



# Paine Field Master Plan 2040

## Appendix C | Capacity Analysis

# C

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PREPARED FOR  
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## C. Existing Airfield Capacity Analysis

The following provides the complete airfield capacity analysis conducted on the existing airfield, as part of the Facility Requirements.

An airfield capacity analysis was conducted to evaluate the capacity of the existing airfield configuration and to determine if it will meet the forecast peak period demand over a 20-year planning horizon time and maintain an acceptable level of average delay per aircraft.

### B.1.1.1 Methodology

To conduct the airfield capacity and delay analysis, SIMMOD fast-time simulation model was used in lieu of using the standard methodology for assessing capacity and delay as prescribed by the FAA in Advisory Circular (AC) 150/5060-5 Airport Capacity and Delay. Using simulation provides more flexibility to assess other operational variables that the FAA formulaic methodology is not equipped to assess. The following basic metrics were used in the simulation analysis:

- Simulate the south flow runway operating configuration as this is the primary operation at PAE
- Runway 16L/34R (3,004 ft. x 75 ft.) is a visual runway which serves small general aviation (GA) piston aircraft
- Runway 16R/34L (9,010 ft. x 150 ft.) is an air carrier runway which serves large jet aircraft
- GA traffic primarily operates on Runway 16L/34R and offloads to Runway 16R/34L when necessary
  - GA arrivals and departures primarily on Runway 16L/34R, however offload to Runway 16R/34L when demand peaks
  - Mixed use runway operation airspace separation (Runway 16L/34R) – 3 miles between arrivals to fit one departure in between
- Mixed use runway operation airspace separation (Runway 16R/34L) – 4.5 miles between arrivals to fit one departure in between. Increased separation due to jet aircraft and increased approach speeds.

### B.1.1.2 20-Year Aviation Demand Forecast

The approved 20-year aviation demand forecast for PAE, and the design day flight operations were used as the basis for simulating aircraft movements in SIMMOD. Each demand level was evaluated to identify the peak hour capacity and average aircraft delays associated with the forecast demand levels. **Table 4-3** provides a summary of the four primary simulated demand years and demand levels.

**Table 4-3** 20-Year Aviation Demand Forecast

Demand	2019	PAL 1	PAL 2	PAL 3
Annual Demand	137,995	148,473	155,028	187,303

Daily Demand	711	769	800	924
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Source: Landrum & Brown, 2021

*B.1.1.3 Existing Airfield Operation Analysis*

Listed below are the modeling assumptions used for simulation of the forecast demand levels under existing airfield operating procedures. The analysis assumes that PAE be operates under Visual Meteorological Conditions (VMC). The simulation runway capacity and delay are based on the airport operating hours of 6 A.M to 11 P.M.

**Runway 16R/34L – Jet Aircraft Operations**

- For simulation purposes, an Airplane Design Group-III (ADG-III) aircraft fleet was simulated (ex. B737-800) and ADG-I (ex. Cessna 172)
- Jet Arrivals: 20 nautical mile (NM) straight-in final approach course with maximum aircraft entry speeds of 240 knots to a final approach speed of 140 knots
  - When a Jet aircraft on final approach trails a slower moving GA aircraft, 9 NM separation applied as the speed differential between the two aircraft requires increased distance to avoid a loss of separation.
  - Mixed use runway operations with arrivals on final approach separated at 5.0 NM intrail to allow for a single departure in between successive arriving aircraft.
- Arrivals on final approach block a waiting departure when the arrival is within 2.5 NM of the runway threshold.
- Runway exit utilization for arrivals in south flow: Taxiway (A6) 80% and Taxiway A8 (20%).
- Successive jet departures separated by a minimum of 3.0 NM increasing to 4.0 NM intrail on same departure route.

**Runway 16R/34L – GA Aircraft Operations**

- For simulation purposes, an ADG-I aircraft fleet was simulated (ex. Cessna 172)
- GA Arrivals: 15 NM approach course with maximum aircraft entry speeds of 120 knots to a final approach speed of 70 knots.
- GA Arrivals: 2/3 of GA arrivals assigned to Runway 16L/34R, while 1/3 of GA arrivals assigned to Runway 16R/34L to balance traffic, reduce delays and increase capacity
- GA arrivals on final approach block a waiting departure when the arrival is within 2.0 NM of the runway threshold.
- Runway exit utilization for arrivals in south flow: Taxiway (A6) 80% and Taxiway A8 (20%).
- GA Departures: 2/3 of GA departures assigned to Runway 16R/34L, while 1/3 of GA departures assigned to Runway 16L/34R
  - Assumes slower moving GA arrivals are the priority on the east runway to avoid mixing with faster moving jet traffic on the west runway.
- GA departures on Runway 16R/34L will make an immediate turn after departure to allow a trailing jet aircraft to depart straight out; assumes GA and jet traffic will never depart and fly the same route intrail of each other.

