APPENDIX A

Forecast and Airport Operational Assumptions

2023 Aviation Forecast Update
Constrained Operating Growth Scenarios (COGS)
FAA Approval of 2023 Forecast Update
Environmental Review Airside Modeling Documentation (TAAM)

APPENDIX A

Forecast and Airport Operational Assumptions

Aviation Activity Forecast Update (2023)

Leigh | Fisher

TECHNICAL MEMORANDUM

AVIATION ACTIVITY FORECAST UPDATE

Seattle-Tacoma International Airport

Prepared for

Port of Seattle
Seattle, Washington

September 2023

Port of Seattle

CONTENTS

The purpose of this memorandum is to assist Port of Seattle staff in developing updated aviation forecasts for Seattle-Tacoma International Airport (the Airport or SEA). The forecasts described in this memorandum (the 2022 Forecasts) are developed using 2022 as the base year.

The 2022 Forecasts were initially developed in September 2022 using estimates for 2022 based on eight months of actual data. This update is based on complete calendar year data for 2022 for enplaned passengers, air cargo, aircraft operations, and aircraft operations by aircraft body and equipment type.

The forecasts presented in this memorandum are "unconstrained" and, therefore, do not include specific assumptions about physical, regulatory, environmental or other impediments to aviation activity growth. The unconstrained forecasts were used as a basis to develop a constrained demand scenario that reflects the Airport's ability to accommodate demand. The analysis of a constrained scenario indicated that SEA would experience a constrained operating environment from 2027 through 2037 due to a shortage of gates and airfield constraints. Therefore, it was determined that the unconstrained forecast of aircraft operations at SEA exceeds the constrained forecast and the Airport's ability to accommodate demand, even with implementation of the Proposed Action in the Environmental Assessment. The updates to the unconstrained forecasts presented in this memorandum do not change the constrained demand scenario which is based on an evaluation of SEA facilities and used as a basis for the Environmental Assessment.

1.0 THE 2022 FORECASTS

The impact of the COVID-19 pandemic and the speed of recovery of both the economy and public confidence in the aviation system will significantly affect aviation activity levels at the Airport. As the Airport predominantly serves origin and destination activity (O&D passengers accounted for approximately 71% of SEA's passengers in 2019), future long-term growth in aviation activity at the Airport (subsequent to recovery from the COVID-19 pandemic) will occur largely as a function of the growth in the population and economy of the Seattle region, as well as regional, national, and international economic performance.

2.0 ENPLANED PASSENGERS

The 2022 Forecasts of enplaned passengers are developed in two parts: (1) short-term (2-year) forecasts and (2) long-term forecasts through 2038 based on forecast growth in the Seattle Region economy and the cost of travel and the role of the Airport as a connecting hub and international gateway.

2.1 Short-Term Passenger Forecasts

The near-term forecasts are based on an analysis of the recovery of passengers at SEA to pre-pandemic 2019 levels including a review of year-to-date passenger traffic, the airline outlooks for Delta and Alaska, SEA's two connecting hub airlines, and recent seat capacity trends.

2.1.1 Recovery to Pre-pandemic Levels

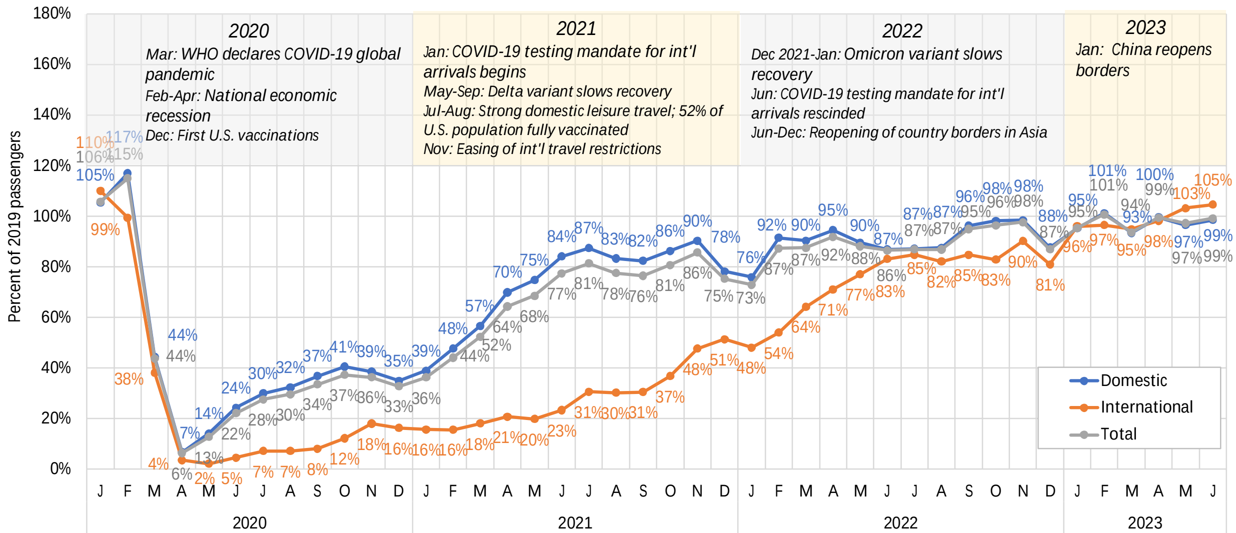
The domestic sector has driven passenger traffic recovery at SEA largely due to strong demand for leisure travel and the substitution of domestic airline trips for international trips given country border closures and international travel restrictions. The recovery of international passenger traffic at SEA accelerated in 2022 following the initial lifting of international travel restrictions in November 2021. The recovery of pre-pandemic passenger levels at SEA is described below and shown on Figure 2-1.

- *In 2020, total passenger traffic at SEA accounted for 39% of 2019 levels.* Regional and state lockdowns and social distancing policies combined with an increasing trend in COVID-19 cases resulted in a 3.4% decrease in U.S. real GDP (adjusted for inflation) and a 61% decrease in U.S.

passenger traffic between 2019 and 2020.* Domestic passengers at SEA accounted for 41% of 2019 levels in 2020, while international passengers accounted for 23%.

- *In 2021, total passenger traffic at SEA accounted for 70% of 2019 levels.* The availability and rapid distribution of approved COVID-19 vaccines contributed to a significant decrease in new COVID-19 cases in the United States, notwithstanding the increase in new cases caused by the Delta variant in July through mid-September and the Omicron variant in December. Domestic passengers at SEA accounted for 75% of 2019 levels in 2021, while international passengers accounted for 29%.

Figure 2-1
RECOVERY OF PRE-PANDEMIC PASSENGER LEVELS
Seattle-Tacoma International Airport



Source: Seattle-Tacoma International Airport records.

- *In 2022, total passenger traffic at SEA accounted for 89% of 2019 levels.* Strong passenger traffic growth in 2022 reflects improved economic conditions, continued pent-up demand for domestic leisure travel, the reopening of U.S. businesses and accelerated corporate travel demand, the easing of international travel restrictions, the rescinding of the COVID-19 testing requirement for international passengers entering the United States in June 2022, and the reopening of country borders in Oceania and Asia including Hong Kong, Japan, the Philippines, Singapore, South Korea, and Taiwan—all of which are key international markets for the Airport. Domestic passengers at SEA accounted for 90% of 2019 levels in 2022, while international passengers accounted for 76%.

- *During the first six months of 2023 (January through June), total passenger traffic at SEA accounted for 98% of 2019 levels.* Domestic passenger traffic increased 10.3% during the first six months of 2023 compared with the same period in 2022, reflecting continued economic growth and strong leisure demand. The reopening of country borders in Asia, including China in January 2023,

* U.S. Bureau of Economic Analysis, Table 1.1.6. Real Gross Domestic Product, Chained Dollars, November 24, 2021, www.bea.gov. U.S. Department of Transportation, Schedule T100 and TSA Throughput Passengers, online database, accessed November 2021.

resulted in a 46.3% increase in international passenger traffic at SEA during the first six months of 2023. Domestic passengers at SEA accounted for 97% of 2019 levels during the first six months of 2023, while international passengers accounted for 99%.

2.1.2 Alaska's Outlook

Alaska's outlook for Q3 2023 and full year 2023 includes capacity increases (in terms of Available Seat Miles or ASMs) of 10% to 13% and 11% to 13%, respectively, compared with the same period in 2022. "Demand remains very strong, even as we've come off the peak of historically high fares, a trend we knew would happen at some point. Notwithstanding this evolution, yield is still meaningfully above 2019 levels on industry capacity that has now surpassed 2019 levels by an estimated 6% for the second half of 2023."*

Domestic Demand. During the first 5 months of 2023 (the most recent period available), Alaska's systemwide mainline domestic passengers accounted for 98% of 2019 levels (an 14.3% increase over the same period in 2022), according to USDOT T100 data. In comparison, Alaska's mainline domestic passengers at SEA accounted for 112% of Alaska's 2019 levels at the Airport during the first 6 months of 2023. Alaska's mainline domestic passengers accounted for 86% of Alaska's total domestic passengers during the first 6 months of 2023, with the remaining 14% accounted for by its regional affiliates (Horizon with 10% and Skywest with 4%).

International Demand. Alaska is primarily a domestic airline with international passengers accounting for a small share of total passengers (mainline and regional)—7% systemwide and 3% at SEA during the first 5 months of 2023. Alaska primarily serves destinations in Canada and Mexico at SEA.

Aircraft Fleet. In Q1 2022, Alaska announced aircraft fleet transition plans, including the removal of all A320 and Q400 aircraft from operating service (completed in January 2023) and the transition to an all-Boeing fleet and all-Embraer fleet. Alaska continues to operate 10 A321neo aircraft until the end of Q3 2023.** As of June 2023, Alaska had orders for 199 B737 narrowbody aircraft and 24 E175 regional jets to be delivered between 2023 and 2030. On its Q2 2023 earnings call, Alaska management noted that "Boeing has also continued to be a great partner, delivering according to expectations despite continued disruptions within their supply chain."

Staffing. In March 2022, Alaska launched its pilot development program, the Ascend Pilot Academy, with an enrollment of 500 pilots. In addition, Hillsboro Aero Academy is training another 200 pilots for Horizon. As of Q2 2023, Alaska employed 23,300 people, a 3% increase compared with the same period in 2022 and an 11% increase over 2019. On its Q2 2023 airline earnings call, Alaska indicated that the airline was maintaining "elevated staffing levels to support operational integrity" and are "carrying a significant amount of surplus pilots on the Airbus" to facilitate the transition to an all-Boeing fleet.

SEA's Role in Alaska's System. SEA ranks first in Alaska's system in 2023 with 29.5% of scheduled departing systemwide seats, followed by Portland with 7.6%. Between 2010 and 2023, the number of Alaska's scheduled departing seats at SEA increased an average of 3.9% per year during the period when Delta was building its connecting hub and gateway at the Airport.

* Alaska Airlines, 2Q 2023 Earnings Transcript, July 25, 2023, www.alakaair.com.

** Alaska Airlines, SEC Form 10-Q, July 25, 2023, www.alakaair.com.

2.1.3 Delta's Outlook

Delta's outlook for near- and longer-term growth is positive with record revenue reported in Q2 2023 driven by domestic and international demand. "Robust demand is continuing into the September quarter where we expect total revenue to be similar to the June quarter, up 11 percent to 14 percent compared to the September quarter 2022 on capacity that is 16 percent higher."*

Domestic Demand. During the first 5 months of 2023 (the most recent period available), Delta's systemwide mainline domestic passengers accounted for more than 100% of 2019 levels (an 11.4% increase over the same period in 2022), according to USDOT T100 data.* In comparison, Delta's mainline domestic passengers at SEA accounted for 106% of Delta's 2019 levels at the Airport during the first 6 months of 2023. Delta's domestic demand is being driven by leisure and business travel. Delta's recent corporate survey showed that businesses expect to increase travel in the second half of 2023 which was also reflected in Morgan Stanley's recent Global Travel Survey where respondents indicated travel was expected to grow 9% year over year in the second half and 8% into 2024.

International Demand. During the first 5 months of 2023, Delta's systemwide mainline international passengers accounted for 93% of 2019 levels (a 42.5% increase over the same period in 2022), according to USDOT T100 data. In comparison, Delta's mainline international passengers at SEA accounted for 117% of Delta's 2019 levels at the Airport during the first 6 months of 2023. Transatlantic passengers to Europe accounted for the largest share of Delta's passengers systemwide and at SEA during the first half of 2023 and represented 108% and 136%, respectively, of 2019 levels systemwide and at SEA. Delta's transpacific passengers to Asia benefited from the re-opening of country borders for Japan (late 2021) and China (January 2023) as well as Delta's joint venture with Korean Air. Transpacific passengers to Asia accounted for 52% and 71%, respectively, of 2019 levels systemwide and at SEA during the first half of 2023.

Aircraft Fleet. As of June 2023, Delta had orders for 290 narrowbody aircraft (70 A220-300s, 120 A321-200neos, and 100 B737-10s) and 33 widebody aircraft (17 A330-900neos and 16 A350-900s). On its Q2 2023 earnings call, Delta management noted that "the industry continues to face multiple constraints across the supply chain, aircraft delivery delays, and training needs. As a result, we see a significant gap between the supply that is in place and what demand could sustain, and we expect this gap will remain for an extended period of time."

Staffing. As of Q2 2023, Delta employed 90,000 people, a 13% increase compared with the same period in 2022 and 2019. In Q1 2023, Delta pilots ratified a new four-year Pilot Working Agreement effective January 1, 2023, including work rule changes and pay rate increases. On its Q1 2023 airline earnings call, Delta reported "putting 600 pilots into production. So, it's really the first time over the last 18 months that are actually -- school house will step down here during the second quarter."

SEA's Role in Delta's System. SEA is the eighth busiest airport in Delta's system in 2023 in terms of scheduled departing seats with 3.4% of systemwide seats. (Atlanta ranked first with 21.2% in 2023.) Between 2010 and 2023, the number of Delta's scheduled departing seats at SEA increased an average of 10.2% per year—the fastest rate of any of Delta's busiest 25 airports, reflecting the buildup of SEA as a West Coast connecting hub and international gateway in Delta's system. In 2023, SEA accounted for the fifth largest share of international scheduled seats in Delta's system, up from its sixth place ranking in 2019 and eighth place in 2010.

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* Delta Air Lines, 2Q 2023 Earnings Transcript, July 13, 2023, www.ir.delta.com.
* U.S. Department of Transportation, Schedule T100, online database, accessed August 2023. During the first 5 months of 2023, Delta's systemwide regional domestic passengers accounted for 71% of 2019 levels (an 2.2% decrease over the same period in 2022), reflecting, in part, the shortage of regional airline pilots.

2.1.4 Key Factors Affecting the Short-Term Passenger Forecasts

The short-term passenger forecasts (i.e., 2023 through 2024) are driven by the pace of recovery from the impacts of the COVID-19 pandemic. The following summarizes several factors that are expected to have the largest impact (both positive and negative) in the short-term.

Positive Impact	Negative Impact
Resumption of Business Travel	Higher than average inflation, sustained by high fuel prices
Continued strong demand for leisure travel	Reductions in airline seat capacity due to airline labor shortages, including pilots
Easing of international travel restrictions	Aircraft delivery delays due to supply chain issues \
The rescinding of the COVID-19 testing requirement for international passengers entering the United States in June 2022	Potential for a "technical" recession, i.e., two consecutive quarters of negative U.S. GDP growth
Country borders reopening in Asia including Hong Kong, Japan, the Philippines, Singapore, South Korea, and Taiwan—all of which are key international markets for the Airport	Emergence of additional COVID-19 variants
	Geo-political conditions, particularly the war in Ukraine and the impact of sanctions on Russia

2.1.4.1 Positive Impact Factors

Resumption of Business Travel. According to Morgan Stanley's June 2023 Global Corporate Travel Survey, business travel budgets are expected to increase 9% year-over-year in the second half of 2023 and 8% in 2024, with 30% of survey respondents indicating that business travel had returned to pre-COVID travel levels.* During Q2 2023 earnings calls, U.S. airlines reported continued improvement in business travel, with recent increases driven primarily by international travel. Unmanaged business travel by small- and medium-sized businesses continues to lead the recovery, although upside growth is expected as business travel by large corporations gradually returns to pre-pandemic levels. Airlines continue to see "blended" travel for both business and leisure purposes, particularly by small- and medium-sized businesses. *Strong bookings for September travel point to an increase in business travel as the peak summer period ends and continued growth in SEA passenger traffic.*

Strong Leisure Demand. According to the Downtown Seattle Association's September 2023 recovery report, "Downtown welcomed nearly 3 million visitors in August 2023, representing 91% of the visitors in August 2019."** Downtown Seattle hotel room demand reached 399,000 in August 2023, representing 99% of the rooms sold in August 2019. CBRE, a U.S. commercial real estate services and investment form, forecasts a recovery in Seattle's hotel market by 2024.*** Continued growth in Seattle's cruise industry has supported passenger traffic growth at SEA with more than 1.4 million passengers expected in 2023 (a 15% increase over 2019 levels) **** and an extension of the cruise schedule from mid-April to the end of

* Markets Insider, Analyzing Corporate Travel Trends: Key Insights From Morgan Stanley's Global Survey, June 12, 2023, www.markets.businessinsider.com.
** Downtown Seattle Association, Downtown Recovery Dashboard, September 2023/August Data, www.downtownseattle.org.
*** Coldwell Banker Richard Ellis (CBRE), Seattle Lodging Market on Pace for Recovery by 2024, June 10, 2022, www.cbre.com.
**** Port of Seattle, 2023 Cruise Season Underway in Seattle, April 15, 2023, www.portofseattle.org and Cruise Industry News, Seattle Expecting Robust Cruise Year, January 27, 2023, www.cruiseindustrynews.com

October. *Continued strong recovery in the Seattle tourism market is expected to positively impact SEA passenger levels.*

Easing of International Travel Restrictions. On November 8, 2021, the U.S. lifted international travel restrictions to allow foreign nationals who provide proof of full vaccination against COVID-19 and a negative pre-arrival test result to travel to the United States (which was rescinded in June 2022). At the end of 2022, the CDC followed the lead of several other countries, implementing a requirement for a negative COVID-19 test from air passengers arriving from China, Hong Kong, and Macao, and rescinded the requirement on March 15, 2023. As a result, scheduled service from SEA to China restarted in March 2023. *The easing of international travel restrictions had a positive impact SEA international passenger traffic. In June 2023, international passengers at SEA accounted for 105% of 2019 levels, up from 83% in June 2022, as shown previously on Figure 2-1.*

Country Borders Reopening in Asia. On September 23, 2022, Hong Kong, Taiwan, and Japan announced the elimination of border restrictions, while China remained as one of the last countries in Asia with strict border controls due to its zero-COVID policy. On January 8, 2023, China opened its borders to foreigners for business travel or family visits and Chinese nationals living abroad. During the first 6 months of 2023, SEA passengers from Asia accounted for 91% of 2019 levels, up from 41% during the same period in 2022. *Since passengers from Asia accounted for 37% of SEA's international passengers in 2019, these border openings are expected to have a positive impact on the rate of recovery of SEA's international passengers.*

