2 (19,080 $yds.^2$) to 187,920 ft^2 (20,880 $yds.^2$) for the same period. Based on existing and projected aircraft storage practices, it is likely that the majority of future based aircraft will require some type of indoor storage facility. It is projected that the future demand for aircraft storage at the airport will likely consist of both individual executive/corporate hangars and T-hangar facilities.

The following table, entitled *GENERAL AVIATION FACILITY REQUIREMENTS, 2000-2021*, depicts the acreage required for general aviation landside facilities during all stages of development. As can be noted, the actual types of indoor storage facilities needed to accommodate future based aircraft have been identified as T-hangars and executive/corporate hangars. It is also apparent that the acreage demands for future aviation facilities cannot be accommodated in the existing location for the 20-year planning period. The current airport layout plan proposes the relocation of the existing general aviation development area to both accommodate the expanded development requirements and improve security at the commercial service ramp. Alternative general aviation development areas will be investigated in the following chapter of this document. Because the actual number, size and location of future large FBO/maintenance hangars will depend on user needs and financial feasibility, the quantity of these facilities has not been projected.

Table C13
GENERAL AVIATION FACILITY REQUIREMENTS, 2000-2021
Paine Field Master Plan Update

	Total Number Required (In yd^2)				
Facility	**2000**	**2006**	**2011**	**2016**	**2021**
Itinerant/GA Apron	39,555	73,077	74,428	75,581	76,497
Based A/C GA Apron	208,500	19,080	19,800	20,880	20,880
Hangar Space					
T-hangars	283	431	449	464	465
Exec/Corp.	92	81	93	108	123

Source: BD & Co. Projections based on FAA AC 150/5300-13

Support Facilities Requirements

In addition to the aviation and airport access facilities described above, there are several airport support facilities that have quantifiable requirements and that are vital to the efficient and safe operation of the airport. The support facilities at Paine Field that require further evaluation include the aircraft rescue and firefighting facility, the fuel storage facility and the air traffic control tower.

Aircraft Rescue and Firefighting Facility (ARFF). FAA requirements for ARFF equipment and staff are based upon the length of the largest passenger air carrier aircraft that serves the airport with an average of five or more daily departures. At the present time, Paine Field is classified as an Index A airport, and satisfies the associated criteria and requirements with its ARFF equipment and staff. If the size of the scheduled passenger aircraft that operate at Paine Field exceeds the Index A criteria, there will be additional requirements for ARFF equipment, manpower, and facilities. The airport maintains a fire department with equipment and staff in excess of Index "A" requirements due to the large size of non-passenger carrying aircraft operations conducted by Boeing and Goodrich Inc. customers.

Fuel Storage Facility. Over the past five years, there has been an average of 3.28 million gallons of fuel sold per year at Paine Field. Based upon 2000 total operation counts, this equates to approximately 15.4 gallons per operation. As operations increase, fuel storage requirements can be expected to increase proportionately. By increasing the ratio of gallons sold per operation to adjust for the increased size of aircraft forecast to operate and be based at the airport, an estimate of future fuel storage needs can be calculated as a two-week supply during the peak month of operations. Further analysis to allocate space for accommodating additional storage for future needs of capacity will be conducted throughout the master planning process of this document.

Summary

The need for facilities, which have been identified in this chapter, can now be utilized to formulate the overall future Development Plan of the airport. The formulation of this plan will begin by establishing goals for future airport development and an analysis of development alternatives whereby demand for future airport facilities can be accommodated. These alternatives will be presented in the following chapter entitled, *CONCEPTS, ALTERNATIVES AND DEVELOPMENT PLAN.*