- Successive GA departures separated by a minimum of 2.0 NM increasing to 3.0 NM intrail on same departure route.

### **Runway 16L/34R – General Aviation Aircraft Operations**

- For simulation purposes, an ADG-I aircraft fleet was simulated (ex. Cessna 172), as small piston propelled aircraft are the predominate aircraft fleet operating on the runway
- 15 NM approach course with maximum aircraft entry speeds of 120 knots to a final approach speed of 70 knots
- Mixed use runway operations with arrivals on final approach separated at 3.0 NM intrail to allow for a single departure in between successive arriving aircraft
- Arrivals on final approach block a waiting departure when the arrival is within 1.5 NM of the runway threshold
- Runway exit utilization for arrivals in south flow: Taxiway (G3) 100%
- Successive departures separated by a minimum of 2.0 NM increasing to 3.0 NM intrail on same departure route

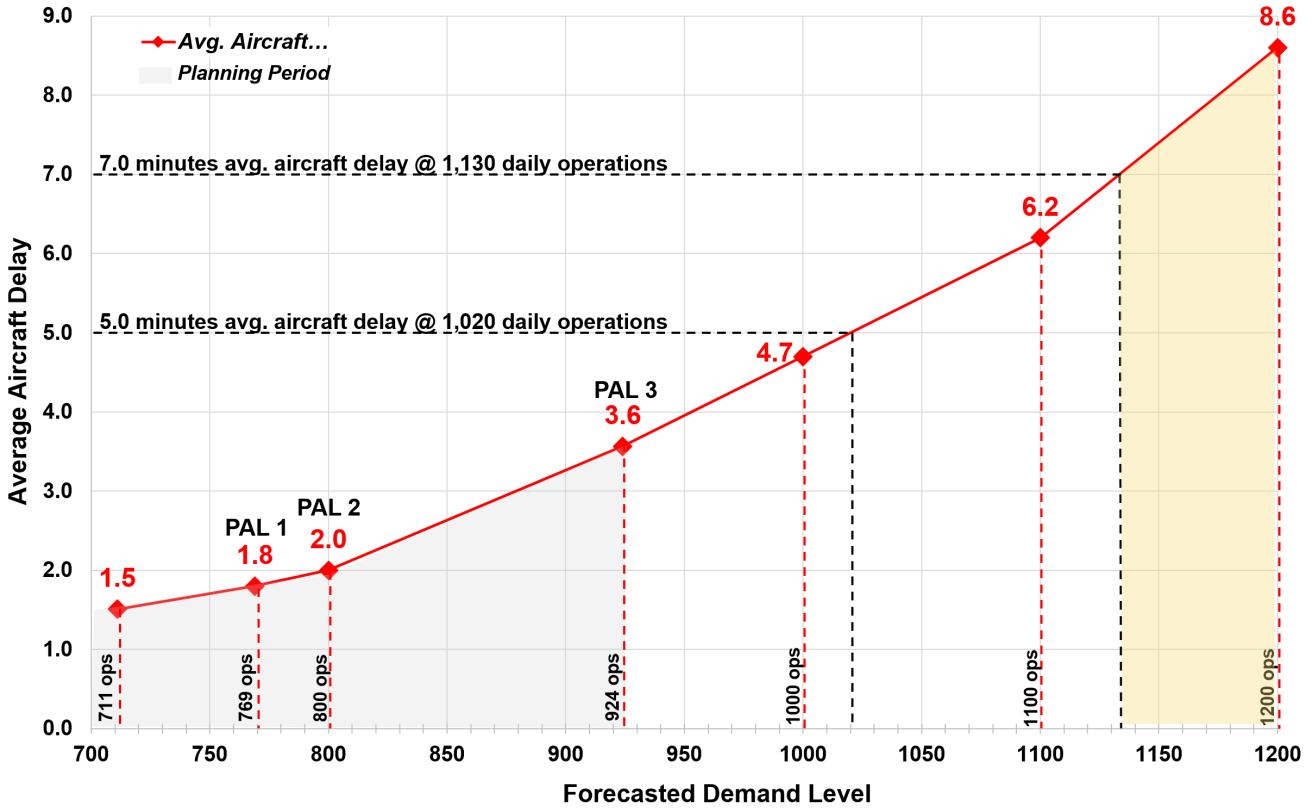
The following assumptions were used:

- A 5.0 – 7.0-minute average aircraft delay threshold was used as theoretical maximum acceptable levels of delay for PAE.
  - The simulation assessment focus was solely on the existing airfield geometry (runway and taxiway system) and the ability to accommodate increased demand levels at PAE.
  - The simulation did not model any proposed passenger terminal or GA facility improvements to accommodate increased demand, however it is assumed that the necessary facilities would be in place to accommodate the aircraft operations and increased demand levels.