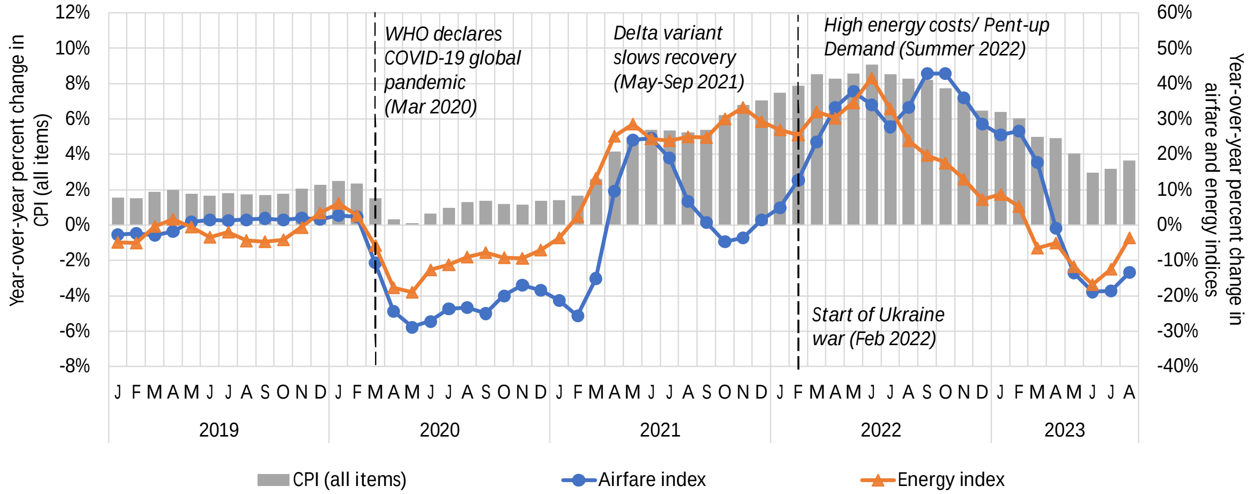
2.1.4.2 Negative Impact Factors

Higher Than Average Inflation. Inflation negatively impacts passenger traffic levels by putting upward pressure on airfares and limiting the amount of disposable income available for travel due to the higher cost of other expenditures. Higher energy costs and pent-up demand for air travel during the summer of 2022 put upward pressure on airfares, as shown on Figure 2-2. However, strong demand for summer air travel together with savings during the pandemic prevailed over higher airfares and other travel costs in the short-term. By July 2022, increases in energy prices and airfares had started to moderate. *Although inflationary pressures are expected to ease over the long-term, continued high inflation rates in the short-term could have a negative impact on passenger demand.*

Airline Seat Capacity Reductions. Airline seat capacity reductions in 2022 reflected underlying issues with pilot and other staffing shortages that resulted in increased irregular operations and ATC delays. The current pilot shortage is most closely linked to early retirement packages offered by airlines during the pandemic but also with longer term changes in the pilot supply chain. For example, fewer pilots are available to be recruited from the military because of the increased use of drones in modern warfare and increased emphasis on training drone pilots rather than aircraft pilots. In addition, the high cost of pilot training is a barrier to expanding the pilot workforce, so much so that airlines are subsidizing training costs and/or establishing their own flight schools to meet the need for pilots. The two airlines accounting for the largest shares of passenger traffic at SEA—Alaska and Delta—have reported large increases in staffing and training programs. Alaska expects all pilot training to be completed by the end of 2023, including the transition and training of its A321 pilots to B737 aircraft.* Delta expects to put 600 pilots into production and step down its pilot training program.** *Continued pilot and other staffing issues in the short-term may have a negative impact on passenger traffic recovery.*

* Alaska Airlines, Q1 2023, Earnings call transcript, April 20, 2023.
** Delta Air Lines, Q1 2023, Earnings call transcript, April 13, 2023.

Figure 2-2
PRICE CHANGES: ALL CONSUMER ITEMS, AIRFARES, AND ENERGY COSTS
Seattle-Tacoma International Airport



Source: U.S. Bureau of labor Statistics, online database, www.bls.gov, accessed September 2023.

New Aircraft Delivery Delays. In 2022, several airlines including American, Delta, Southwest, Spirit, and United reported delays in the delivery of new aircraft. In February 2022, American Airlines announced the removal of certain routes from its 2022 schedule due to delayed B787 deliveries. Airbus and Boeing cite supply chain issues as the primary reason for the delay. Boeing has also faced a slow FAA certification process for the B787, B737 Max7 and Max 10, and B777x. On its Q2 2023 earnings call, Alaska reported that "Boeing has also continued to be a great partner, delivering according to expectations despite continued disruptions within their supply chain."* On its Q2 2023 earnings call, Delta noted that "the industry continues to face multiple constraints across the supply chain, aircraft delivery delays, and training needs. As a result, we see a significant gap between the supply that is in place and what demand could sustain, and we expect this gap will remain for an extended period of time."** *Continued delays in the delivery of new aircraft will have an impact in the short-term which is already reflected in capacity reductions.*

Emergence of COVID-19 Variants. According to the CDC, new variants of the COVID-19 virus are expected to occur with some variants disappearing and others persisting. The CDC's capabilities for monitoring, testing, and developing vaccines and treatments for new variants are in place. *The 2022 Forecasts do not incorporate assumptions on any future variants; however, the expectation is that the negative impacts would be minimal should there be future variants.*

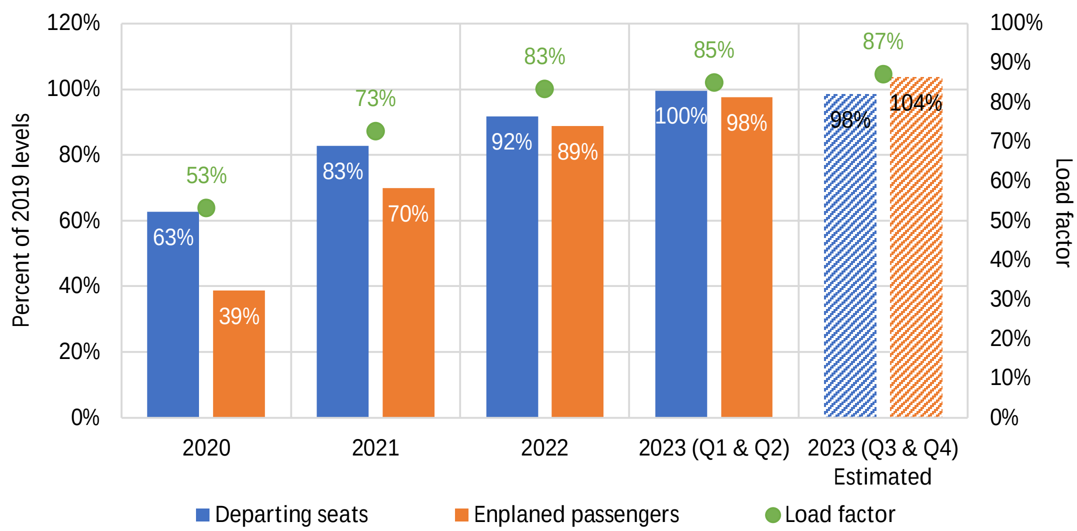
2.1.5 Short-Term Passenger Forecasts: 2023 - 2024

In 2023, SEA passenger traffic is expected to account for 97% of 2019 levels based on actual passenger traffic for the first six months of 2023 and seat capacity for the remainder of the year published in advance airline schedules, as shown on Figure 2-3 and Figure 2-4. Passenger traffic at SEA is expected to recover to 2019 levels in 2024 and total 25.9 million, as shown on Figure 2-6. Similarly, the number of domestic and

* Alaska Airlines, Q2 2023 Earnings call transcript, July 25, 2023.
** Delta Air Lines, Q2 2023 Earnings call transcript, July 13, 2023.

international passengers are expected approximate 2019 levels in 2024. *The 2022 Forecasts of enplaned passengers at the Airport is shown in Table 1 in the Appendix.*

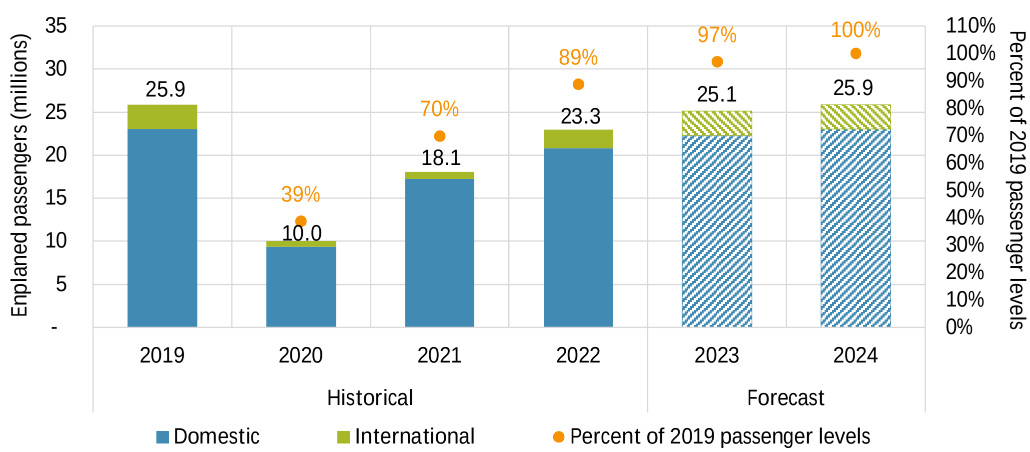
Figure 2-3
RECOVERY OF PRE-PANDEMIC PASSENGER AIRLINE ACTIVITY
Seattle-Tacoma International Airport



Note: Advance airline schedules are subject to change.

Sources: Seattle-Tacoma International Airport records and Airline Data Inc., airline schedules online database, accessed August 2023.

Figure 2-4
SHORT-TERM FORECASTS OF ENPLANED PASSENGERS: 2023 AND 2024
Seattle-Tacoma International Airport

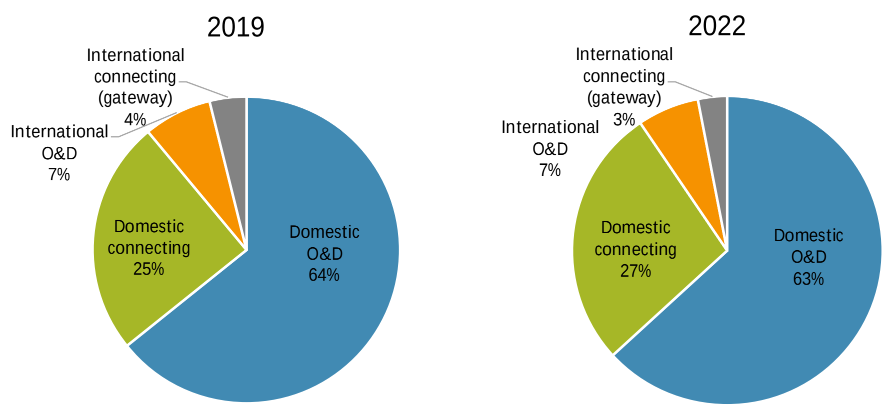


Sources: Historical—Seattle-Tacoma International Airport records. Forecast—LeighFisher, June 2022, updated August 2023.

2.2 Long-Term Passenger Forecasts Through 2038

The long-term forecast approach included a review of the key components of demand in 2019 before the pandemic and 2022 (the most recent calendar year available), as shown on Figure 2-5, and an evaluation of the key drivers of each component.

Figure 2-5
KEY COMPONENTS OF PASSENGER DEMAND IN 2019 AND 2022
Seattle-Tacoma International Airport



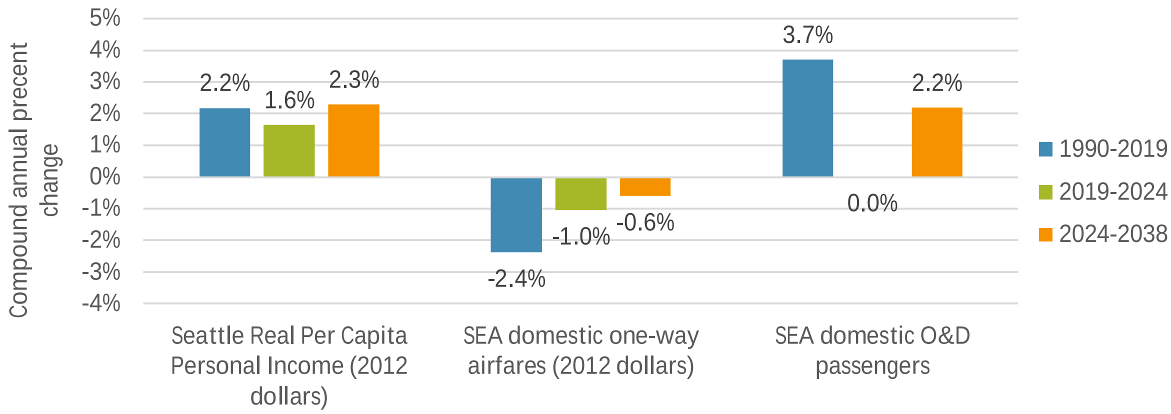
Sources: Historical—Seattle-Tacoma International Airport records and U.S. Department of Transportation, Origin-Destination Survey, online database, accessed August 2023.

2.2.1 Domestic Origin-Destination Passengers

As the largest demand component, domestic O&D passengers at SEA accounted for 64% of total enplaned passengers in 2019. Historically, the key drivers of SEA domestic O&D passengers have included an income variable such as per capita income and a cost of travel variable such as SEA domestic airfares.

- As shown on Figure 2-6, historical and forecast growth rates for Seattle per capita personal income are similar—an average increase of 2.2% per year between 1990 and 2019, 1.6% per year between 2019 and 2024 during the COVID-19 pandemic and recovery, and 2.2% per year between 2024 and 2038.
- SEA domestic airfares, in constant dollars, are forecast to continue to decrease through 2038 but at slower than historical rates, based on the FAA's 2022 National Aerospace Forecast assumptions for domestic yield.
- SEA domestic O&D passengers increased an average of 3.7% per year between 1990 and 2019. No growth in SEA domestic O&D passengers is expected between 2019 and 2024 during the COVID-19 pandemic and while passenger traffic recovers to 2019 pre-pandemic levels. Between 2024 and 2038, the number of SEA domestic O&D passengers is forecast to increase an average of 2.2% per year based on the analytical framework from previous econometric analyses.

Figure 2-6
HISTORICAL AND FORECAST PER CAPITA PERSONAL INCOME,
SEA DOMESTIC AIRFARES, AND SEA DOMESTIC O&D PASSENGERS



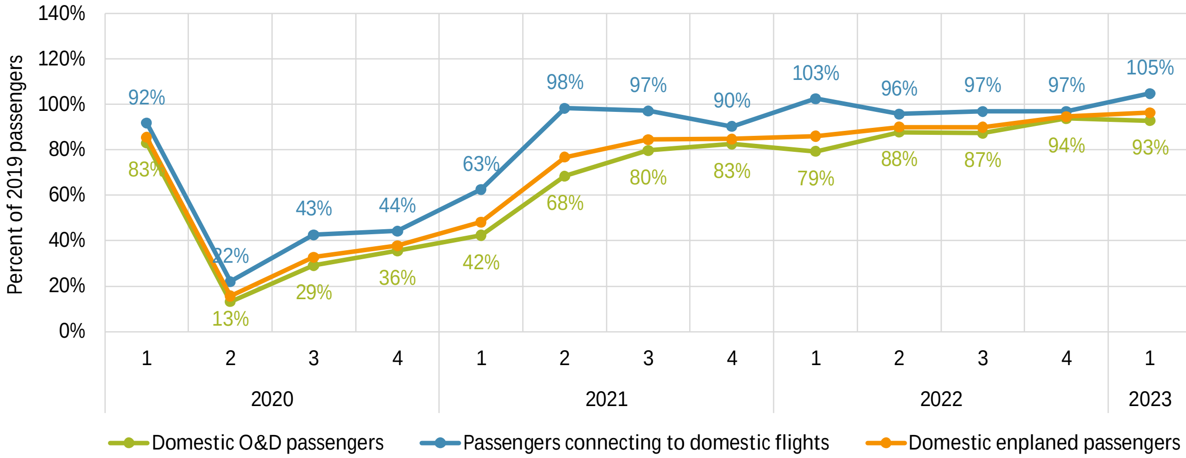
Note: Per capita personal income data area for Seattle-Tacoma-Bellevue Metropolitan Statistical Area (MSA). Forecasts of SEA domestic airfares were based on the FAA's forecast growth rates for domestic yield.

Sources: *Per Capita Personal Income*—I HS Markit Economics, June 2022 Forecast.
SEA Domestic Airfares—U.S. Department of Transportation, Origin-Destination Survey, online database, accessed June 2022 and Federal Aviation Administration, FAA Aerospace Forecast FY 2022–2042, www.faa.gov, June 28, 2022.
SEA domestic O&D passengers— Seattle-Tacoma International Airport records and U.S. Department of Transportation, Origin-Destination Survey, online database, accessed June 2022. Forecast—LeighFisher, June 2022.

2.2.2 Domestic Connecting Passengers

Domestic connecting passengers at SEA accounted for 25% of total enplaned passengers in 2019 and include domestic passengers boarding another domestic flight and international passengers boarding a domestic flight. The increasing base of domestic connecting passengers reflects the ongoing role of the Airport as a primary connecting hub in Alaska's system and the development of the Airport as West Coast connecting hub and international gateway in Delta's system. Domestic connecting passengers at SEA are recovering at a faster pace than domestic O&D and total domestic enplaned passengers, as shown on Figure 2-7. It is expected that SEA's domestic connecting passengers will recover to 2019 pre-pandemic levels in 2024 and increase at a slightly faster rate than domestic O&D passengers between 2024 and 2038, increasing an average of 2.4% per year.

Figure 2-7
RECOVERY OF DOMESTIC O&D AND CONNECTING PASSENGERS BY QUARTER
Seattle-Tacoma International Airport



Sources: Seattle-Tacoma International Airport records and U.S. Department of Transportation, Origin-Destination Survey, online database, accessed August 2023.

2.2.3 International Origin-Destination Passengers

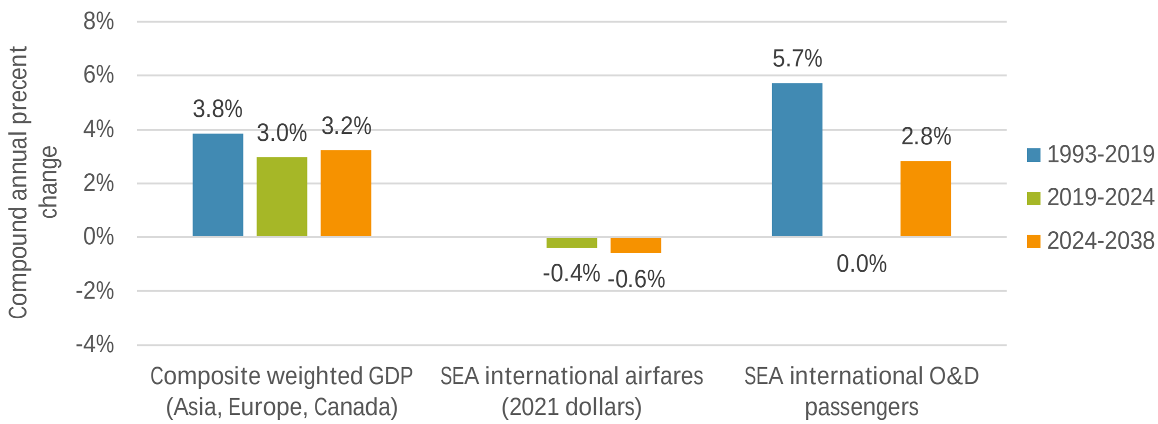
International O&D passengers at SEA accounted for 7% of total enplaned passengers in 2019. The number of international O&D passengers at the Airport is related to the strength of the Seattle economy and the location of global companies and strong international communities of interest in the Seattle area. In addition, the level of international service provided at the Airport is supported by shorter flight times to Asian destinations compared with other West Coast gateways, the increasing presence of oneworld and SkyTeam members at SEA, and the cost advantages of Delta's Pacific gateway at Seattle compared with Asian gateways.