**Exhibit 4-1** summarizes the simulated demand levels and the associated levels of average aircraft delay per operation. The results for the four demand years were processed, and it was determined, the average aircraft delay per operation did not exceed the 5.0-minute level of acceptable delay by the end of the twenty-year planning timeframe. Therefore, it is assumed the existing airfield system at PAE can accommodate additional aircraft operations beyond the 907 daily operations forecasted in 2040.

Three additional simulation experiments were evaluated to assess the capacity and delays at demand levels beyond 907 daily operations. Simulation experiments assuming 1,000, 1,100, and 1,200 daily operations were conducted. The results indicate that at 5.0 minutes of average aircraft delay, the existing airfield can accommodate approximately 1,020 daily operations. At 7.0 minutes of average aircraft delay, the existing airfield can accommodate approximately 1,130 daily operations. It is estimated the maximum practical airfield capacity at PAE is roughly between **1,020–1,130** daily operations if GA traffic can utilize both runways and growth in commercial aviation traffic increases gradually rather than exponentially. Demand levels beyond the maximum practical capacity will result in excessive levels of delay that may not be acceptable to the airport operators or the aviation community which operates at the airport.

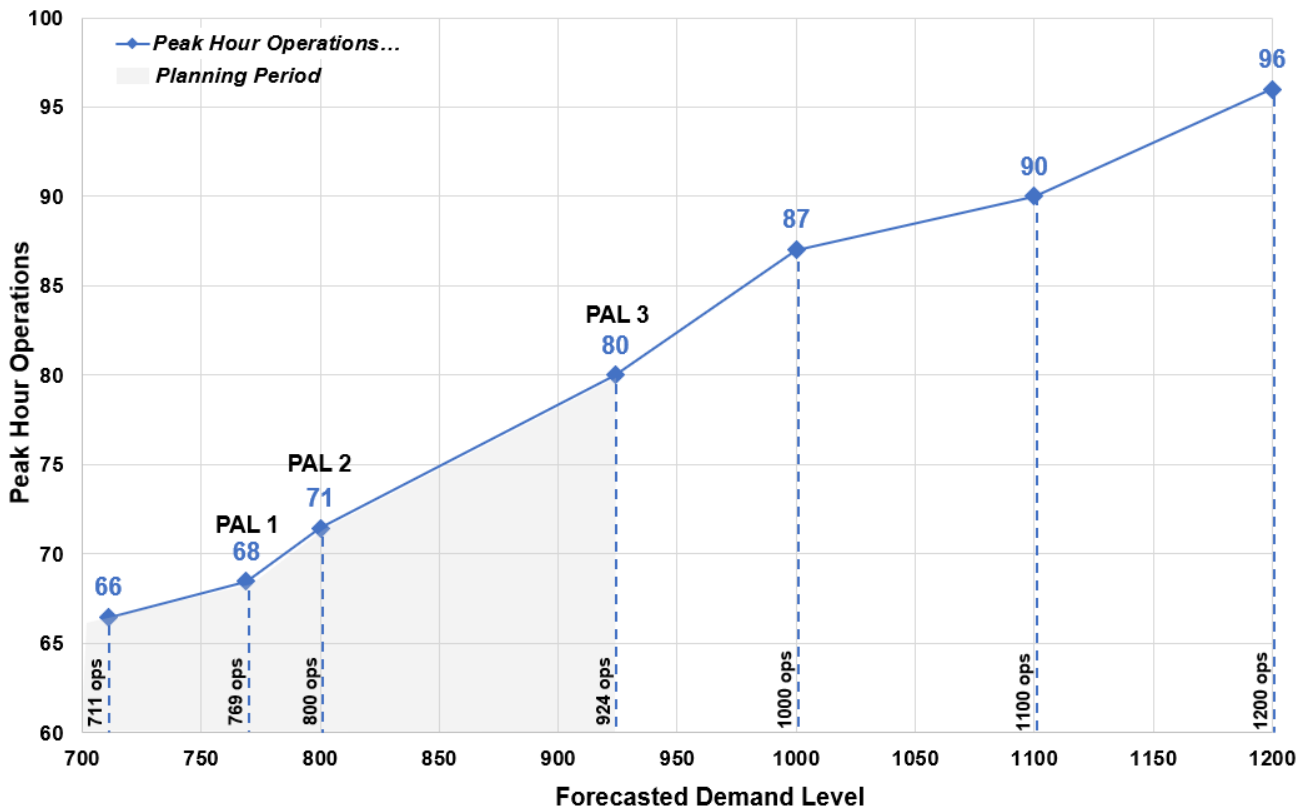
**Exhibit 4-1 Simulated Average Aircraft Delay**



Source: Landrum & Brown, 2021

**Exhibit 4-2** summarizes the simulation peak hour runway capacity for PAE at the seven demand levels that were evaluated in SIMMOD. Between demand years 2019-2040, the simulation results indicate the existing airfield can accommodate forecast demand within acceptable average aircraft delays. Given the tolerance for aircraft delays, it is estimated the peak hour throughput at PAE can range from **90-96** operations per hour.

**Exhibit 4-2 Simulated Peak Hour Operations Flow**



Source: Landrum & Brown, 2021

*B.1.1.4 Future Airfield Operation Analysis*

A secondary simulation analysis was conducted to evaluate the maximum practical capacity on each runway at PAE assuming all GA aircraft are restricted to Runway 16L/34R. PAE’s two runways operate independent of each other, however, given the design of each runway and aircraft fleet mix capabilities, the airfield capacity for each runway differs. A SIMMOD analysis was conducted to evaluate the maximum practical daily capacity for each runway under different operating assumption.

**Runway 16R/34L – Jet Aircraft Operations**

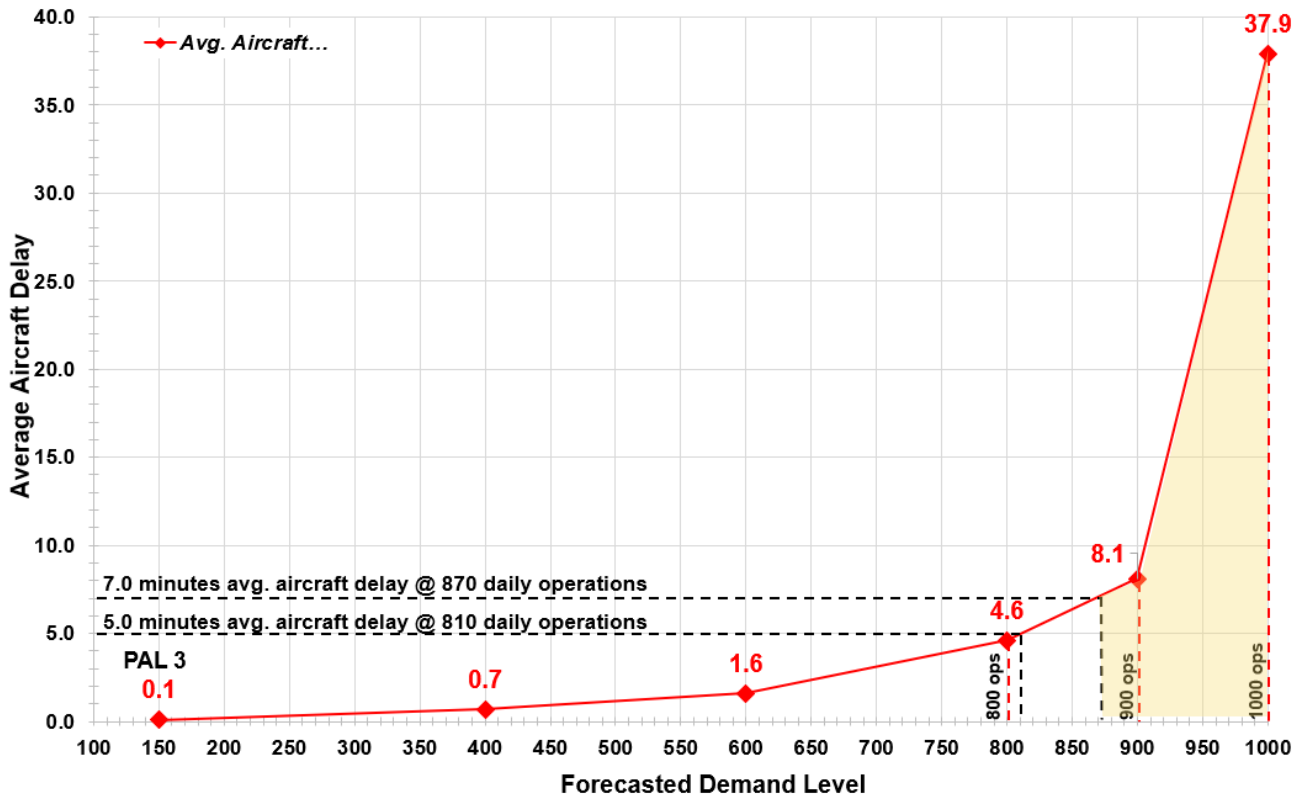
- For simulation purposes, an ADG-III aircraft fleet was simulated (ex. B737-800), as future commercial aviation traffic at PAE would likely be predominately an ADG-III fleet mix.
- 20 NM straight-in final approach course with maximum aircraft entry speeds of 240 knots to a final approach speed of 140 knots
- Mixed use runway operations with arrivals on final approach separated at 5.0 NM intrail to allow for a single departure in between successive arriving aircraft
- Arrivals on final approach block a waiting departure when the arrival is within 2.5 NM of the runway threshold
- Runway exit utilization for arrivals in south flow: Taxiway (A6) 80% and Taxiway A8 (20%)