- In 2019, international airline service was provided from SEA to three world regions—Asia, Canada, and Europe. Asia accounted for the largest share of international enplaned passengers at the Airport in 2019, with 40%, followed by Canada and Europe, each with 30%.
- International O&D passengers at SEA accounted for 65% of total international enplaned passengers in 2019, international connecting passengers accounted for the remaining 35%.
- In 2019, 22 foreign-flag airlines served the Airport and accounted for 55% of international enplaned passengers; U.S. airlines accounted for the remaining 45%.
- Historical and forecast growth rates for composite weighted GDP for Asia, Canada, and Europe are developed to represent the three international regions served at the Airport and are based on each region's share of international enplaned passengers at SEA in 2019. As shown on Figure 2-8, composite weighted GDP for Asia, Canada, and Europe increased an average increase of 3.8% per year between 1993 and 2019 and is forecast to increase 3.0% per year between 2019 and 2024 during the COVID-19 pandemic and recovery, and 3.2% per year between 2024 and 2038.
- SEA international airfares, in constant dollars, are forecast to decrease through 2038 but at slower than historical rates, based on the FAA's 2022 National Aerospace Forecast assumptions for

international yield. Historical data for international airfares are not available for 1990 through 2019.*

- SEA international O&D passengers increased an average of 5.7% per year between 1990 and 2019. No growth in SEA international O&D passengers is expected between 2019 and 2024 during the COVID-19 pandemic and while passenger traffic recovers to 2019 pre-pandemic levels. Between 2024 and 2038, the number of SEA international O&D passengers is forecast to increase an average of 2.8% per year based on the analytical framework from previous econometric analyses.

Figure 2-8
HISTORICAL AND FORECAST COMPOSITE WEIGHTED GDP,
SEA INTERNATIONAL AIRFARES, AND SEA INTERNATIONAL O&D PASSENGERS



Note: Forecasts of SEA international airfares were based on the FAA's forecast growth rates for international yield.

Sources: *Composite weighted Gross Domestic Product (GDP)*—I HS Markit Economics, June 2022 Forecast. Data are weighted based on each region's share of international enplaned passengers at SEA in 2019 prepared by LeighFisher.
SEA International Airfares—OAG Worldwide Aviation Ltd, online database, accessed June 2022 and Federal Aviation Administration, FAA Aerospace Forecast FY 2022–2042, www.faa.gov, June 28, 2022.
SEA international O&D passengers— Seattle-Tacoma International Airport records and U.S. Department of Transportation, Origin-Destination Survey, online database, accessed June 2022. Forecast—LeighFisher, June 2022, updated August 2023.

2.2.4 International Connecting Passengers

International connecting passengers at SEA accounted for 4% of total enplaned passengers in 2019. The number of international connecting passengers at the Airport is related to the development of the Airport as an international gateway by Delta and foreign-flag airlines. It is expected that SEA's international connecting passengers will recover to 2019 pre-pandemic levels in 2024 and increase at the same rate as international O&D passengers between 2024 and 2038—an average of 2.8% per year.

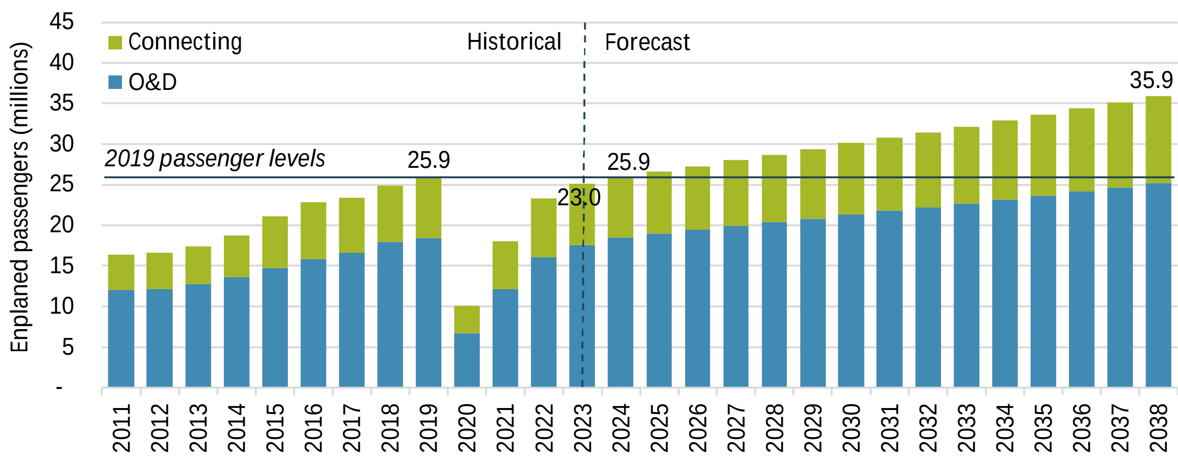
* Although the USDOT O&D Survey collects data for international airfares, only U.S. airlines are required to report; therefore, the data do not include airfares for foreign-flag airlines. Bookings data for international airfares are available which include both U.S. and foreign-flag airlines; however, a historical data series back to 1990 is not available.

2.2.5 Total Enplaned Passengers

As shown on Figure 2-19, the number of total enplaned passengers at SEA is expected to recover to 2019 levels in 2024 and increase to 36.3 million in 2038. The percentages of O%D and connecting passengers are expected to return to 2019 levels (71% and 29%, respectively) by 2024. Between 2024 and 2038, the share of O&D passengers is expected to decrease slightly to 70% but continue to increase an average of 2.2% per year.

The 2022 Forecasts of enplaned passengers at the Airport is shown in Table 1 in the Appendix.

Figure 2-9
HISTORICAL AND FORECAST ENPLANED PASSENGERS: 2023-2038
Seattle-Tacoma International Airport



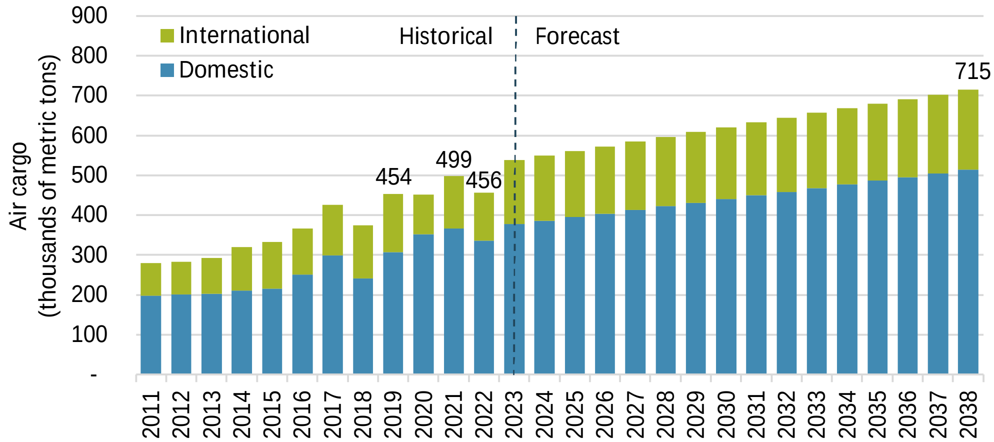
Sources: Historical—Seattle-Tacoma International Airport records and U.S. Department of Transportation, Origin-Destination Survey, online database, accessed June 2022. Forecast—LeighFisher, June 2022, updated August 2023.

3.0 AIR CARGO

Total air cargo at SEA decreased 0.2% in 2020, driven by a 31.1% decrease in international air cargo as the COVID-19 pandemic closed international borders and resulted in the loss of long-haul passenger belly capacity on widebody aircraft fleets. In contrast, domestic air cargo increased 14.6% in 2020 and 4.3% in 2021, reflecting strong growth in e-commerce as consumers increasingly relied on online sales and delivery and reduced in-store visits to limit their exposure to the coronavirus. As shown on Figure 3-1, air cargo at SEA is forecast to increase to 715,000 metric tons in 2038, representing an average increase of 2.4% per year between 2019 and 2024 during the pandemic and recovery, and an average increase of 1.9% per year between 2024 and 2038.

The 2022 Forecasts of air cargo at the Airport is shown in Table 2 in the Appendix.

Figure 3-1
AIR CARGO FORECASTS
Seattle-Tacoma International Airport



(a) Includes general aviation, military, and other unscheduled operations.
Sources: Historical—Seattle-Tacoma International Airport records. Forecast—LeighFisher, June 2022, updated August 2023.

4.0 AIRCRAFT OPERATIONS

As shown on Figure 4-1, total aircraft operations at SEA are expected to recover to 2019 levels in 2024 and increase to 574,100 in 2038, with passenger airlines accounting for 95% of total aircraft operations.

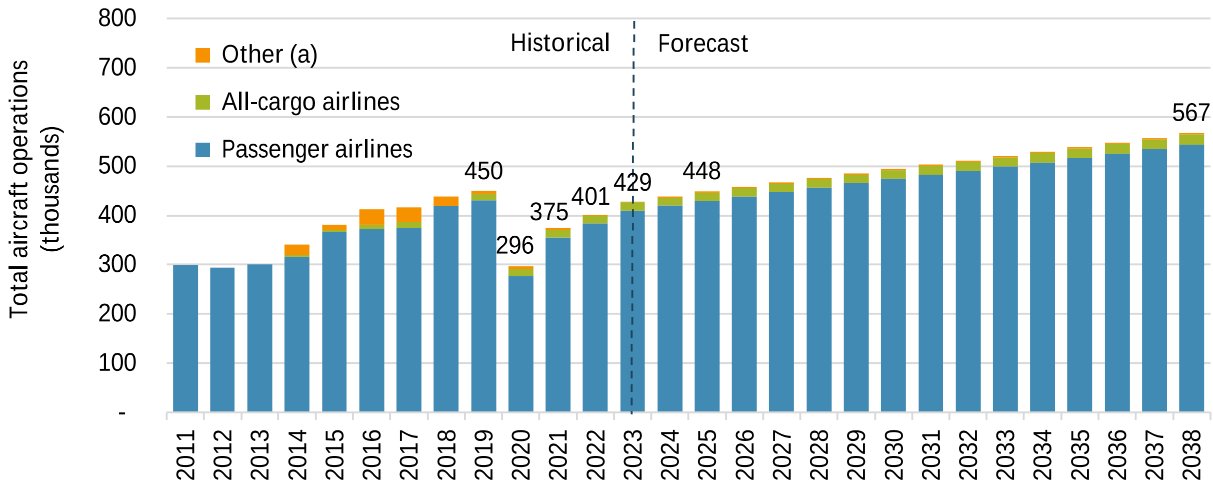
The forecasts of passenger airline operations are derived from the enplaned passenger forecasts and based on assumptions for average seats per departure and load factor (the percentage of occupied seats).

- Average seats per departure for the Airport as a whole are forecast to increase from 143.2 in 2022 to 155.3 in 2038.
  - Domestic seats per operation at SEA are forecast to increase from 141.2 in 2022 to 153.0 in 2038, consistent with the assumptions for the 2018 Hybrid Forecast. The domestic aircraft gauge reflects the large share of passenger airline operations by Alaska Airlines (58% in 2021) with a predominantly narrowbody fleet (averaging 136 seats at SEA in 2021) and the increasing number of regional jet operations related to the continued development of the Airport as a connecting hub.
  - International seats per operation at SEA are forecast to increase from 162.0 in 2022 to 172.7 in 2038, consistent with the assumptions for the 2018 Hybrid Forecast.* The international aircraft gauge reflects the large share of short-haul Canadian operations (27% of total passenger airline operations in 2021) served primarily with regional jet aircraft and an all narrowbody aircraft flown from SEA to Mexico.

* In 2021, the average seats per departure for international flights increased to 181.4 (from 155.9 in 2020) which reflects the substitution of narrowbody aircraft for regional jets (primarily by Alaska and Delta) and the restoration of narrowbody aircraft service.

- SEA load factors for the Airport as a whole are forecast to approximate 85% through 2038. Domestic load factors are forecast to increase from 84% in 2022 to 85% in 2038, while international load factors are forecast to increase from 83% in 2022 to 85% in 2038.

Figure 4-1
TOTAL AIRCRAFT OPERATION FORECASTS
Seattle-Tacoma International Airport



(b) Includes general aviation, military, and other unscheduled operations.
Sources: Historical—Seattle-Tacoma International Airport records. Forecast—LeighFisher, June 2022, updated August 2023.

Tables 3 and 4 in the Appendix present the forecast assumptions for load factor and average seats per departure and total aircraft operations at the Airport for 2023 through 2038.

5.0 AIRCRAFT FLEET DISTRIBUTION

The analysis of the aircraft fleet distribution at SEA was based on:

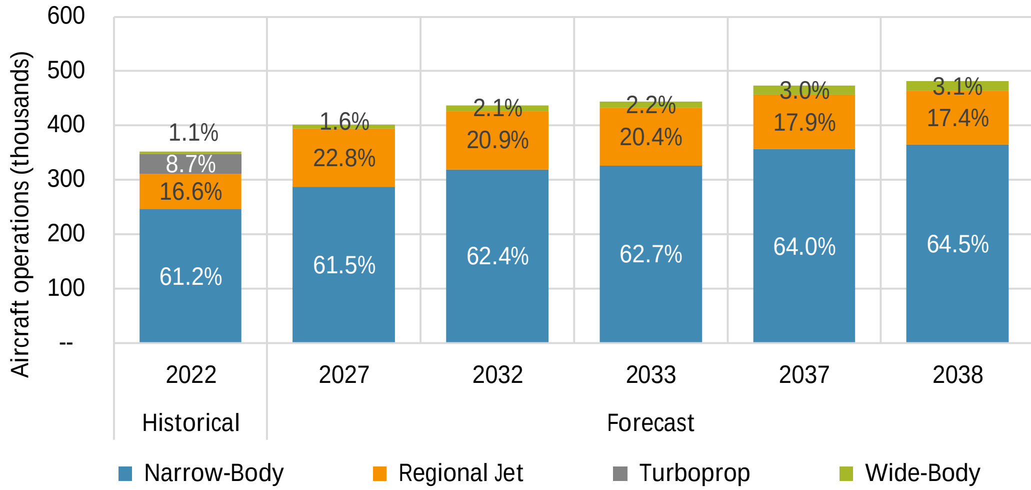
- An evaluation of the current fleet serving the airport using SEA aviation records, published airline schedules, and the FAA's Traffic Flow Management System Counts (TFMSC)
- A review of individual airline fleets, orders for new aircraft, new aircraft delivery schedules, and airline plans for retiring aircraft using airline SEC filings and the Aviation Week Intelligence Network (AWIN) commercial aviation database
- A maximum useful life of 30 years for air carrier aircraft and 25 years for regional aircraft plus a 5-year buffer period as older aircraft are phased out of service
- Airline plans for replacement of retired aircraft as available

The September 2023 update of the fleet distribution for the 2022 Forecasts was revised to include full calendar year data for 2022 from the Port of Seattle's Noise Office and reconciled with domestic and international landings submitted by the airlines serving SEA.

5.1 Domestic Passenger Airline Fleet

Narrowbody aircraft accounted for the largest number of domestic passenger airline operations in 2022, with 61.2% of total aircraft operations, and are forecast to gradually increase to 64.5% in 2038, as shown on Figure 5-1.

Figure 5-1
ACTUAL AND FORECAST
DOMESTIC PASSENGER AIRLINE OPERATIONS BY AIRCRAFT BODY TYPE
Seattle-Tacoma International Airport



Sources: Historical—Seattle-Tacoma International Airport records. Forecast—LeighFisher, June 2022, updated August 2023.

Narrowbody aircraft expected to reach their maximum useful life during the forecast period include:

- Airbus A319 with an average age of 20 years in 2022
- Boeing B757-200 and B757-300 with average ages of 26 and 21 years, respectively, in 2022

In addition, the percentage of Airbus A320 aircraft are expected to decrease in the short-term with Alaska's transition to an all-Boeing fleet and the retirement of the airline's A320s by early 2023. Alaska also plans to remove the A321neo from its fleet by the end of 2023.

New aircraft expected to account for an increasing share of the narrowbody fleet used in domestic service include:

- Airbus A220-100 and A220-300 operated by Delta
- Boeing 737MAX 8/9/10 operated by Alaska, American, Southwest, and United

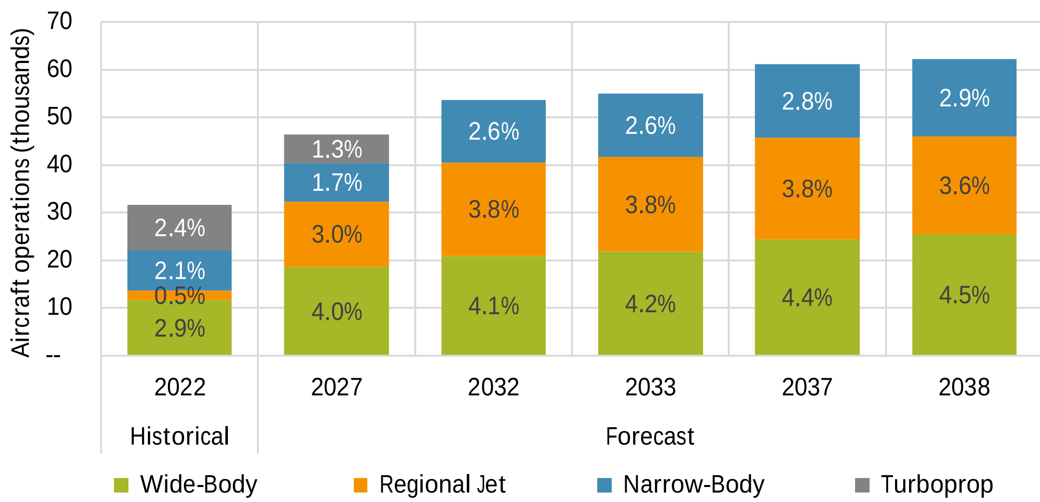
Regional aircraft, regional jets and turboprops, together accounted for the second largest number of domestic passenger airline operations in 2022, with 25.3% of total aircraft operations, are forecast to decrease to 17.4% in 2038. In the short-term, changes in the regional aircraft fleet reflect the retirement of the Q400 by Alaska in early 2023 (replaced with the E175) and the shortage of regional pilots. The increasing number of operations by small narrowbody aircraft such as the A220-100 may also limit the share of regional aircraft operations.

Widebody aircraft accounted for the smallest number of domestic passenger airline operations in 2022, with 1.1% of total aircraft operations, are forecast to gradually increase to 3.1% in 2038.

5.2 International Passenger Airline Fleet

Widebody aircraft accounted for the largest number of international passenger airline operations in 2022, with 2.9% of total aircraft operations, and are forecast to gradually increase to 4.5% in 2038, as shown on Figure 5-2.

Figure 5-2
ACTUAL AND FORECAST
INTERNATIONAL PASSENGER AIRLINE OPERATIONS BY AIRCRAFT BODY TYPE
Seattle-Tacoma International Airport



Sources: Historical—Seattle-Tacoma International Airport records. Forecast—LeighFisher, June 2022, updated August 2023.

Widebody aircraft expected to reach their maximum useful life during the forecast period include:

- Airbus A340 with an average age of 21 years in 2022
- Boeing B747-400 and B767-300 each with average ages of 24 years in 2022
- Boeing B777-200 and B777-300 with average ages of 22 and 23 years, respectively, in 2022

New aircraft expected to account for an increasing share of the widebody fleet used in international service include:

- Airbus A330-300/900 and A350
- Boeing 787-8/9/10

Regional aircraft, regional jets and turboprops, together accounted for a similar number of international passenger airline operations as widebody aircraft in 2022, with 2.9% of total, are forecast to increase to 3.86% in 2038 as the number of E175 aircraft are added to the regional fleet. In 2022, the Q400 was used in international service by Alaska, Air Canada Jazz, and WestJet.

Narrowbody aircraft accounted for the smallest largest number of international passenger airline operations in 2022, with 2.1%, are forecast to gradually increase to 2.9% in 2038.

The 2022 Forecasts of the aircraft fleet distribution in terms of total aircraft operations by aircraft type at the Airport is shown in Table 5 in the Appendix.

6.0 COMPARISON WITH THE FAA 2022 TAF

Table 7 in the Appendix presents a comparison of the 2022 Forecasts prepared for Seattle-Tacoma International Airport with the FAA 2022 TAF for the Airport. The forecasts are compared for the components of total enplaned passengers, commercial aircraft operations and total aircraft operations.

As noted on page 1, the forecasts presented in this memorandum are unconstrained and were used as a basis to develop a constrained demand scenario that reflects the Airport's ability to accommodate demand. The analysis of a constrained scenario indicated that SEA would experience a constrained operating environment from 2027 through 2037 due to a shortage of gates and airfield constraints. Although it was determined that the unconstrained forecast of aircraft operations at SEA exceeds the constrained forecast, the updates to the unconstrained forecasts presented in this memorandum do not change the constrained demand scenario which is based on an evaluation of SEA facilities and used as a basis for the Environmental Assessment.

The format of Table 6 is based on the template provided by the FAA for the comparison of airport planning forecasts and the FAA TAF.* As required, the results are presented for the base year of 2022 and forecast horizons years which are equal to the base year, plus 1, 5, 10 and 15 years (2022, 2023, 2027, 2032, and 2037).

The key findings of the comparison of the updated aviation demand forecasts with the FAA 2022 TAF are:

- The forecast of enplaned passengers for SEA varies from the 2022 TAF by:
  - 4.6% in 2027
  - 6.4% in 2032
  - 8.1% in 2037
- The forecast of commercial operations for SEA varies from the 2022 TAF by:
  - 7.5% in 2027
  - 10.7% in 2032
  - 13.8% in 2037
- The forecast of total aircraft operations for SEA varies from the FAA 2022 TAF by:
  - 7.7% in 2027
  - 10.9% in 2032
  - 13.9% in 2037

*U.S. Department of Transportation, Federal Aviation Administration, *Forecasting Aviation Activity by Airport*, July 2001, and *Review and Approval of Aviation Forecasts*, June 2008, http://www.faa.gov.

- Overall, the 2022 Forecasts are similar to the FAA 2022 TAF for the Airport and "differ by less than 10 percent in the 5-year forecast period, and 15 percent in the 10-year forecast period", as stipulated in the FAA forecast guidance.

Table 8 in the Appendix presents a summary of the 2022 Forecasts using a second template provided by the FAA.

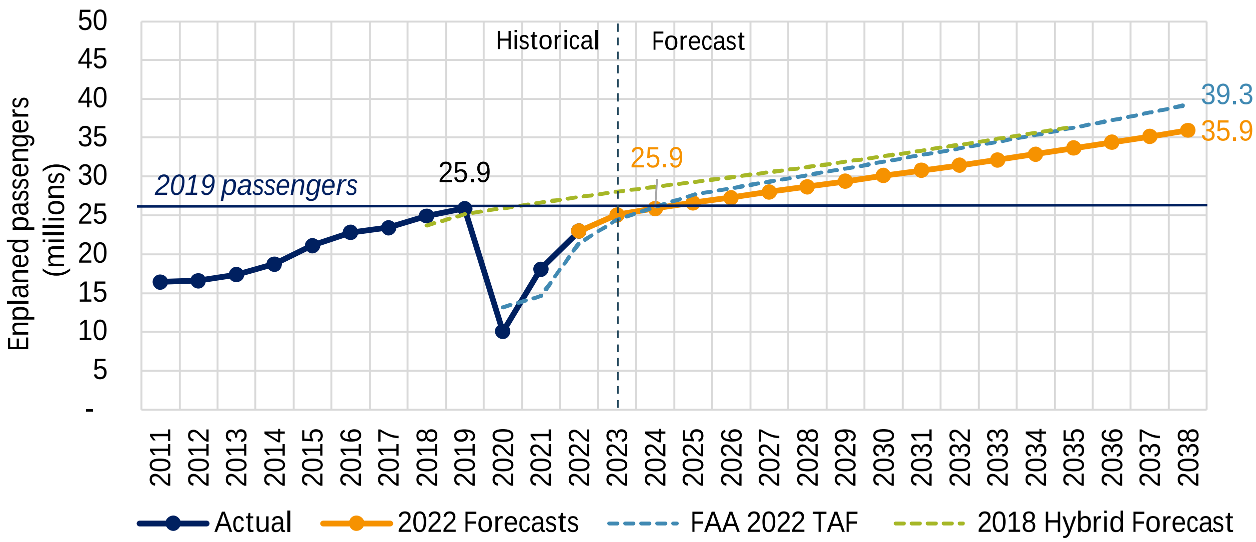
7.0 FORECAST COMPARISON

Table 8 in the Appendix present a comparison of the 2022 Forecasts with the 2022 TAF for SEA, the 2018 Hybrid Forecasts, and the 2014 Sustainable Airport Master Plan (SAMP) in terms of enplaned passengers, air freight, and total aircraft operations. Figure 7-1 presents a graphical comparison of the enplaned passenger forecasts.

The 2022 Forecasts of enplaned passengers are somewhat higher than the FAA 2022 TAF in the short-term but lower in the long-term; but as noted earlier, are within the allowed variance of the TAF. In the short-term, the forecasts for 2022 through 2024 differ, reflecting:

- <u>Significant differences in the historical reporting of SEA enplaned passengers in 2021.</u> In the FAA 2022 TAF, SEA enplaned passengers total 14.6 million in 2021, compared with 18.1 million in SEA actual traffic counts, for a difference of 23.8%. Although part of the difference may be attributable to data for a Federal Fiscal Year compared with a calendar year, the historical difference between FAA TAF and SEA data during pre-pandemic years averaged 5%.

Figure 7-1
COMPARISON OF ENPLANED PASSENGER FORECASTS
Seattle-Tacoma International Airport



Sources: Historical—Seattle-Tacoma International Airport records.
2022 Forecast—LeighFisher, June 2022, updated August 2023.
FAA 2022 TAF—Federation Aviation Administration, March 2022, www.faa.gov.
2018 Hybrid Forecast (FAA 2018 TAF)—Federal Aviation Administration, March 2018, www.faa.gov.
2014 SAMP Forecast—LeighFisher, September 2015.

- As a result of the significantly lower 2021 data and the strength of the recovery in 2022, the FAA 2022 TAF estimated a 46.5% increase in SEA enplaned passengers between 2021 and 2022, compared with a 27.1% actual increase in the 2022 Forecasts.

- Significant differences in SEA enplaned passenger base year data for 2022. In the FAA 2022 TAF, SEA enplaned passengers are estimates (i.e., 21.4 million enplaned passengers, representing an estimated increase of 46.5% between 2021 and 2022). In contrast, the 2022 base year data for the 2022 Forecasts are actual (i.e., 23.0 million enplaned passengers, representing an actual increase of 27.1%).

- The 2022 Forecast for 2023 is based on 6 months of actual data. The FAA 2022 TAF forecasts a 14.2% increase in enplaned passengers In 2023, compared with a 9.3% increase in the 2022 Forecasts which is based on six months of 2023 actual data.

In the long-term, SEA enplaned passengers are forecast to increase:

- An average of 2.8% per year between 2023 and 2038 in the 2022 Forecasts for a total of 35.9 million in 2038, reflecting short-term growth rates of 2.9% per year between 2023 and 2025 and long-term growth rates of 2.3% between 2025 and 2038

- An average of 3.9% per year between 2023 and 2038 in the FAA 2022 TAF for a total of 39.3 million in 2038, reflecting short-term growth rates of 6.4% per year between 2023 and 2025 and long-term growth rates of 2.7% between 2025 and 2038

The 2018 Hybrid Forecasts, adopted from the FAA 2018 TAF, are significantly higher than both the 2022 Forecasts and the FAA 2022 TAF due to the negative impacts of the COVID-19 pandemic on SEA passenger traffic.

The 2022 Forecasts of enplaned passengers are consistent with the 2014 SAMP Forecasts.

Appendix

FORECAST TABLES

Table 1
HISTORICAL AND FORECAST ENPLANED PASSENGERS
Seattle-Tacoma International Airport
In millions, except as noted

	Domestic			International			Total enplaned passengers			Percent of total	
Year	O&D	Connecting	Total	O&D	Connecting	Total	O&D	Connecting	Total	O&D	Connecting
Historical											
2019	16.6	6.4	23.0	1.9	1.0	2.9	18.5	7.4	25.9	71.4%	28.6%
2020	6.3	3.1	9.4	0.4	0.2	0.7	6.7	3.3	10.0	66.7%	33.3%
2021	11.6	5.7	17.3	0.6	0.2	0.8	12.2	5.9	18.1	67.4%	32.6%
2022	14.5	6.3	20.8	1.5	0.7	2.2	16.0	7.0	23.0	69.6%	30.4%
Forecast											
2023	15.9	6.5	22.3	1.7	1.0	2.8	17.6	7.5	25.1	70.1%	29.9%
2024	16.6	6.4	23.0	1.9	1.0	2.9	18.5	7.4	25.9	71.4%	28.6%
2025	17.0	6.6	23.6	1.9	1.1	3.0	19.0	7.6	26.6	71.3%	28.7%
2026	17.4	6.7	24.2	2.0	1.1	3.1	19.4	7.8	27.3	71.2%	28.8%
2027	17.9	6.9	24.8	2.0	1.2	3.2	19.9	8.1	28.0	71.1%	28.9%
2028	18.3	7.1	25.4	2.1	1.2	3.3	20.4	8.3	28.7	71.0%	29.0%
2029	18.7	7.3	26.0	2.1	1.3	3.4	20.8	8.5	29.4	70.9%	29.1%
2030	19.2	7.4	26.6	2.2	1.3	3.5	21.4	8.8	30.1	70.8%	29.2%
2031	19.6	7.6	27.2	2.2	1.4	3.6	21.8	9.0	30.8	70.7%	29.3%
2032	19.9	7.8	27.7	2.3	1.5	3.8	22.2	9.2	31.5	70.6%	29.4%
2033	20.3	7.9	28.3	2.4	1.5	3.9	22.7	9.5	32.2	70.5%	29.5%
2034	20.8	8.1	28.9	2.4	1.6	4.0	23.2	9.7	32.9	70.4%	29.6%
2035	21.2	8.3	29.5	2.5	1.7	4.1	23.7	10.0	33.6	70.3%	29.7%
2036	21.6	8.5	30.1	2.5	1.7	4.3	24.2	10.2	34.4	70.2%	29.8%
2037	22.1	8.7	30.8	2.6	1.8	4.4	24.7	10.5	35.2	70.1%	29.9%
2038	22.5	8.9	31.4	2.6	1.9	4.5	25.2	10.8	35.9	70.0%	30.0%

	Percent change								
2019-2020	-62.2%	-51.6%	-59.3%	-76.8%	-76.0%	-76.5%	-63.7%	-54.9%	-61.2%
2020-2021	84.9%	82.4%	84.0%	35.9%	-1.4%	22.5%	81.7%	76.4%	79.9%
2021-2022	25.1%	10.9%	20.5%	153.3%	197.6%	166.0%	31.3%	18.4%	27.1%
2022-2023	9.3%	3.1%	7.4%	17.8%	45.9%	26.9%	10.1%	7.4%	9.3%
2023-2024	4.8%	-1.1%	3.1%	7.4%	-2.4%	3.8%	5.1%	-1.2%	3.2%
2024-2025	2.5%	2.9%	2.6%	2.9%	5.2%	3.7%	2.5%	3.2%	2.7%
2025-2026	2.4%	2.4%	2.4%	2.8%	5.1%	3.6%	2.4%	2.7%	2.5%
2026-2027	2.5%	2.7%	2.6%	2.7%	5.0%	3.5%	2.6%	3.0%	2.7%
2027-2028	2.3%	2.5%	2.3%	2.6%	4.9%	3.4%	2.3%	2.8%	2.5%
2028-2029	2.2%	2.4%	2.3%	2.5%	4.7%	3.3%	2.3%	2.8%	2.4%
2029-2030	2.4%	2.6%	2.5%	2.4%	4.6%	3.3%	2.4%	2.9%	2.6%
2030-2031	2.1%	2.3%	2.1%	2.3%	4.5%	3.2%	2.1%	2.6%	2.2%
2031-2032	1.9%	2.1%	2.0%	2.3%	4.5%	3.2%	2.0%	2.5%	2.1%
2032-2033	2.0%	2.2%	2.0%	2.3%	4.5%	3.2%	2.0%	2.5%	2.2%
2033-2034	2.1%	2.3%	2.2%	2.3%	4.5%	3.2%	2.1%	2.7%	2.3%
2034-2035	2.1%	2.3%	2.2%	2.3%	4.5%	3.2%	2.1%	2.6%	2.3%
2035-2036	2.1%	2.3%	2.1%	2.3%	4.4%	3.2%	2.1%	2.6%	2.3%
2036-2037	2.1%	2.2%	2.1%	2.3%	4.4%	3.2%	2.1%	2.6%	2.2%
2037-2038	2.0%	2.2%	2.1%	2.3%	4.4%	3.2%	2.1%	2.6%	2.2%

Note: The forecasts presented in this table were prepared using the information and assumptions described in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and those differences may be material.

Sources: Historical--Seattle-Tacoma International Airport records. Forecast--LeighFisher, June 2022, updated August 2023.

Table 2
HISTORICAL AND FORECAST AIR CARGO
Seattle-Tacoma International Airport
Thousands of metric tons

Year	Domestic	International	Total
Historical			
2019	306.7	146.9	453.5
2020	351.3	101.2	452.5
2021	366.3	132.4	498.7
2022	335.5	120.8	456.3
Forecast			
2023	378.2	160.3	538.5
2024	386.6	163.0	549.6
2025	395.3	165.7	561.0
2026	404.1	168.5	572.6
2027	413.1	171.4	584.4
2028	422.3	174.3	596.5
2029	431.5	177.1	608.6
2030	440.7	179.9	620.6
2031	449.8	182.7	632.5
2032	458.9	185.4	644.4
2033	468.0	188.1	656.1
2034	477.0	190.7	667.7
2035	486.0	193.3	679.3
2036	495.1	195.9	691.0
2037	504.4	198.5	702.9
2038	513.9	201.1	715.0
	Percent change		
2019-2020	14.6%	-31.1%	-0.2%
2020-2021	4.3%	30.9%	10.2%
2021-2022	-8.4%	-8.8%	-8.5%
2022-2023	12.7%	32.7%	18.0%
2023-2024	2.2%	1.7%	2.1%
2024-2025	2.2%	1.7%	2.1%
2025-2026	2.2%	1.7%	2.1%
2026-2027	2.2%	1.7%	2.1%
2027-2028	2.2%	1.7%	2.1%
2028-2029	2.2%	1.6%	2.0%
2029-2030	2.1%	1.6%	2.0%
2030-2031	2.1%	1.5%	1.9%
2031-2032	2.0%	1.5%	1.9%
2032-2033	2.0%	1.4%	1.8%
2033-2034	1.9%	1.4%	1.8%
2034-2035	1.9%	1.3%	1.7%
2035-2036	1.9%	1.3%	1.7%
2036-2037	1.9%	1.3%	1.7%
2037-2038	1.9%	1.3%	1.7%

Note: The forecasts presented in this table were prepared using the information and assumptions described in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and those differences may be material.

(a) Includes enplaned and deplaned tonnage.

Sources: Historical--Seattle-Tacoma International Airport records. Forecast--LeighFisher, June 2022, updated August 2023 (2022 base year).

Table 3
2022 FORECAST ASSUMPTIONS
Seattle-Tacoma International Airport

	Load factor			Average seats per departure		
Year	Domestic	International	Total	Domestic	International	Total
Historical						
2019	86.0%	85.4%	85.9%	138.2	154.2	139.8
2020	53.2%	54.8%	53.3%	131.9	155.9	133.2
2021	74.1%	55.0%	73.0%	138.2	181.4	140.2
2022	84.2%	78.6%	83.7%	141.2	162.0	143.2
Forecast						
2023	85.2%	81.6%	84.8%	142.0	162.6	144.1
2024	85.3%	83.6%	85.1%	142.7	163.3	144.7
2025	85.3%	83.6%	85.1%	143.4	163.9	145.5
2026	85.3%	83.6%	85.1%	144.1	164.6	146.2
2027	85.3%	83.6%	85.1%	144.8	165.2	146.9
2028	85.3%	83.7%	85.1%	145.5	165.9	147.7
2029	85.3%	83.7%	85.1%	146.3	166.6	148.4
2030	85.3%	83.7%	85.1%	147.0	167.2	149.2
2031	85.3%	83.7%	85.1%	147.7	167.9	149.9
2032	85.3%	83.7%	85.1%	148.5	168.6	150.7
2033	85.3%	83.7%	85.1%	149.2	169.2	151.4
2034	85.4%	83.7%	85.2%	150.0	169.9	152.2
2035	85.4%	83.7%	85.2%	150.7	170.6	152.9
2036	85.4%	83.7%	85.2%	151.5	171.3	153.7
2037	85.4%	83.7%	85.2%	152.2	172.0	154.5
2038	85.4%	83.8%	85.2%	153.0	172.7	155.3
	Percent change					
2019-2020	-38.1%	-35.8%	-37.9%	-4.6%	1.1%	-4.7%
2020-2021	39.3%	0.4%	36.8%	4.8%	16.4%	5.3%
2021-2022	13.6%	42.9%	14.6%	2.2%	-10.7%	2.1%
2022-2023	1.2%	3.8%	1.4%	0.5%	0.4%	0.6%
2023-2024	0.0%	2.5%	0.3%	0.5%	0.4%	0.5%
2024-2025	0.0%	0.0%	0.0%	0.5%	0.4%	0.5%
2025-2026	0.0%	0.0%	0.0%	0.5%	0.4%	0.5%
2026-2027	0.0%	0.0%	0.0%	0.5%	0.4%	0.5%
2027-2028	0.0%	0.0%	0.0%	0.5%	0.4%	0.5%
2028-2029	0.0%	0.0%	0.0%	0.5%	0.4%	0.5%
2029-2030	0.0%	0.0%	0.0%	0.5%	0.4%	0.5%
2030-2031	0.0%	0.0%	0.0%	0.5%	0.4%	0.5%
2031-2032	0.0%	0.0%	0.0%	0.5%	0.4%	0.5%
2032-2033	0.0%	0.0%	0.0%	0.5%	0.4%	0.5%
2033-2034	0.0%	0.0%	0.0%	0.5%	0.4%	0.5%
2034-2035	0.0%	0.0%	0.0%	0.5%	0.4%	0.5%
2035-2036	0.0%	0.0%	0.0%	0.5%	0.4%	0.5%
2036-2037	0.0%	0.0%	0.0%	0.5%	0.4%	0.5%
2037-2038	0.0%	0.0%	0.0%	0.5%	0.4%	0.5%

Note: The forecasts presented in this table were prepared using the information and assumptions described in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and those differences may be material.

Sources: Historical--Seattle-Tacoma International Airport records. Forecast--LeighFisher, June 2022, updated August 2023 (2022 base year).