- Successive departures separated by a minimum of 3.0 NM increasing to 4.0 NM intrail on same departure route

### Simulated Aircraft Delays and Peak Hour Capacity

The 2040 forecast demand level for non-GA aviation traffic at PAE is estimated to be 170 daily operations. For simulation purposes, this demand level was simulated as the baseline case for jet operations on Runway 16R/34L. Simulation results indicate an average of 0.1 minutes of aircraft delay per operation was produced at this demand level and a maximum of 12 operations an hour was achieved in the peak hour. In this scenario, the peak hour demand is strictly a representation of the demand in the system and not a limitation of capacity. Given the very low level of demand and average aircraft delay per operation, increased demand levels were simulated to identify when delays and actual runway capacity was achieved on this runway. For simulation purposes, five additional daily demand levels were simulated (400, 600, 800, 900, and 1,000 daily operations). **Exhibit 4-3** summarizes the average aircraft delay per operation for Runway 16R/34L at each of the simulated demand levels. For this analysis, an acceptable level of delay threshold of 5.0-7.0 minutes per operations is assumed. Simulation results indicate that between 5.0 - 7.0 minutes of average aircraft delay, approximately **810-870 daily operations** can be accommodated on Runway 16R/34L. Beyond these demand levels, aircraft delays spike upward rapidly and exceed a reasonable acceptable level of delay.