Table 4
HISTORICAL AND FORECAST TOTAL AIRCRAFT OPERATIONS
Seattle-Tacoma International Airport
In thousands

Year	Passenger airlines	All-cargo airlines	Other (a)	Total
Historical				
2019	431.3	13.2	5.9	450.5
2020	277.1	14.6	4.4	296.1
2021	355.2	15.3	3.9	374.5
2022	384.2	14.9	2.3	401.4
Forecast				
2023	410.7	15.5	2.5	428.7
2024	420.6	15.8	2.5	438.9
2025	429.9	16.2	2.5	448.5
2026	438.4	16.5	2.5	457.4
2027	447.9	16.8	2.5	467.3
2028	456.6	17.2	2.5	476.3
2029	465.3	17.5	2.5	485.3
2030	474.7	17.9	2.5	495.1
2031	482.9	18.2	2.5	503.7
2032	491.0	18.5	2.5	512.0
2033	499.1	18.9	2.6	520.5
2034	507.7	19.2	2.6	529.4
2035	516.6	19.5	2.6	538.7
2036	525.6	19.9	2.6	548.0
2037	534.7	20.2	2.6	557.5
2038	543.7	20.6	2.6	566.9
	Percent change			
2019-2020	-35.7%	10.0%	-26.3%	-34.3%
2020-2021	28.2%	5.1%	-9.7%	26.5%
2021-2022	8.1%	-3.0%	-40.7%	7.2%
2022-2023	6.9%	4.4%	6.0%	6.8%
2023-2024	2.4%	2.1%	0.3%	2.4%
2024-2025	2.2%	2.1%	0.3%	2.2%
2025-2026	2.0%	2.1%	0.3%	2.0%
2026-2027	2.2%	2.1%	0.3%	2.2%
2027-2028	1.9%	2.1%	0.3%	1.9%
2028-2029	1.9%	2.0%	0.3%	1.9%
2029-2030	2.0%	2.0%	0.3%	2.0%
2030-2031	1.7%	1.9%	0.3%	1.7%
2031-2032	1.7%	1.9%	0.3%	1.7%
2032-2033	1.7%	1.8%	0.3%	1.7%
2033-2034	1.7%	1.8%	0.3%	1.7%
2034-2035	1.8%	1.7%	0.3%	1.7%
2035-2036	1.7%	1.7%	0.3%	1.7%
2036-2037	1.7%	1.7%	0.3%	1.7%
2037-2038	1.7%	1.7%	0.3%	1.7%

Note: The forecasts presented in this table were prepared using the information and assumptions described in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and those differences may be material.

(a) Includes general aviation, military, and other unscheduled operations.

Sources: Historical--Seattle-Tacoma International Airport records. Forecast--LeighFisher, June 2022, updated August 2023 (2022 base year).

Table 5
FORECAST COMPARISON
Seattle-Tacoma International Airport

	Enplaned passengers (millions)				Air freight (thousands of metric tons)			Total aircraft operations (thousands)			
Year	2022 Forecast	FAA 2022 TAF	2018 Hybrid Forecast	2014 SAMP	2022 Forecast	2018 Hybrid Forecast	2014 SAMP	2022 Forecast	FAA 2022 TAF	2018 Hybrid Forecast	2014 SAMP
Historical											
2019	25.9	24.6	25.1	22.4	453.5	457.8	351.5	450	445	454	399
2020	10.0	13.4	25.9	23.2	452.5	485.3	358.0	296	330	466	411
2021	18.1	14.3	26.7	23.9	498.7	515.0	364.3	375	358	476	421
2022	23.0	17.7	27.4	24.6	456.3	547.3	370.5	401	379	484	430
Forecast							-				
2023	25.1	22.2	28.0	25.2	538.5	560.0	376.8	429	436	493	439
2024	25.9	24.1	28.7	25.9	549.6	572.9	383.0	439	457	500	449
2025	26.6	25.1	29.3	26.6	561.0	586.2	389.2	448	479	506	458
2026	27.3	25.9	29.9	27.3	572.6	599.8	395.4	457	501	512	468
2027	28.0	26.7	30.6	28.0	584.4	613.8	401.6	467	522	519	478
2028	28.7	27.5	31.2	28.7	596.5	627.7	407.7	476	535	527	487
2029	29.4	28.3	31.9	29.5	608.6	641.7	413.8	485	547	534	497
2030	30.1	29.1	32.6	30.2	620.6	655.7	419.7	495	559	542	507
2031	30.8	29.8	33.3	30.8	632.5	669.7	425.4	504	568	549	515
2032	31.5	30.6	34.1	31.5	644.4	683.7	431.0	512	578	557	524
2033	32.2	31.4	34.9		656.1	697.6		521	587	566	
2034	32.9	32.2	35.6		667.7	711.5		529	598	576	
2035	33.6	33.0	36.4		679.3	725.3		539	609	585	
2036	34.4	33.8			691.0			548	620		
2037	35.2	34.6			702.9			557	630		
2038	35.9	35.4			715.0			567	641		
	Percent change										
2019-2020	-61.2%	-45.5%	3.1%	3.7%	-0.2%	6.0%	1.8%		-25.9%	2.5%	3.1%
2020-2021	79.9%	6.8%	2.9%	2.9%	10.2%	6.1%	1.7%		8.7%	2.2%	2.3%
2021-2022	27.1%	23.6%	2.6%	2.8%	-8.5%	6.3%	1.7%	7.2%	5.7%	1.7%	2.2%
2022-2023	9.3%	25.3%	2.4%	2.7%	18.0%	2.3%	1.7%	6.8%	15.0%	1.8%	2.2%
2023-2024	3.2%	8.9%	2.2%	2.7%	2.1%	2.3%	1.7%	2.4%	4.8%	1.3%	2.1%
2024-2025	2.7%	4.1%	2.2%	2.7%	2.1%	2.3%	1.6%	2.2%	4.8%	1.3%	2.1%
2025-2026	2.5%	3.2%	2.1%	2.6%	2.1%	2.3%	1.6%	2.0%	4.6%	1.3%	2.1%
2026-2027	2.7%	3.1%	2.2%	2.6%	2.1%	2.3%	1.6%	2.2%	4.2%	1.4%	2.1%
2027-2028	2.5%	3.0%	2.2%	2.6%	2.1%	2.3%	1.5%	1.9%	2.5%	1.4%	2.0%
2028-2029	2.4%	2.8%	2.2%	2.5%	2.0%	2.2%	1.5%	1.9%	2.2%	1.4%	2.0%
2029-2030	2.6%	2.7%	2.2%	2.5%	2.0%	2.2%	1.4%	2.0%	2.2%	1.4%	2.0%
2030-2031	2.2%	2.6%	2.2%	2.1%	1.9%	2.1%	1.3%	1.7%	1.7%	1.4%	1.6%
2031-2032	2.1%	2.6%	2.2%	2.1%	1.9%	2.1%	1.3%	1.7%	1.7%	1.3%	1.6%
2032-2033	2.2%	2.5%	2.2%		1.8%	2.0%		1.7%	1.7%	1.7%	
2033-2034	2.3%	2.5%	2.2%		1.8%	2.0%		1.7%	1.8%	1.7%	
2034-2035	2.3%	2.5%	2.2%		1.7%	1.9%		1.7%	1.8%	1.6%	
2035-2036	2.3%	2.5%			1.7%			1.7%	1.8%		
2036-2037	2.2%	2.3%			1.7%			1.7%	1.7%		
2037-2038	2.2%	2.3%			1.7%			1.7%	1.7%		

Note: The forecasts presented in this table were prepared using the information and assumptions described in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and those differences may be material.

Note: Areas highlighted in gray are estimates or forecasts prepared on a base year before 2022.

Sources: 2022 Forecast--Historical--Seattle-Tacoma International Airport records. Forecast--LeighFisher, June 2022, updated August 2023 (2022 base year).
FAA 2022 TAF for SEA—U.S. Department of Transportation, Federal Aviation Administration, www.faa.gov, accessed March 2022.
2018 Hybrid Forecast-- Passengers: FAA 2018 TAF for SEA—U.S. Department of Transportation, Federal Aviation Administration, www.faa.gov,
2014 SAMP Forecast—LeighFisher, September 2015.

Table 6
FORECASTS OF TOTAL AIRCRAFT OPERATIONS BY AIRCRAFT TYPE
Seattle-Tacoma International Airport

	Average	Seat	Historical	Forecast					Historical	Forecast				
Sector/Aircraft type/Equipment	age (years) (a)	configuration	2022	2027	2032	2033	2037	2038	2022	2027	2032	2033	2037	2038
PASSENGER AIRLINES														
DOMESTIC														
Air carrier														
Narrow-Body														
A220-100	2	109	9,132	18,393	20,149	22,976	28,899	30,476	2.3%	3.9%	3.9%	4.4%	5.2%	5.4%
A220-300	1	133	--	4,210	4,412	4,488	9,439	10,263	0.0%	0.9%	0.9%	0.9%	1.7%	1.8%
A319	20	127	3,247	2,778	1,375	899	--	--	0.8%	0.6%	0.3%	0.2%	0.0%	0.0%
A320-200	13	151	19,922	14,581	8,612	6,260	2,433	1,387	5.0%	3.1%	1.7%	1.2%	0.4%	0.2%
A320 NEO	2	185	1,679	3,108	9,293	11,941	17,072	18,449	0.4%	0.7%	1.8%	2.3%	3.1%	3.3%
A321-200	11	191	8,049	8,875	9,231	7,887	3,107	2,072	2.0%	1.9%	1.8%	1.5%	0.6%	0.4%
A321 NEO	1	195	6,397	12,162	22,647	25,515	33,223	35,416	1.6%	2.6%	4.4%	4.9%	6.0%	6.2%
B737-300	30	124	8	--	--	--	--	--	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
B737-700	16	143	19,936	7,959	4,888	3,788	1,069	544	5.0%	1.7%	1.0%	0.7%	0.2%	0.1%
B737-800	12	162	61,003	70,662	72,010	70,706	51,183	43,895	15.2%	15.1%	14.1%	13.6%	9.2%	7.7%
B737-900	9	178	9,874	9,416	9,345	8,494	5,917	3,934	2.5%	2.0%	1.8%	1.6%	1.1%	0.7%
B737-900ER	9	178	75,615	110,000	120,000	118,000	112,000	110,000	18.8%	23.5%	23.4%	22.7%	20.1%	19.4%
B737-7 MAX	1	138	--	1,000	1,200	1,400	2,000	3,000	0.0%	0.2%	0.2%	0.3%	0.4%	0.5%
B737-8 MAX	2	171	2,381	8,921	18,115	21,906	46,462	54,315	0.6%	1.9%	3.5%	4.2%	8.3%	9.6%
B737-9 MAX	2	178	20,699	13,886	18,156	21,948	43,833	51,642	5.2%	3.0%	3.5%	4.2%	7.9%	9.1%
B757-200	26	171	5,958	--	--	--	--	--	1.5%	0.0%	0.0%	0.0%	0.0%	0.0%
B757-300	21	234	1,753	1,356	--	--	--	--	0.4%	0.3%	0.0%	0.0%	0.0%	0.0%
Narrow-Body Total			245,653	287,306	319,435	326,210	356,637	365,393	61.2%	61.5%	62.4%	62.7%	64.0%	64.5%
Wide-Body														
A330-200	13	273	1,510	2,449	2,682	2,727	2,922	2,972	0.4%	0.5%	0.5%	0.5%	0.5%	0.5%
A330-300	11	282	1,331	774	848	862	924	940	0.3%	0.2%	0.2%	0.2%	0.2%	0.2%
A330-900	2	281	--	282	309	314	337	342	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%
A340-300	20	250	2	--	--	--	--	--	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
A350-900	2	290	198	681	746	758	1,347	1,370	0.0%	0.1%	0.1%	0.1%	0.2%	0.2%
B767-300ER	24	241	1,039	408	--	--	--	--	0.3%	0.1%	0.0%	0.0%	0.0%	0.0%
B767-400ER	21	238	263	808	394	401	--	--	0.1%	0.2%	0.1%	0.1%	0.0%	0.0%
B777-200ER	22	287	48	--	--	--	--	--	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
B777-300ER	23	355	4	--	--	--	--	--	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
B787-10	1	262	--	--	491	499	535	544	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%
B787-8	7	182	4	1,792	2,944	2,993	5,346	5,980	0.0%	0.4%	0.6%	0.6%	1.0%	1.1%
B787-9	3	257	--	448	2,454	2,993	5,346	5,436	0.0%	0.1%	0.5%	0.6%	1.0%	1.0%
Wide-Body Total			4,400	7,642	10,869	11,547	16,756	17,583	1.1%	1.6%	2.1%	2.2%	3.0%	3.1%
Regional Jet														
CRJ-200	20	50	6	--	--	--	--	--	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
CRJ-700	17	65	143	--	--	--	--	--	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
E175	8	76	66,541	106,742	106,949	106,222	99,934	98,364	16.6%	22.8%	20.9%	20.4%	17.9%	17.4%
Regional Jet Total			66,691	106,742	106,949	106,222	99,934	98,364	16.6%	22.8%	20.9%	20.4%	17.9%	17.4%
Turboprop														
DH8-400	13	76	35,107	--	--	--	--	--	8.7%	0.0%	0.0%	0.0%	0.0%	0.0%
DOMESTIC TOTAL			351,851	401,689	437,252	443,979	473,327	481,340	87.7%	85.9%	85.4%	85.3%	84.9%	84.9%

Table 6 (page 2 of 4)
FORECASTS OF TOTAL AIRCRAFT OPERATIONS BY AIRCRAFT TYPE
Seattle-Tacoma International Airport

	Average	Seat	Historical	Forecast					Historical	Forecast				
Sector/Aircraft type/Equipment	age (years) (a)	configuration	2022	2027	2032	2033	2037	2038	2022	2027	2032	2033	2037	2038
PASSENGER AIRLINES (continued)														
INTERNATIONAL														
Air carrier														
Narrow-Body														
A220-100	1	109	638	600	900	800	1,000	1,200	0.2%	0.1%	0.2%	0.2%	0.2%	0.2%
A220-300	1	133	2,278	2,376	4,642	4,732	5,997	6,459	0.6%	0.5%	0.9%	0.9%	1.1%	1.1%
A319	16	127	2	--	--	--	--	--	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
A320-200	13	151	932	1,200	1,200	1,200	1,200	1,200	0.2%	0.3%	0.2%	0.2%	0.2%	0.2%
A320 NEO	2	185	79	227	364	390	504	532	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%
A321-200	11	191	2	--	--	--	--	--	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
A321 NEO	2	196	--	--	--	--	--	--	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
B737-300	31	126	6	--	--	--	--	--	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
B737-800	12	163	2,011	1,678	1,639	1,669	1,603	1,537	0.5%	0.4%	0.3%	0.3%	0.3%	0.3%
B737-900	20	179	47	--	--	--	--	--	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
B737-900ER	9	179	1,474	1,336	1,412	1,419	1,449	1,456	0.4%	0.3%	0.3%	0.3%	0.3%	0.3%
B737-8 MAX	2	171	237	296	1,554	1,494	1,673	1,718	0.1%	0.1%	0.3%	0.3%	0.3%	0.3%
B737-9 MAX	2	178	229	242	1,472	1,696	2,004	2,131	0.1%	0.1%	0.3%	0.3%	0.4%	0.4%
B757-200	26	171	567	108	--	--	--	--	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Narrow-Body Total			8,502	8,064	13,182	13,400	15,429	16,233	2.1%	1.7%	2.6%	2.6%	2.8%	2.9%
Wide-Body														
A330-200	13	273	351	78	86	87	94	95	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
A330-300	11	282	1,436	2,296	2,515	2,557	2,740	2,786	0.4%	0.5%	0.5%	0.5%	0.5%	0.5%
A330-900	2	281	2,659	4,808	5,206	5,300	6,172	6,277	0.7%	1.0%	1.0%	1.0%	1.1%	1.1%
A340-300	21	279	52	0	0	0	--	--	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
A350-900	2	290	566	1,146	1,318	1,331	2,494	3,080	0.1%	0.2%	0.3%	0.3%	0.4%	0.5%
A350-1000	--	350-410	4	--	--	--	--	--	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
B767-300ER	24	241	650	464	--	--	--	--	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%
B777-200ER	22	287	822	933	1,022	1,038	--	--	0.2%	0.2%	0.2%	0.2%	0.0%	0.0%
B777-300ER	23	355	1,386	1,266	1,387	1,409	--	--	0.3%	0.3%	0.3%	0.3%	0.0%	0.0%
B787-10	1	262	562	980	1,073	1,091	1,704	1,732	0.1%	0.2%	0.2%	0.2%	0.3%	0.3%
B787-8	7	182	776	3,307	4,604	4,680	5,550	5,644	0.2%	0.7%	0.9%	0.9%	1.0%	1.0%
B787-9	3	257	2,404	3,289	3,736	4,296	5,673	5,769	0.6%	0.7%	0.7%	0.8%	1.0%	1.0%
Wide-Body Total			11,667	18,568	20,946	21,791	24,427	25,384	2.9%	4.0%	4.1%	4.2%	4.4%	4.5%
Regional Jet														
CRJ-700	18	66-70	18	--	--	--	--	--	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
CRJ-900	12	76	22	--	--	--	--	--	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
E175	8	76	1,992	13,817	19,552	19,875	21,299	20,573	0.5%	3.0%	3.8%	3.8%	3.8%	3.6%
Regional Jet Total			2,032	13,817	19,552	19,875	21,299	20,573	0.5%	3.0%	3.8%	3.8%	3.8%	3.6%
Turboprop														
B99	51	15-17	607	--	--	--	--	--	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%
DH8-400	11	76	9,480	5,889	--	--	--	--	2.4%	1.3%	0.0%	0.0%	0.0%	0.0%
S KING AIR 200	33	13	20	--	--	--	--	--	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Turboprop Total			10,108	5,889	--	--	--	--	2.5%	1.3%	0.0%	0.0%	0.0%	0.0%
INTERNATIONAL TOTAL			32,309	46,337	53,680	55,066	61,155	62,190	8.1%	9.9%	10.5%	10.6%	11.0%	11.0%
TOTAL PASSENGER AIRLINES			384,160	448,026	490,932	499,044	534,482	543,530	95.7%	95.9%	95.9%	95.9%	95.9%	95.9%

Table 6 (page 3 of 4)
FORECASTS OF TOTAL AIRCRAFT OPERATIONS BY AIRCRAFT TYPE
Seattle-Tacoma International Airport

Sector/Aircraft type/Equipment	Average age (years) (a)	Historical 2022	Forecast 2027	Forecast 2032	Forecast 2033	Forecast 2037	Forecast 2038	Historical 2022	Forecast 2027	Forecast 2032	Forecast 2033	Forecast 2037	Forecast 2038
ALL-CARGO AIRLINES													
DOMESTIC													
Air carrier													
A300F	25	242	378	379	348	--	--	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%
B747-F/BCF/ERF/LCF	21	255	179	147	89	--	--	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
B757-200F	30	200	173	--	--	--	--	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
B767-200F/300F	3-10	6,707	8,038	8,961	9,739	11,471	11,634	1.7%	1.7%	1.8%	1.9%	2.1%	2.1%
B777F	9	--	917	1,548	1,670	2,815	2,897	0.0%	0.2%	0.3%	0.3%	0.5%	0.5%
MD10	42	65	--	--	--	--	--	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
MD11	28	2,271	2,049	1,908	1,332	--	--	0.6%	0.4%	0.4%	0.3%	0.0%	0.0%
Air Carrier Total		9,740	11,734	12,944	13,179	14,286	14,531	2.4%	2.5%	2.5%	2.5%	2.6%	2.6%
Air taxi/Regional feeder													
ATR72-600f	2	--	101	204	226	323	349	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
B99	50	--	129	185	196	239	251	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
C208	30	2,308	2,303	2,309	2,305	2,277	2,268	0.6%	0.5%	0.5%	0.4%	0.4%	0.4%
C408 SkyCourier	1	--	101	204	226	323	349	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
Total air taxi/regional feeder		2,308	2,633	2,902	2,954	3,163	3,217	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%
DOMESTIC TOTAL		12,048	14,368	15,846	16,133	17,449	17,748	3.0%	3.1%	3.1%	3.1%	3.1%	3.1%
INTERNATIONAL													
Air carrier													
A300F	27	2	--	--	--	--	--	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
B747-F/BCF/ERF/LCF	10-20	1,048	910	1,034	1,082	1,154	1,179	0.3%	0.2%	0.2%	0.2%	0.2%	0.2%
B747-8F	6-10	597	558	615	637	671	682	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
B757-200F	31	2	--	--	--	--	--	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
B767-200F/300F	3-10	--	106	138	150	168	174	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
B777F	6	1,081	885	925	940	963	971	0.3%	0.2%	0.2%	0.2%	0.2%	0.2%
Air Carrier Total		2,730	2,460	2,711	2,809	2,956	3,006	0.7%	0.5%	0.5%	0.5%	0.5%	0.5%
Air taxi/Regional feeder													
S KING AIR 300		72	--	--	--	--	--	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
INTERNATIONAL TOTAL		2,803	2,460	2,711	2,809	2,956	3,006	0.7%	0.5%	0.5%	0.5%	0.5%	0.5%
TOTAL CARGO AIRLINES		14,851	16,828	18,557	18,942	20,405	20,754	3.7%	3.6%	3.6%	3.6%	3.7%	3.7%
OTHER (b)													
Air carrer		548	600	600	600	600	600	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Air taxi		365	400	400	400	400	400	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Subtotal--OTHER		913	1,000	1,000	1,000	1,000	1,000	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%

Table 6 (page 4 of 4)
FORECASTS OF TOTAL AIRCRAFT OPERATIONS BY AIRCRAFT TYPE
Seattle-Tacoma International Airport

Sector/Aircraft type/Equipment	Average age (years) (a)	Historical 2022	Forecast 2027	2032	2033	2037	2038	Historical 2022	Forecast 2027	2032	2033	2037	2038
GENERAL AVIATION													
Business Jet	--	838	1,190	1,235	1,244	1,281	1,290	0.2%	0.3%	0.2%	0.2%	0.2%	0.2%
Turboprop	--	535	219	210	208	201	199	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Subtotal--GENERAL AVIATION		1,373	1,409	1,445	1,452	1,481	1,489	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
MILITARY													
Jet	--	40	72	72	72	72	72	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Turbine	--	14	26	26	26	26	26	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Piston	--	1	2	2	2	2	2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Subtotal--MILITARY		55	100	100	100	100	100	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
TOTAL		401,351	467,363	512,033	520,538	557,468	566,873	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Note: Totals may not match Table 4 due to rounding.
(a) Aviation Week Intelligence Network, Commercial Aviation, online cdatabase, accessed August 2023.
(b) Includes unscheduled, empty, ferry flights. No detail available on aircraft types.
Sources: Historical—Federal Aviation Administration, ATADS, accessed March 2023 and Seattle-Tacoma International Airport Noise Office. Forecast--LeighFisher, September 2022, updated August 2023.

Table 7
FAA TAF FORECAST COMPARISON
Seattle-Tacoma International Airport
2022 – 2037

	Year (a)	SEA 2022 Forecasts	FAA 2022 TAF	SEA 2022 Forecasts vs. 2022 TAF (percent variance)
Passenger enplanements				
Base yr.	2022	22,966,119	21,385,264	7.4%
Base yr. + 1yr.	2023	25,097,659	24,428,087	2.7%
Base yr. + 5yrs.	2027	28,004,000	29,339,819	-4.6%
Base yr. + 10yrs.	2032	31,471,000	33,632,579	-6.4%
Base yr. + 15yrs.	2037	35,169,000	38,250,886	-8.1%
Commercial operations *(b)*				
Base yr.	2022	399,923	395,644	1.1%
Base yr. + 1yr.	2023	427,200	427,449	-0.1%
Base yr. + 5yrs.	2027	465,800	503,661	-7.5%
Base yr. + 10yrs.	2032	510,500	571,906	-10.7%
Base yr. + 15yrs.	2037	555,900	644,556	-13.8%
Total operations *(c)*				
Base yr.	2022	401,351	397,095	1.1%
Base yr. + 1yr.	2023	428,700	428,942	-0.1%
Base yr. + 5yrs.	2027	467,300	506,372	-7.7%
Base yr. + 10yrs.	2032	512,000	574,684	-10.9%
Base yr. + 15yrs.	2037	557,500	647,404	-13.9%

(a) The SEA 2022 Forecasts were prepared on a calendar year basis and the FAA 2022 TAF was prepared on a U.S. government fiscal year basis (October through September).

(b) Commercial operations include operations by passenger airlines, all-cargo airlines, and air taxi operators.

(c) Total operations include commercial operations plus operations by general aviation and military.

Sources: Base year 2022 (actual)—Seattle-Tacoma International Airport records.

FAA 2022 TAF for SEA--U.S. Department of Transportation, Federal Aviation Administration, www.faa.gov, accessed February 2023.

Forecast--LeighFisher, June 2022, updated August 2023 (2022 base year).

Table 8
SUMMARY OF SEA SAMP PLANNING FORECASTS USING FAA TEMPLATE
Seattle-Tacoma International Airport
Sustainable Airport Master Plan

		Forecast				Average annual compound growth rates			
	Base year 2022	Base year + 1 year 2023	Base year + 5 years 2027	Base year + 10 years 2032	Base year + 15 years 2037	Base year to +1 year 2022 - 2023	Base year to +5 years 2022 - 2027	Base year to +10 years 2022 - 2032	Base year to +15 years 2022 - 2037
Passenger enplanements (millions)									
Air carrier *(a)*	19.9	20.9	23.3	26.2	29.3	4.8%	3.2%	2.8%	2.6%
Commuter *(b)*	3.0	4.2	4.7	5.3	5.9	38.9%	9.2%	5.7%	4.5%
Total	23.0	25.1	28.0	31.5	35.2	9.3%	4.0%	3.2%	2.9%
Aircraft operations (thousands)									
Itinerant									
Air carrier	395,997	423,200	461,500	505,900	550,900	6.9%	3.1%	2.5%	2.2%
Commuter/air taxi	3,926	4,000	4,300	4,600	4,900	1.9%	1.8%	1.6%	1.5%
Total commercial operations	399,923	427,200	465,800	510,500	555,800	6.8%	3.1%	2.5%	2.2%
General aviation	1,373	1,400	1,410	1,440	1,500	2.0%	0.5%	0.5%	0.6%
Military	55	100	100	100	100	81.8%	12.7%	6.2%	4.1%
Local									
General aviation	--	--	--	--	--	--	--	--	--
Military	--	--	--	--	--	--	--	--	--
Total operations	401,351	428,700	467,310	512,040	557,400	6.8%	3.1%	2.5%	2.2%
Cargo/mail (enplaned + deplaned tons)	456,281	538,500	584,400	644,400	702,900	18.0%	5.1%	3.5%	2.9%
Operational factors									
Average aircraft size (seats)									
Air Carrier *(a)*	177	178	181	186	191				
Commuter *(b)*	74	75	76	78	80				
Average enplaning load factor									
Air Carrier *(a)*	0%	85%	85%	85%	85%				
Commuter *(b)*	0%	84%	84%	84%	84%				

Note: The SEA Sustainable Airport Master Plan forecasts were prepared on a calendar year basis and the FAA 2014 TAF was prepared on a U.S. government fiscal year basis (October through September).

(a) Includes mainline and low cost airline activity as summarized in the previous tables in this report.

(b) Includes regional affiliate airline activity, which includes flights using regional aircraft with more than 60 seats.

Sources: Base year 2022 (actual)—Seattle-Tacoma International Airport records.

FAA 2022 TAF for SEA--U.S. Department of Transportation, Federal Aviation Administration, www.faa.gov, accessed March 2022.

Forecast--LeighFisher, June 2022, updated August 2023.

APPENDIX A

Forecast and Airport Operational Assumptions

Constrained Operating Growth Scenarios (COGS)

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Sustainable Airport Master Plan – Near-Term Projects

Constrained Operating Growth Scenario

September 2023

PREPARED FOR

Port of Seattle

PREPARED BY

Landrum & Brown, Incorporated

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1. Constrained Operating Growth Scenario

The forecasts prepared as part of the Sustainable Airport Master Plan (SAMP) for the Seattle-Tacoma International Airport (SEA or Airport) were completed in 2015 using 2014 as the base year.[1] The SAMP used this forecast to develop and evaluate alternatives to satisfy activity associated with the 20-year unconstrained demand. The alternatives analysis resulted in a Long-Term Vision (LTV) for airport development. Modeling of the LTV airfield using Total Airport and Airspace Modeler (TAAM) software determined that, with no other changes to how the airfield/airspace is operated, simulated average aircraft delays at the Airport would exceed 20 minutes with activity forecast for 2029. FAA benefit cost and planning analysis has historically used 20 minutes of delay as an indicator of unacceptable levels of delay, whereby airlines would significantly reduce growth at that airport. The delay would be even greater in 2034, with projected delays of 37 minutes.[2] SAMP implementation planning determined that substantial gate, hardstand and terminal capacity could be constructed by 2027 to alleviate portions of the projected delay. Additional TAAM modeling of these improvements (included in the "Near-Term Projects" or NTPs) determined that, with an assumed medium level of efficiency improvement[3] to the airfield, average delay per aircraft operation would be 16.6 minutes in 2027. This level of average delay is considered to be within the range of what has been shown to be viable at congested airports in operation today. Consequently, without the NTPs, the 2027 projected aircraft operations demand could not be accommodated due to unsustainable levels of delay. The delay in the near term is primarily a result of a lack of aircraft gates and resulting congestion on the ramps. Delays due to departure procedure constraints and taxiway congestion will increase with traffic growth, but will remain secondary factors until gate capacity is increased.

In 2019, as part of the initiation of the environmental review for the Proposed Action, the FAA and the Port of Seattle reviewed the SAMP forecasts for use in the studies. Since the SAMP forecasts were prepared, actual passenger traffic at SEA had exceeded the SAMP forecasts, reflecting strong economic growth, decreases in domestic airfares, airline competition, the continued development of Delta Air Lines' hub, and strong growth in both origin-destination and connecting passengers. The Port, in collaboration with the FAA, determined that an updated forecast was warranted given the faster than forecasted economic and passenger growth. The Seattle-Tacoma International Airport Aviation Demand Forecast Update (2019 Updated Forecast) was approved by FAA for use in the National Environmental Policy Act (NEPA) Environmental Assessment (EA). The analysis conducted to prepare the 2019 Updated Forecast indicated that the resulting level of aircraft operations could exceed the Airport's ability to accommodate the demand, even with implementation of the Proposed Action.

In March 2020 the Covid-19 pandemic began to have a significant impact on air travel, resulting in unprecedented reductions in passengers and aircraft operations worldwide. In 2022 passenger and aircraft operations approached 2019 levels at many airports in the US, including SEA. Due to the

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[1] Sustainable Airport Master Plan, Technical Memorandum 2, prepared by the Port of Seattle.
[2] Average delay per aircraft operation is determined by through annualized weighting values applied to models run to simulate specific airfield operating conditions. The weighting values represent the proportion of the year that the airport operates under the conditions simulated in the individual models.
[3] Medium level of efficiency improvement assumes that various future NextGen technologies will increase runway throughput by 3-4 additional operations per hour (roughly a 5% increase in throughputs) over the calibrated Maximum Sustainable Throughput (MST) (SAMP Technical Memorandum No. 6, Appendix G, page 56)

reduction in activity between 2020 and 2022, the Port of Seattle re-evaluated the projected passenger and aircraft operations demand for SEA, as well as the timing of opening year for the Proposed Action.

The Port of Seattle prepared the 2023 Updated Forecast to capture the impact of the Covid-19 pandemic on future passenger and aircraft operations at SEA. Based on the projections of activity in the 2023 Updated Forecast and the time it will take to construct the Proposed Action, the Port of Seattle has determined that the opening year for the Proposed Action should be shifted from 2027 to 2032. Similar to the analysis conducted for the 2019 Updated Forecast, the resulting level of aircraft operations under the 2023 Updated Forecast could exceed the Airport's ability to accommodate the demand, even with implementation of the Proposed Action.

As a result, the FAA and Port of Seattle decided to consider the activity levels that could be accommodated in the opening year and five years beyond opening year under both the No Action and Proposed Action cases. The process for conducting this assessment included:

1. Considering the capability of the Airport to accommodate the projected demand in the 2023 Updated Forecast and at what point the constraints result in unacceptable aircraft operational delay (Section 2).
2. Developing estimated annual growth rates for aircraft operations and passengers for the years beyond the point where the unsustainable aircraft operational delay would occur under No Action and Proposed Action conditions. This would include an evaluation of opportunities airlines and the Airport may reasonably undertake to add incremental service during the constrained periods (Section 3) that does not exacerbate delay levels.
3. Applying the annual growth rates and calculating constrained annual aircraft operations and passenger levels for use in the NEPA EA. This is particularly important for the assessment of environmental impacts for categories where the number of passengers and/or operations is a primary driver of the impacts. The categories where this is directly relevant include noise, air quality, climate, and traffic impact studies. Other categories, including Department of Transportation Section 4(F), environmental justice, and historical, architectural, archeological, and cultural resources, incorporate the results of these primary assessments directly or indirectly to determine impacts (Section 4).

The following describes the results of each of the steps in the process.

1.1 2023 Forecast Update

The SAMP NTP environmental review will include a discussion on the 2023 Updated Forecasts. **Table 1** presents the aircraft operating and passenger levels for 2032 and 2037 from the 2023 Updated Forecast.

TABLE 1: 2023 UPDATED FORECAST

Year	Aircraft Operations	Passengers
2032 (Opening Year)	511,800	63,000,000
2037 (Five Years Beyond Opening)	557,300	70,400,000

Source: Seattle-Tacoma International Airport Aviation Demand Forecast Update, Table 5, Forecast Comparison and Table 6 Forecasts of Total Aircraft Operations by Aircraft Type, prepared by Leigh Fisher for the Port of Seattle (2023).

1.2 Capability of Airport to Accommodate Demand

The SAMP included detailed simulation modeling of airport capacity and delay based on peak month average day activity levels. The peak month average day activity was converted to annual activity levels for future years to approximate annual activity levels for master planning purposes. Based on the simulation modeling of peak month average day activity and subsequent annualization of delay, the SAMP concluded that in order to accommodate the 2027 annual demand of approximately 477,000 aircraft operations and 56 million annual passengers (56 MAP), and to improve level of delay, the Airport would need to implement the NTPs. In addition to addressing the unsustainable level of delay, the NTPs are also anticipated to provide an improved level of service for these volumes. It should be noted that the annual activity levels (from which simulations of peak day activity are estimated) are approximations and should not be considered caps or maximum activity levels for an airport. Passengers and operations can continue to grow at capacity constrained airports, as evidenced by activity at other airports that continue to grow (e.g., DCA, JFK, and LGA).

Because the Proposed Action is in large part an expansion of passenger terminal facilities, an assessment of the average turns per gate per day was conducted to identify where constraints would occur due to lack of passenger gates. A 'turn' can be defined as an aircraft unloading and then loading passengers for the next departure. In general, passenger gates can reasonably accommodate 8 to 10 turns per day based on ACRP Research Report 163, *Guidebook for Preparing and Using Airport Design Day Flight Schedules* (2016). While it is possible to exceed 8 to 10 turns per day at an individual gate, beyond this number of turns airport-wide is considered a sign of excessive congestion and likely a point where the airport has reached a constraint point. For example, in 2019 SEA experienced turns per gate per day that approached 8 and airlines reacted by changing schedules and using more ground loading and hardstand operations, which resulted in a lower level of service for passengers.

To calculate average turns per gate per day, the total number of projected daily passenger aircraft departures was divided by the available passenger gates for 2023 through 2037 (daily aircraft departures/available gates=turns per gate per day). The number of available passenger gates for each year took into consideration gate outages due to planned terminal and apron redevelopment programs independent of the SAMP NTP. For the Proposed Action, an additional 19 passenger gates were assumed to be available in 2032 and remain available through 2037.

Based on the resulting turns per gate per day, it was identified that SEA would reach 8 turns per gate per day in 2027. Under the No Action the turns per gate per day would continue to reach 8 through 2037 meaning that from 2027 through 2037 the No Action would experience a constrained operating environment. Under the Proposed Action the turns per gate per day would drop below 8 in 2032 due to the additional 19 gates. Based solely on the turns per gate per day evaluation, the turns per gate per day would not exceed 8 through 2037. However, as discussed above, the Airport will experience airfield constraints with the additional aircraft operations that are expected to occur after the 19 gates become available. When that is considered, it is projected that the Airport would return to a constrained operating environment under Proposed Action in 2036 due to lack of airfield capacity, rather than lack of gate capacity. **Table 2** provides the year by year turns per gate per day results.

TABLE 2: SEA TURNS PER GATE PER DAY ANALYSIS

Year	Passenger Airline Landings (or Departures)	No Action Number of Gates/Hard Stands/Parking Positions	No Action Total Turns Per Gate Per Day (All PAX Airlines)	Proposed Action Number of Gates/Hard Stands/Parking Positions	Proposed Action Total Turns Per Gate Per Day (All PAX Airlines)
2023	205,371	83	7	83	7
2024	210,313	82	7	82	7
2025	214,926	83	7	83	7
2026	219,193	83	7	83	7
2027	223,970	78	8	78	8
2028	228,303	80	8	80	8
2029	232,632	83	8	83	8
2030	237,369	83	8	83	8
2031	241,459	83	8	83	8
2032	245,353	83	8	102	7
2033	249,408	87	8	106	6
2034	253,841	87	8	106	7
2035	258,298	87	8	106	7
2036	262,776	87	8	106	7
2037	267,277	87	8	106	7

Note: Green shading represents periods of unconstrained growth. Tan shading represents periods of constrained growth.

During periods of constrained operating environments, the assumption is that without additional capacity, airlines will significantly reduce adding new service at the Airport because the expected added delays will significantly impact their ability to maintain network and schedule integrity.

1.3 Annual Constrained Growth Rates

During periods where the Airport would experience constrained operating environments there are strategies that airlines and the Airport can reasonably use to allow additional growth in passengers and aircraft operations. These strategies include:

1.3.1 Use of Additional Hardstands and Overnight Aircraft Parking Positions

Observations of other airports that experience constrained operating environments indicate that a small amount of growth in aircraft operations can be expected (See **Table 3**). When the constraint is related to lack of gates/aircraft parking positions, airports can take actions to provide incremental capabilities. Historically at SEA, these actions have included designating taxiways for parking aircraft overnight and designating cargo aircraft positions as passenger hardstands where bus loading/unloading can occur.

SEA has incorporated these approaches over the years as the situation has warranted and could do so again to accommodate some of the demand. For example, overnight aircraft have parked on Taxiway A near the terminal area. Other areas on the Airport that have been used for overnight passenger aircraft parking include: Taxiway T, the northern portion of Taxiway A (as noted above), various cargo parking positions, and the tri-taxilanes around the North Satellite. Using these areas for overnight parking would be at the expense of cargo operations, requiring increased operational coordination, and forcing cargo to be pushed back to non-peak times as their parking space would be overtaken by passenger operations. It is anticipated that using cargo parking spots for overnight parking would occur on a limited basis and would likely affect cargo operators that are not shipping next day packages. Overall, overnight parking on any movement area is not ideal due to complexities that occur from aircraft repositions, aircraft pushbacks onto taxiways, deicing, and general traffic flow north and south. While none of these areas are currently preferred overnight parking locations, if the situation warranted, they could be used again in the future.

Similarly, other areas on the Airport could be used for hardstand operations, including: various cargo parking positions, various general aviation parking positions, and the Alaska, Delta, and United Airlines maintenance areas. As with the overnight parking positions, these areas are not ideal from an operational perspective and would be used on a limited basis. The same types of tradeoffs in activities would occur as described above and would provide a poor level of service to passengers requiring bussing, ground boarding of the aircraft, extended minimum connection times, and exposure to varying weather conditions. However, if the situation warranted, they could be used to provide incremental hardstand capability. More recently, the airline scheduling strategy has been to add additional evening revenue flights to other nearby airports and flying those aircraft back to SEA in the morning.