**Exhibit 4-3 Simulated Average Aircraft Delay – Jet Aircraft Runway 16R/34L**

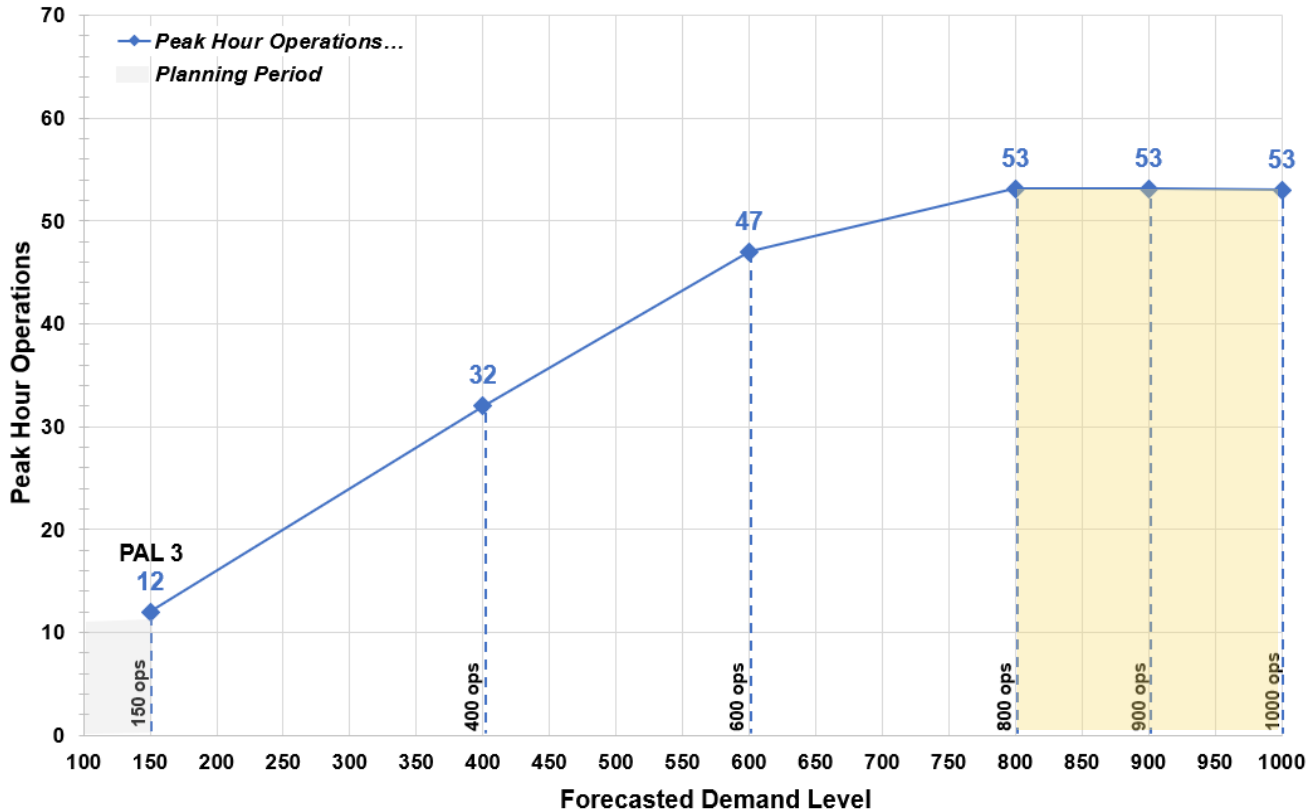


Source: Landrum & Brown, 2021

**Exhibit 4-4** summarizes the simulated peak hour runway capacity for each demand level simulated for jet traffic operations on Runway 16R/34L. The peak hour simulated capacity for this runway is approximately 53 operations per hour and is capped at 800 daily operations.

At demand levels beyond 800 daily operations, average aircraft delays increase exponentially since the hourly runway capacity does not exceed 53 operations per hour.

**Exhibit 4-4 Simulated Peak Hour Operations – Jet Aircraft Runway 16R/34L**



Source: Landrum & Brown, 2021

### Runway 16L/34R – General Aviation Aircraft Operations

- For simulation purposes, an ADG-I aircraft fleet was simulated (ex. Cessna 172), as small piston propelled aircraft are the predominate aircraft fleet operating on the runway
- 15 NM approach course with maximum aircraft entry speeds of 120 knots to a final approach speed of 70 knots
- Mixed use runway operations with arrivals on final approach separated at 3.0 NM intrail to allow for a single departure in between successive arriving aircraft
- Arrivals on final approach block a waiting departure when the arrival is within 1.5 NM of the runway threshold
- Runway exit utilization for arrivals in south flow: Taxiway (G3) 100%

- Successive departures separated by a minimum of 2.0 NM increasing to 3.0 NM intrail on same departure route

### **Simulated Aircraft Delays and Peak Hour Capacity**

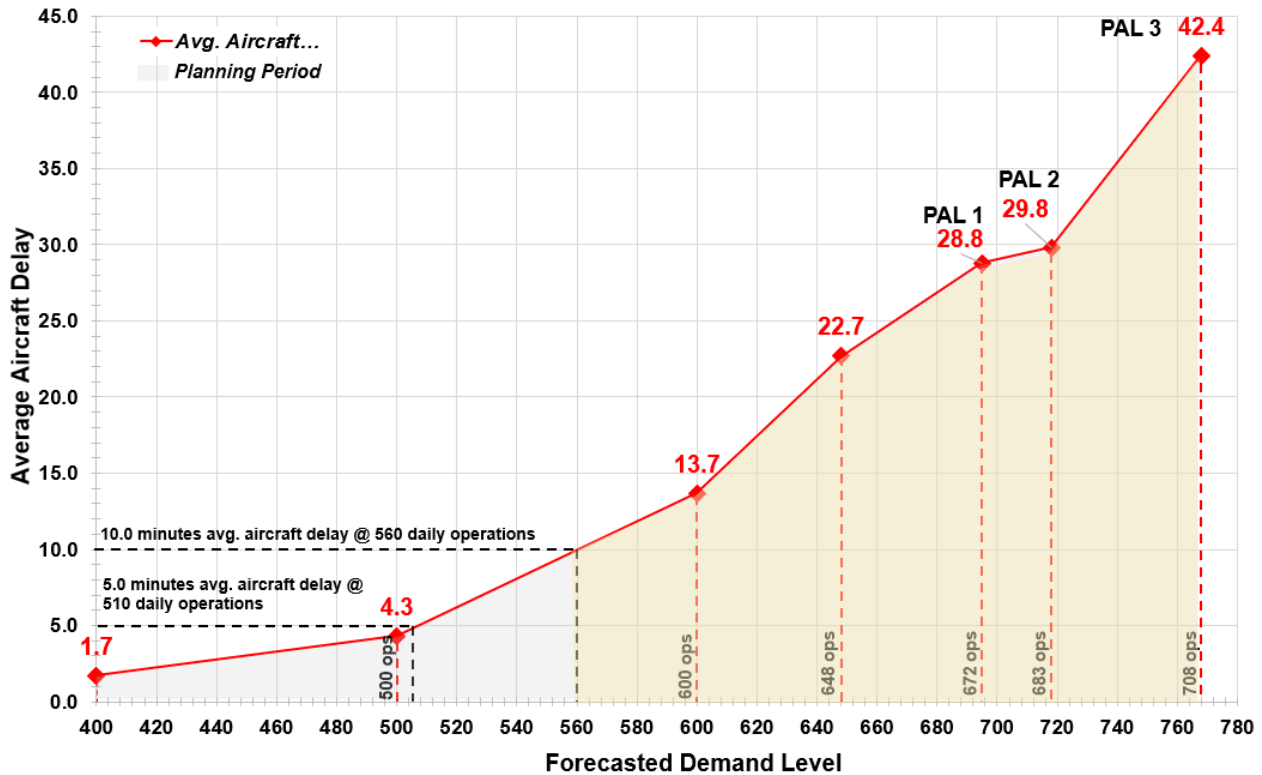
The 2019 forecast demand level for GA aviation traffic at PAE is estimated to be 648 operations for design day .

For simulation purposes, this demand level was simulated as the baseline case for GA operations are restricted on Runway 16L/34R. Simulation results indicate an average of 22.7 minutes of aircraft delay per operation was produced at this demand level and a maximum of 50 operations an hour was achieved in the peak hour. The simulation results indicate the capacity of the runway cannot accommodate this amount of daily demand without incurring excessive aircraft delays which may not be acceptable to the GA aviation community and may not be able to be absorbed at PAE given the geometry of the existing taxiway system and departure queuing space for this runway.

Therefore, three additional simulation experiments were evaluated at demand levels less than 648 daily operations (400, 500, and 600 daily operations) to gain an understanding of when delays reach a reasonable acceptable level. Unlike scheduled commercial aviation service, the GA community may have an increased tolerance for delays, specifically non-itinerant operations operating under visual flight rules (VFR) for casual flying or circuit training operations. For analysis purposes, a 5.0 - 10.0-minute acceptable level of delay was assessed for GA operations on Runway 16L/34R.

**Exhibit 4-5** summarizes the average aircraft delay per operation for Runway 16L/34R at each of the simulated demand levels. Simulation results indicate at 5.0 - 10.0 minutes of average aircraft delay, approximately **510-560 daily operations** can be accommodated on Runway 16L/34R. Beyond these demand levels, aircraft delays spike upward rapidly and exceed a reasonable acceptable level of delay.