TABLE 3: SIMILARLY CONSTRAINED AIRPORT ACTIVITY

DCA

Enplanements					Operations					Local Operations			Total Operations	
Year	Air Carrier	Commuter	Total	Percent Growth	Air Carrier	Commuter	GA	Military	Total	Civil	Military	Total	Total OPS	Percent Growth
2010	5,860,238	2,678,537	8,538,775	N/A	174,353	88,716	5,151	2,040	270,260	0	0	0	270,260	N/A
2011	6,161,824	2,903,545	9,065,369	6.167%	194,831	84,268	5,099	601	284,799	0	0	0	284,799	5.380%
2012	6,227,743	3,074,409	9,302,152	2.612%	190,311	89,912	6,183	1,460	287,866	0	0	0	287,866	1.077%
2013	6,485,558	3,366,228	9,851,786	5.909%	195,295	92,624	5,435	2,082	295,436	0	0	0	295,436	2.630%
2014	6,482,557	3,393,224	9,875,781	0.244%	197,859	82,072	4,230	2,806	286,967	0	0	0	286,967	-2.867%
2015	7,828,412	3,170,011	10,998,423	11.368%	222,103	67,612	3,163	3,372	296,250	0	0	0	296,250	3.235%
2016	8,215,871	3,260,187	11,476,058	4.343%	230,188	62,950	3,261	3,500	299,899	0	0	0	299,899	1.232%
2017	7,993,630	3,483,109	11,476,739	0.006%	241,993	49,033	3,844	3,255	298,125	0	0	0	298,125	-0.592%
2018	7,706,640	3,704,728	11,411,368	-0.570%	232,124	59,324	3,290	2,797	297,535	0	0	0	297,535	-0.198%
2019	7,825,300	3,681,209	11,506,509	0.834%	239,639	52,557	2,829	2,818	297,843	0	0	0	297,843	0.104%
2010 - 2019 Compound Average Growth Rate:				3.80%										1.22%
2014 - 2019 Compound Average Growth Rate:				3.89%										0.93%

JFK

Enplanements					Operations					Local Operations			Total Operations	
Year	Air Carrier	Commuter	Total	Percent Growth	Air Carrier	Commuter	GA	Military	Total	Civil	Military	Total	Total OPS	Percent Growth
2010	21,003,452	1,566,765	22,570,217	N/A	327,598	68,158	7,013	325	403,094	0	0	0	403,094	N/A
2011	21,841,550	1,706,320	23,547,870	4.332%	341,874	63,390	7,506	310	413,080	0	0	0	413,080	2.477%
2012	22,900,922	1,564,623	24,465,545	3.897%	352,109	51,655	7,755	354	411,873	0	0	0	411,873	-0.292%
2013	23,305,418	1,433,101	24,738,519	1.116%	353,389	47,992	6,860	518	408,759	0	0	0	408,759	-0.756%
2014	24,326,331	1,574,357	25,900,688	4.698%	374,668	43,307	7,332	313	425,620	0	0	0	425,620	4.125%
2015	25,904,178	1,488,418	27,392,596	5.760%	401,737	32,782	7,462	649	442,630	0	0	0	442,630	3.997%
2016	27,262,869	1,734,087	28,996,956	5.857%	419,274	30,912	8,274	370	458,830	0	0	0	458,830	3.660%
2017	27,729,638	1,774,008	29,503,646	1.747%	414,743	30,829	8,224	403	454,199	0	0	0	454,199	-1.009%
2018	28,120,424	1,919,896	30,040,320	1.819%	417,966	29,819	8,152	440	456,377	0	0	0	456,377	
2019	29,257,150	1,841,199	31,098,349	3.522%	423,230	30,903	10,501	369	465,003	0	0	0	465,003	
2010 - 2019 Compound Average Growth Rate:				4.09%										1.80%
2014 - 2019 Compound Average Growth Rate:				4.68%										2.24%

LGA

Enplanements					Operations					Local Operations			Total Operations	
Year	Air Carrier	Commuter	Total	Percent Growth	Air Carrier	Commuter	GA	Military	Total	Civil	Military	Total	Total OPS	Percent Growth
2010	8,800,460	2,999,395	11,799,855	N/A	209,318	147,957	7,028	349	364,652	0	0	0	364,652	N/A
2011	8,911,019	3,111,017	12,022,036	1.883%	242,305	121,170	6,401	311	370,187	0	0	0	370,187	1.518%
2012	9,287,598	3,350,963	12,638,561	5.128%	265,301	104,339	6,535	344	376,519	0	0	0	376,519	1.710%
2013	9,509,944	3,730,246	13,240,190	4.760%	299,500	64,766	6,903	271	371,440	0	0	0	371,440	-1.349%
2014	9,410,339	4,020,193	13,430,532	1.438%	313,952	49,364	6,831	228	370,375	0	0	0	370,375	-0.287%
2015	10,232,320	3,835,472	14,067,792	4.745%	311,016	51,921	6,024	463	369,424	0	0	0	369,424	-0.257%
2016	10,546,044	4,236,488	14,782,532	5.081%	313,818	54,384	6,344	174	374,720	0	0	0	374,720	1.434%
2017	10,025,632	4,413,153	14,438,785	-2.325%	307,642	52,853	5,474	278	366,247	0	0	0	366,247	-2.261%
2018	10,265,435	4,787,946	15,053,381	4.257%	309,327	53,444	4,954	212	367,937	0	0	0	367,937	0.461%
2019	10,842,835	4,517,629	15,360,464	2.040%	317,158	52,183	4,853	203	374,397	0	0	0	374,397	1.756%
2010 - 2019 Compound Average Growth Rate:				3.35%										0.33%
2014 - 2019 Compound Average Growth Rate:				3.41%										0.27%

Source: FAA Terminal Area Forecast, accessed online 2/1/2023.

1.3.2 Upgauging of Aircraft

Airlines make choices about the size of aircraft and the overall number of seats available at an airport based on passenger demand, the capability of the airport to accommodate the aircraft, and alignment with their network strategy. Over time, airlines have been 'upgauging'; that is, replacing regional jet aircraft with narrowbody aircraft that offer more seats, as well as replacing smaller narrowbody aircraft with larger narrowbody aircraft that offer more seats.

Most airports, including SEA, experienced the upgauging prior to the Covid-19 pandemic. The 2023 Updated Forecast projects upgauging will continue to occur based upon the airline's aircraft orders and retirements. Upgauging would not exclusively occur at SEA. In fact, it is observed at most large hub airports as airlines are choosing to operate larger aircraft versus a greater number of smaller aircraft due to the financial performance of those aircraft.

At airports with high demand but limited capability to accommodate more flights, airlines could, in theory, quicken the pace at which they use larger aircraft at that airport. Some airlines at SEA, like Alaska Airlines, do not have the number of larger aircraft to notably upgauge their fleet at SEA. Other airlines at SEA, like Delta Air Lines, have the aircraft and the capability to somewhat quicken the pace at which they upgauge aircraft. However, the airlines may also be experiencing capacity constraints at other airports, which limits their ability to increase the pace of upgauging at a specific airport. Accordingly, this forecast scenario does not assume a notably higher pace of upgauging at SEA, but rather a continuation of the expected system-wide upgauging trend.

1.3.3 Increasing Load Factors

During periods when growth in aircraft operations is constrained, the demand for air travel is expected to continue to increase. One result of this situation may be an increase in 'load factor' or the average percentage of an aircraft's seats that are filled by passengers. This results in fewer empty seats per aircraft, which allows for overall passenger growth even without additional aircraft operations. Like most airports, SEA experienced increasing load factors prior to the Covid-19 pandemic. The 2023 Updated Forecast projects load factor increases will continue to occur. If passenger demand continues to grow as predicted in the 2023 Updated Forecast and if growth in aircraft operations and size of aircraft cannot provide the seat capacity, it is possible that the load factors will increase at a quicker pace during constrained growth periods. However, airlines could opt to increase fares and adjust their yield management programs in the constrained environment. Accordingly, because SEA has relatively high load factors already, there is limited potential for this trend to result in a substantial increase in total passengers.

Based on the strategies described above an estimate of aircraft operations and passenger annual growth rates for constrained growth periods at SEA was prepared. For the purposes of the constrained scenario analysis, it is assumed that the Airport could accommodate additional, incremental flights during non-peak times by utilizing all or some of the locations discussed above for overnight parking and hardstands. No increase in passengers was assumed in this analysis based on a higher pace of upgauging or load factors during constrained periods.

1.3.4 Constrained Annual Growth Rates

Passenger – 0.89%

Aircraft Operations – 0.27%

These constrained growth rates were compared to several other airports that experience constrained operating environments (JFK, LGA, and DCA). While the constraints at each of these airports are unique to their situation, the growth rates offer the best examples of how activity changes in constrained operating environments. Table 3 shows the recent and average growth rates for these airports.

- Annual passenger growth rates ranged from 3.35 percent to 4.09 percent with an average growth rate from 2010 through 2019 of 3.75 percent.
- Annual aircraft operations growth rates ranged from 0.33 percent to 1.8 percent with an average growth rate from 2010 through 2019 of 1.12 percent.

Comparing these individual and average growth rates to the constrained growth rate scenarios for SEA indicates that the constrained growth rates for SEA are lower than the other constrained airports. This is a more conservative approach so as not to overestimate the capability of the Airport.

1.4 Resulting Constrained Growth Aircraft Operations and Passengers

1.4.1 No Action

The constrained growth rates were applied to the 2023 Updated Forecast level of activity from 2027 and beyond to calculate the annual aircraft operations and passengers for the 2032 and 2037 No Action scenario. **Table 4** below compares the unconstrained aircraft operations and passenger levels from the 2023 Updated Forecast to the constrained aircraft operations and passenger levels for the 2032 and 2037 No Action scenario. The resulting number of passengers under the 2032 No Action scenario are higher than what the SAMP projected for 2027 (original opening year). While that level of activity can be accommodated, it comes at a lower level of service to passengers and airlines than what the Port of Seattle prefers to offer.

TABLE 4: NO ACTION AIRCRAFT OPERATIONS AND PASSENGERS

	2032 (Opening Year) Aircraft Operations	2032 (Opening Year) Total Passengers	2037 (5 Years Beyond Opening) Aircraft Operations	2037 (5 Years Beyond Opening) Total Passengers
SAMP Forecast (unconstrained)	477,000	56,000,000	527,000	63,000,000
2023 Forecast (Unconstrained)	511,800	63,000,000	557,300	70,400,000
No Action Constrained Scenario	466,901	57,171,652	474,874	59,483,817
Unmet Demand (2023 Forecast)	44,899	5,828,348	82,426	10,961,183

Note: SAMP Forecast operations and passengers are 2032 (opening year) and 2037 (5 years beyond opening) for comparison of similar conditions.

1.4.2 Proposed Action

Implementation of the Near-Term Projects, with full build-out completing in 2032, will increase the Airport's ability to accommodate increased aircraft operations and passenger activity at an acceptable level of delay by adding aircraft gates and passenger processing facilities. As a result, it is assumed that after implementation, the number of aircraft operations and passengers will increase toward the projected unconstrained levels identified in the 2023 Updated Forecast. This higher growth rate (known as latent demand) is expected to occur for three years after implementation (2032 to 2035) as airlines adjust their schedules to the additional gate availability. However, because the airfield and airspace also have constraints in regard to the level of aircraft operations, it is not anticipated that the Airport will be able to accommodate the projected unconstrained aircraft operations and passengers from the 2023 Updated Forecast, even with the implementation of the Near-Term Projects. Therefore, it is assumed that the Airport will again experience constrained growth rates between 2036 and 2037 as airfield and airspace capacity, exhibited through departure delay, then become the primary constraining factors. **Table 5** below compares the unconstrained aircraft operations and passenger levels from the 2023 Updated Forecast to the anticipated aircraft operations and passenger levels for the 2032 and 2037 Proposed Action scenario.

TABLE 5: PROPOSED ACTION AIRCRAFT OPERATIONS AND PASSENGERS

	2032 (Opening Year) Aircraft Operations	2032 (Opening Year) Total Passengers	2037 (5 Years Beyond Opening) Aircraft Operations	2037 (5 Years Beyond Opening) Total Passengers
SAMP Forecast (unconstrained)	477,000	56,000,000	527,000	63,000,000
2023 Forecast (Unconstrained)	511,800	63,000,000	557,300	70,400,000
Proposed Action Constrained Scenario	475,655	58,294,388	509,892	64,093,41
Unmet Demand (2023 Forecast)	36,145	4,705,612	47,408	6,306,588

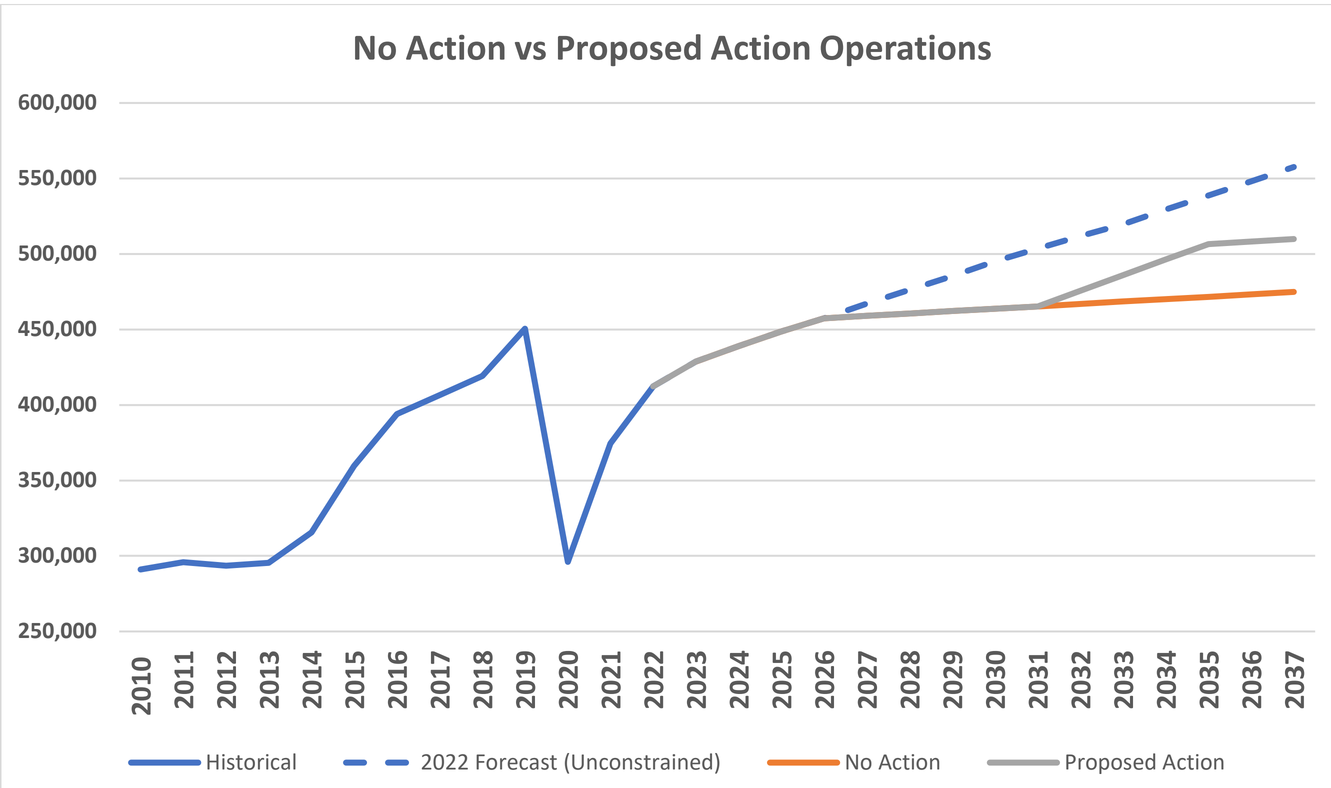
Note: SAMP Forecast operations and passengers are 2032 (opening year) and 2037 (5 years beyond opening) for comparison of similar conditions.

Table 6 below and the graph that follows compare the No Action and Proposed Action aircraft operations and passenger levels for 2032 and 2037. As discussed above, the comparison of these activity levels will be an important input into several different environmental impact categories.

TABLE 6: PROPOSED ACTION AND NO ACTION AIRCRAFT OPERATIONS AND PASSENGERS

	2032 (Opening Year) Aircraft Operations	2032 (Opening Year) Total Passengers	2037 (5 Years Beyond Opening) Aircraft Operations	2037 (5 Years Beyond Opening) Total Passengers
No Action	466,900	57,171,652	474,874	59,483,817
Proposed Action	475,655	58,294,388	509,892	64,093,412
Difference Between Proposed Action and No	8,755	1,122,736	35,018	4,609,595

Note: SAMP Forecast operations and passengers are 2032 (opening year) and 2037 (5 years beyond opening) for comparison of similar conditions.



APPENDIX A

Forecast and Airport Operational Assumptions

FAA Approval of 2023 Forecast Update and COGS

U.S. Department
of Transportation
**Federal Aviation
Administration**

Northwest Mountain Region
Colorado · Idaho · Montana · Oregon · Utah
Washington · Wyoming

Seattle Airports District Office
2200 S. 216th Street
Des Moines, WA 98198

April 1, 2024

Steve Rybolt
Senior Environmental Program Manager
Port of Seattle
Sea-Tac International Airport

RE: Seattle-Tacoma International Airport, Seattle, WA Forecast Approval

Dear Mr. Rybolt:

The Federal Aviation Administration (FAA) approves the Seattle-Tacoma International Airport Aviation Activity Forecast Update, dated September 2023, and the Sustainable Airport Master Plan (SAMP) Near Term Projects (NTPs) Constrained Operating Growth Scenario, dated September 2023. The review included coordination with APP-400 in FAA Headquarters. We found the unconstrained forecast to be generally consistent with the FY23 TAF (see Table 1). The forecasts use current data and are supported by generally accepted planning methodologies. We understand the primary use of these forecasts will be in support of the SAMP NTP environmental process. Accordingly, derivative forecasts that incorporate specific fleet mix trends and the average annual day schedule used for NEPA analysis must align with these approved forecasts.

Justification for future projects will be made based on activity levels at the time the project is requested for development, rather than this forecast approval. Further documentation of actual activity levels reaching the planned activity levels may be needed prior to FAA participation in future funding for eligible projects. Finally, the approved forecasts are subject to re-validation prior to use in other environmental or Part 150 noise planning purposes or if the fundamental rationale of the forecast changes materially.

Sincerely,

Kandice Krull
Environmental Protection Specialist
FAA - Denver Airport District Office

Table 1: TAF Comparison to SEA Unconstrained Forecasts

Enplanements			
	SEA Forecast	**2023 TAF**	**Difference**
2022	22,966,119	21,387,052	7.10%
2023	25,097,659	24,274,222	3.30%
2027	28,004,000	28,261,940	-0.90%
2032	31,471,000	32,106,737	-2.00%
2037	35,169,000	36,165,615	-2.80%
Commercial Operations			
	SEA Forecast	**2023 TAF**	**Difference**
2022	399,923	395,644	1.10%
2023	427,200	415,264	2.80%
2027	465,800	473,170	-1.60%
2032	510,500	530,798	-3.90%
2037	555,900	590,974	-6.10%
Total Operations			
	SEA Forecast	**2023 TAF**	**Difference**
2022	401,351	397,095	1.10%
2023	428,700	416,651	2.90%
2027	467,300	475,694	-1.80%
2032	512,000	533,385	-4.10%
2037	557,500	593,626	-6.30%

APPENDIX A

Forecast and Airport Operational Assumptions

Environmental Review Airside Modeling Documentation (TAAM)

The Total Airspace and Airport Modeler (TAAM) analysis was prepared to support the noise and air quality modeling in this Environmental Assessment (EA) by providing information on the runway use, taxi times (including delay and taxi distance), and operations by time of day (day (after 7am and before 10pm) and night (after 10pm and before 7am)). The TAAM analysis in the attached report relied upon the 2019 Aviation Activity Forecast Update and Constrained Operating Growth Scenario (COGS) developed in 2019 and approved for use in the EA by FAA in 2020. Due to the reduction in activity between 2020 and 2022 from the COVID-19 pandemic, the Port of Seattle (Port) re-evaluated the projected passenger and aircraft operations demand for SEA by preparing a 2023 Aviation Activity Forecast Update. Based on the projections of activity in the 2023 Aviation Activity Forecast Update and the time it will take to construct the Near Term Projects (NTPs), the Port determined the opening year for the NTPs will be 2032. Similar to the analysis conducted for the 2019 Aviation Activity Forecast Update, the resulting level of aircraft operations under the 2023 Aviation Activity Forecast Update could exceed the Airport's ability to accommodate the demand, even with implementation of the NTPs. Therefore, the 2023 COGS were developed for use in the EA.