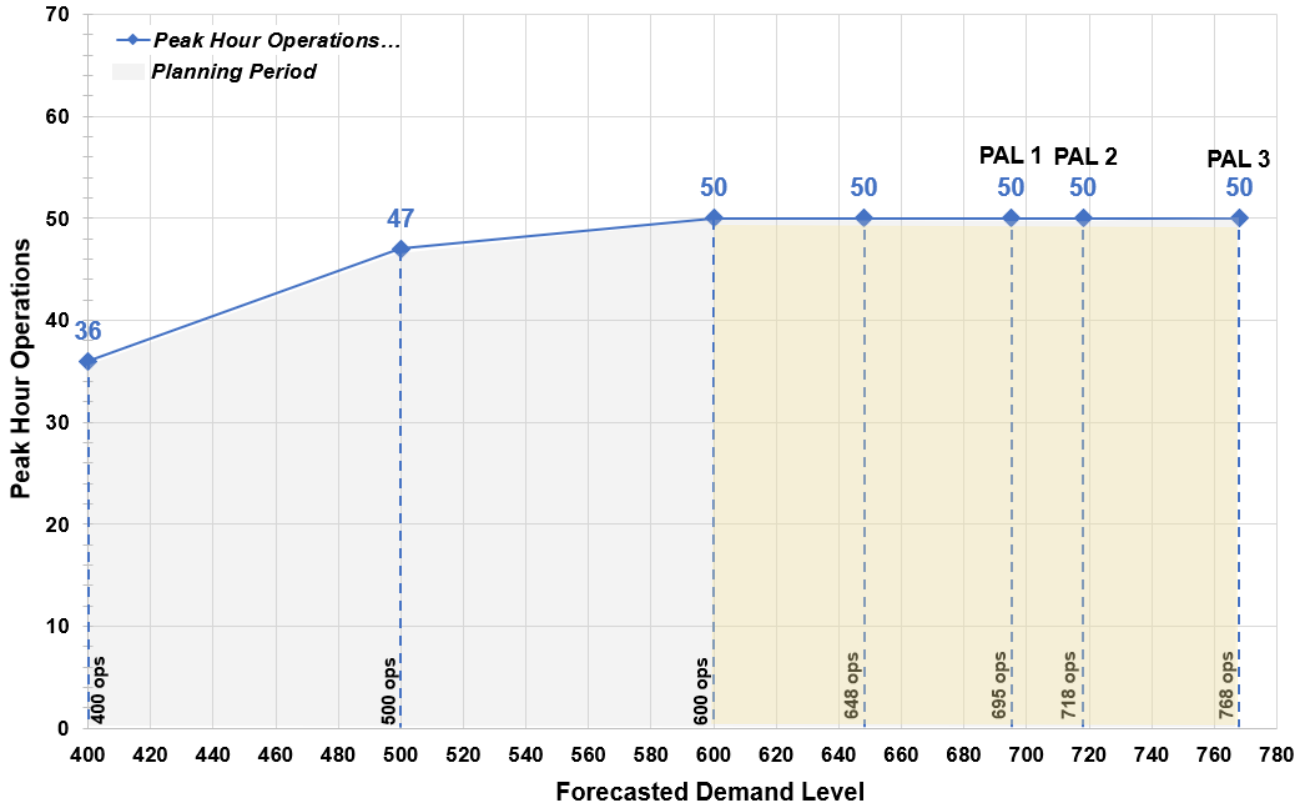
**Exhibit 4-5 Simulated Average Aircraft Delay – GA Aircraft Operations on Runway 16L/34R**



Source: Landrum & Brown, 2021

**Exhibit 4-6** summarizes the simulated peak hour runway capacity for each demand level simulated for GA traffic operations on Runway 16L/34R. The peak hour simulated capacity at daily demand levels between **510-560 operations** is approximately **47-50 operations** per hour.

**Exhibit 4-6 Simulated Peak Hour Operations – GA Aircraft Runway 16L/34R**



Source: Landrum & Brown, 2021

**Estimated Maximum Practical Daily Capacity**

The two runway analyses result in the following estimated maximum practical runway capacity for PAE:

- Runway 16R/34L (assumes ADG-III large jet aircraft operations) – approximately **810-870 daily operations** assuming an acceptable level of average aircraft delay of 5.0 - 7.0 minutes per operation.
- Runway 16L/34R (assumes ADG-I small aircraft operations) – approximately **510-560 daily operations** assuming an acceptable level of average aircraft delay of 5.0 - 10.0 minutes per operation.
- Resulting in an estimated maximum practical runway capacity for both runways of **1320-1430 daily operations** in VMC operating conditions.

**Estimated Annual Service Volume (ASV)**

The annual service volume for each runway operation was computed using the formula from the FAA as listed in AC 150/5060-5 Airport Capacity and Delay. It is estimated the annual service volume for PAE, assuming no delay, is approximately **267,500** operations annually.

Assuming an acceptable level of average aircraft delay between 5.0 - 7.0 minutes the ASV increases to **294,000** annual operations. To better understand the ability of the existing airfield to meet the projected

demand in the 20-year planning timeframe, the percentage of runway capacity utilized was computed as summarized in **Table 4-4**.

**Table 4-4 Estimated Airfield Capacity Utilization**

Forecast Year	Forecast Annual Demand	% of Existing Runway Capacity Utilized (ASV)	% of Existing Runway Capacity Utilized (ASV with Delay)
2019	133,668	50%	45%
2025	147,174	55%	50%
2030	153,474	57%	52%
2040	185,171	69%	63%

Source: Landrum & Brown, 2021

*B.1.1.5 Conclusions*

The results of the simulation analysis indicate that PAE has enough runway capacity to accommodate future growth well beyond the 20-year planning timeframe.

The distribution of aircraft operations for both runways at PAE will likely change when demand grows, specifically when passenger commercial aviation activity increases. Mixing slower moving GA aircraft into the traffic stream with faster moving jet aircraft presents operational restrictions, increased air traffic management workload, and increased separation requirements which ultimately will impact runway capacity and delays.

To improve operational efficiency at PAE, the following airfield infrastructure is recommended

- Airfield taxilane/taxiway improvements for improved traffic flow, and
- High-speed runway exits taxiway improvements to reduce occupancy times.