The following tables present a comparison of the 2019 and 2023 COGS operation levels on an average annual day (#annual operations/365). As shown, the operation levels for 2032 and 2037 in the 2023 COGS are lower than the operations levels for 2027 and 2032 in the 2019 COGS.

	2019 COGS	2019 COGS	2023 COGS	2023 COGS	Difference	Difference
Year	2027	2032	2032	2037		
No Action	1,367	1,386	1,279	1,301	(88)	(86)
With NTPs (Proposed Action)	1,392	1,436	1,303	1,396	(89)	(39)

Sources: Sustainable Airport Master Plan – Near Term Projects, Constrained Operating Growth Scenarios, Seattle-Tacoma International Airport, Landrum & Brown, January 2020
Sustainable Airport Master Plan – Near Term Projects, Constrained Operating Growth Scenarios, Seattle-Tacoma International Airport, Landrum & Brown, September 2023

The results of the TAAM analysis, using the 2019 COGS operation levels, was reviewed and it was determined the runway use assumptions, taxi distance, and day night split would remain approximately the same regardless of the number of operations. Delay times would more than likely be lower due to the decrease in operations. Therefore, it was determined to continue using the runway use, taxi times, and operations by time of day developed using the 2019 COGS for the 2023 COGS in the EA noise and air quality analysis.

ENVIRONMENTAL REVIEW AIRSIDE MODELING

Seattle-Tacoma International Airport

1 BACKGROUND AND OBJECTIVES

The Port of Seattle is currently preparing an Environmental Assessment (EA) as part of the National Environmental Policy Act (NEPA) process for the Near Term Projects at Seattle-Tacoma International Airport (SEA, or the Airport) proposed in the Sustainable Airport Master Plan (SAMP). The Proposed Action includes various improvements to Airport facilities. For the purposes of this analysis, which focuses on airfield operational considerations, the following elements of the Near-Term Projects were included:

- Constructing a new Second Terminal to the north consisting of 19 narrow-body equivalent aircraft gates
- Relocating Taxiway S, which connects Runway 16L-34R and Taxiway B, approximately 300' to the south
- Realigning a portion of Taxiway B to achieve 500' of separation from Runway 16L-34R
- Extending parallel Taxiways A and B to the Runway 34R entrance, enabling additional departure queueing space and a dual departure queue in North flow
- Constructing a new high-speed exit from Runway 34L between Taxiways E and J
- Extending Taxiway D from Runway 16C-34C to Taxiway T
- Constructing new aircraft holding and parking positions in portions of the north cargo area and north of Concourse D

The objective of this Environmental Review Airside Modeling was to generate simulated airfield operational metrics for use in the environmental team's NEPA analyses.

2 APPROACH

LeighFisher developed models using Jeppesen's Total Airspace and Airport Modeller (TAAM) for previous SAMP airside modeling efforts. TAAM is a fast-time airfield and airspace simulation program that enables the user to model gate-to-gate aircraft operations. TAAM is an industry-accepted tool widely used by aviation modelers for a variety of uses. It produces performance metrics that are well understood and adequately suited to airport planning efforts, including environmental review.

LeighFisher calibrated the previous TAAM models to 2016 airfield performance metrics at SEA. These models were the basis for the development of new TAAM models to support the environmental effort. Several key factors changed since the SAMP and pre-NEPA modeling, including the demand forecasts, the daily demand profile, and the acceptable operational growth parameters. LeighFisher updated these assumptions accordingly for the Environmental Review Airside Modeling.

2.1 Forecasts and Constrained Operating Growth Scenarios

As part of the SAMP, LeighFisher prepared unconstrained forecasts of aviation activity for SEA through 2034. The first iteration of these forecasts—which drove much of the facility programming in the SAMP—were based on 2014 activity at SEA. Rapid growth in activity at SEA after 2014 and changes to airline operating profiles necessitated subsequent updates to the near-term SAMP forecasts, using base years of 2016, 2017, and 2018. In the first two updates, the out-year SAMP forecasts (i.e., through 2034/2035) were not changed from the 2014 out-year SAMP forecasts. Each of these forecasts were unconstrained, meaning that demand was forecast to grow predominantly following forecast regional economic growth and other explanatory factors irrespective of potential airport capacity limitations.

For the EA, LeighFisher updated the forecasts with 2019 as the base year, as shown in Table 1 on the following page. In addition, two Constrained Operating Growth Scenarios (COGS) were produced—one for the No Action scenario and one for the Proposed Action scenario. The SAMP revealed several potential capacity limitations at the Airport, and the scenarios prepared for the EA took these facility limitations into account. Accordingly, both the No Action and the Proposed Action scenarios were constrained, with the Proposed Action scenario accommodating more growth than the No Action scenario, representing the potential capacity enhancement benefits of the Proposed Action.

LeighFisher and the Port's environmental team developed the constraint assumptions in the No Action and the Proposed Action scenarios based on discussions with the FAA, summarized as follows:

- An average of four Average Day Peak Month (ADPM) passenger airline aircraft operations were added per year between 2019 and 2032, with increased additions during the period after the new north terminal opens in 2027.
- The percent distribution of total aircraft operations in the No Action and the Proposed Action scenarios remained unchanged from the unconstrained scenario. Specifically, passenger airline operations accounted for 96% of total operations, followed by cargo airline operations with less than 4%, and general aviation operations with less than 1%.
- The ratio of annual to ADPM total aircraft operations remained relatively unchanged through 2032.

Completion of the near-term projects is expected by 2027, so 2027 was selected as the Date of Beneficial Occupancy (DBO) for the EA. Accordingly, 2032 was the "DBO + 5" year. The No Action and Proposed Action constrained scenarios for these years are shown in Table 1 on the following page, which also includes the unconstrained SAMP forecasts for comparison.

Table 1
Summary of Aviation Activity Forecasts and Forecast Assumptions
Seattle-Tacoma International Airport

	2019	2027	2032	2035
Total passengers (millions)				
SAMP (2014 base)*		56.0	63.0	
SAMP (2019 base)*	50.3	61.1	68.2	72.9
No Action Scenario**		58.1	60.7	
Proposed Action Scenario**		59.2	63.1	
Total annual aircraft operations				
SAMP (2014 base)*		477,000	524,000	
SAMP (2019 base)*	454,470	519,360	556,540	584,880
No Action Scenario**		499,000	506,000	
Proposed Action Scenario**		508,000	524,000	
Average Annual Day (AAD) total operations				
SAMP (2014 base)*		1,307	1,436	
SAMP (2019 base)*	1,245	1,423	1,525	1,602
No Action Scenario**		1,367	1,386	
Proposed Action Scenario**		1,392	1,436	
Average Day Peak Month (ADPM) total operations				
Total aircraft operations				
SAMP (2014 base)*		n.a	n.a	
SAMP (2019 base)*	1,247	1,427	1,529	1,607
No Action Scenario**		1,372	1,396	
Proposed Action Scenario**		1,398	1,444	
Passenger airline aircraft operations				
SAMP (2014 base)*	1,225	1,459	1,604	
SAMP (2019 base)*	1,196	1,354	1,466	1,464
No Action Scenario**		1,310	1,332	
Proposed Action Scenario**		1,334	1,380	
Cargo airline and general aviation aircraft operations				
SAMP (2014 base)*		n.a	n.a	
SAMP (2019 base)*	52	64	64	64
No Action Scenario**		62	64	
Proposed Action Scenario**		64	64	
Ratio of Annual to ADPM total operations				
SAMP (2014 base)*		n.a	n.a	
SAMP (2019 base)*	364	364	364	364
No Action Scenario**		364	362	
Proposed Action Scenario**		363	363	

Note: *Unconstrained; **Constrained; n.a. = not available
Sources: OAG Aviation Worldwide Ltd, OAG Analyser database, accessed December 2019; LeighFisher, January 2020. Flight track data for 2019 provided by the Port of Seattle.

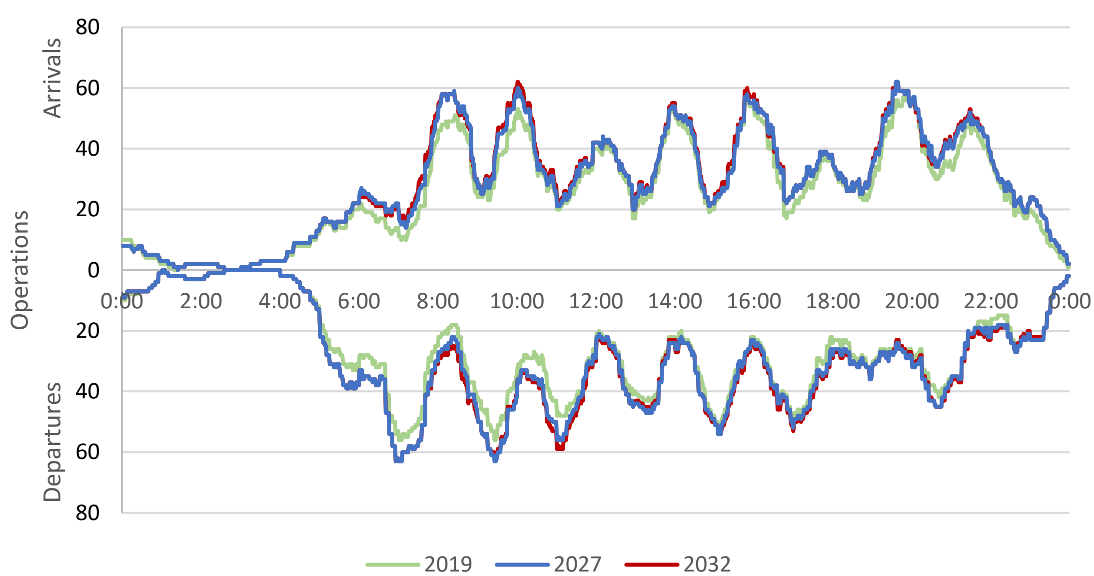
2.2 Design Day Flight Schedules

Based on the constrained scenarios, LeighFisher created four design day flight schedules (DDFS) for use in the Environmental Review Airside Modeling: 2027 No Action, 2027 Proposed Action, 2032 No Action, and 2032 Proposed Action. Conforming to guidelines for NEPA analyses, the DDFS were representative of an Average Annual Day (AAD) flight schedule in 2019.

LeighFisher developed the DDFS using standard methods consistent with previous forecasting efforts. The future-year flight schedules consisted of a base-year flight schedule—in this case, a 2019 AAD—with activity added on top of the base. Historical scheduled passenger flights sourced from the Official Airline Guide and historical air cargo and general aviation operations sourced from Port data comprised the base-year flight schedule. LeighFisher applied professional judgment and experience to identify future markets served, future airline entrants, airline fleet changes and upgauges, and the scheduled times of added flights. Generally, the characteristics of the base-year flight schedule (e.g., peaking) were preserved in the future-year schedules.

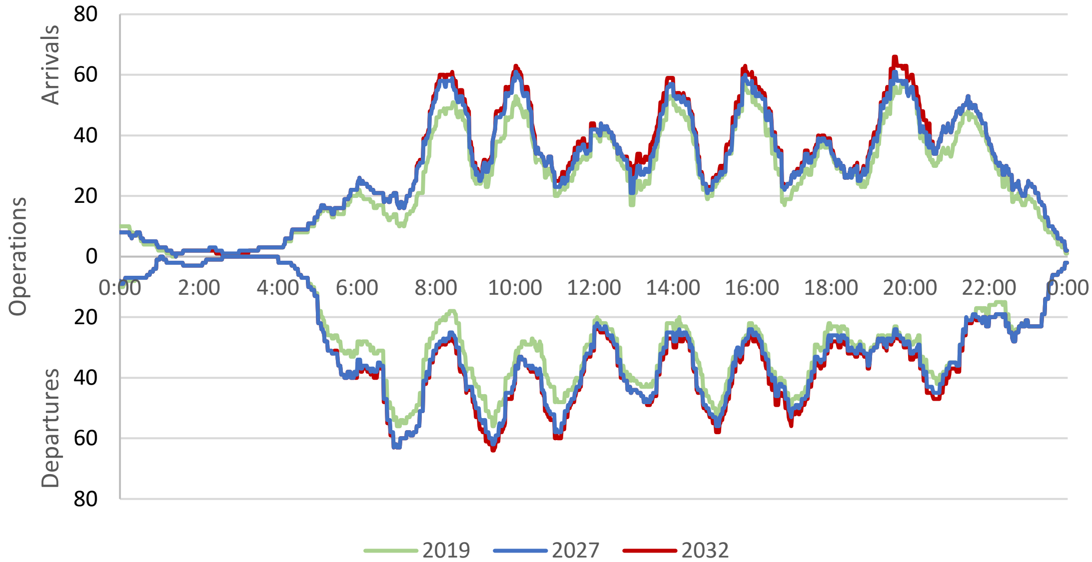
Figures 1 and 2 show the rolling hour arrival and departure profiles for the four DDFS. Figures 3 and 4 show the rolling hour total operations profiles for the four DDFS. Each of these figures also includes the base-year 2019 AAD rolling hour profiles for comparison. Table 2 presents summaries of the four DDFS.

Figure 1
Rolling Hour Profiles: No Action Design Day Flight Schedules (Arrivals and Departures)
Seattle-Tacoma International Airport



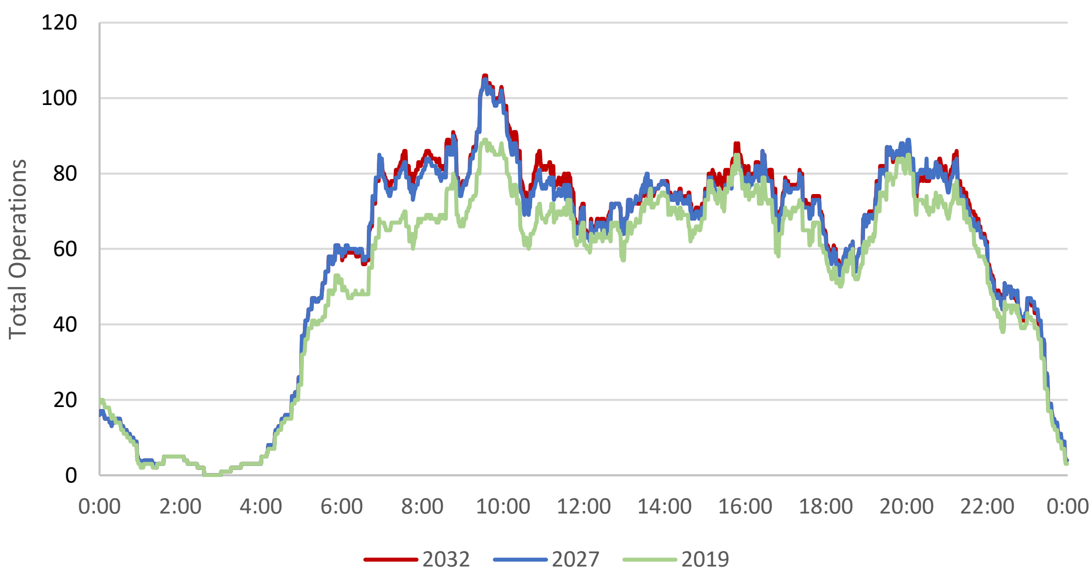
Source: LeighFisher analysis of LeighFisher AAD DDFS.

Figure 2
Rolling Hour Profiles: Proposed Action Design Day Flight Schedules (Arrivals and Departures)
Seattle-Tacoma International Airport



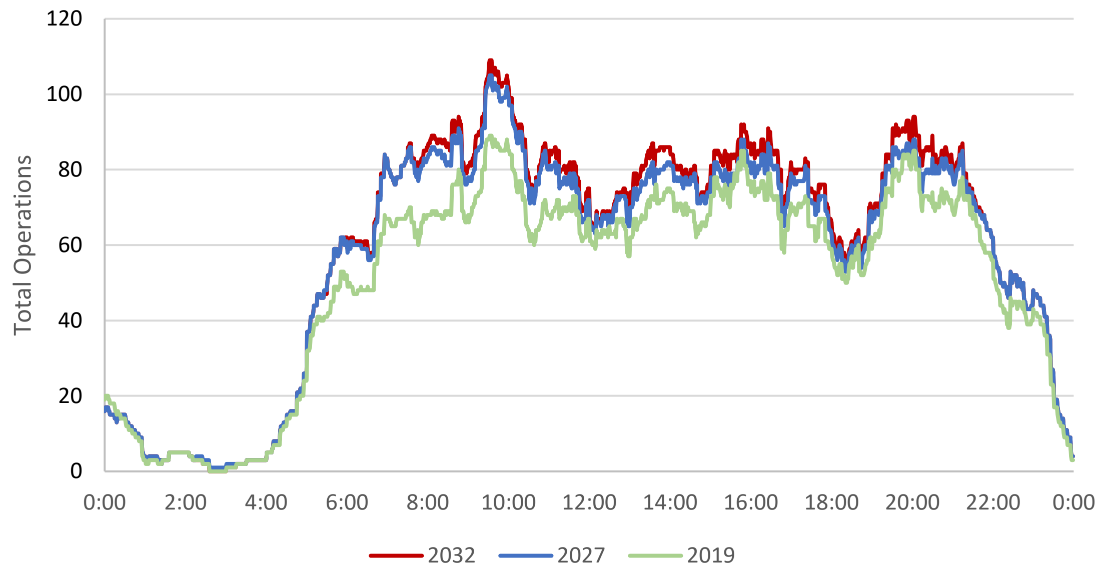
Source: LeighFisher analysis of LeighFisher AAD DDFS.

Figure 3
Rolling Hour Profiles: No Action Design Day Flight Schedules (Total Operations)
Seattle-Tacoma International Airport



Source: LeighFisher analysis of LeighFisher AAD DDFS.

Figure 4
Rolling Hour Profiles: Proposed Action Design Day Flight Schedules (Total Operations)
Seattle-Tacoma International Airport



Source: LeighFisher analysis of LeighFisher AAD DDFS.

Table 2
Summary of Design Day Flight Schedules
Seattle-Tacoma International Airport

	2027 No Action			2027 Proposed Action			2032 No Action			2032 Proposed Action		
	Arrivals	Departures	Total	Arrivals	Departures	Total	Arrivals	Departures	Total	Arrivals	Departures	Total
Operations												
DDFS Operations	684	684	1,368	693	693	1,386	696	697	1,393	718	719	1,437
Peak Hour Operations	62	63	105	62	63	106	61	63	105	66	64	109
Peak Hour Start Time	19:36	6:56	9:32	10:01	6:56	9:32	10:01	6:56	9:32	19:36	9:26	9:32
Fleet Mix												
Wide-body jet	7.3%	7.0%	7.2%	7.3%	7.0%	7.2%	7.1%	6.8%	6.9%	7.4%	7.2%	7.3%
Narrow-body jet	64.3%	64.5%	64.4%	64.1%	64.3%	64.2%	64.4%	64.5%	64.4%	64.1%	64.1%	64.1%
Regional jet	20.6%	20.6%	20.6%	21.1%	20.9%	21.0%	23.4%	23.4%	23.4%	23.5%	23.4%	23.5%
Turboprop	7.0%	7.0%	7.0%	6.9%	6.9%	6.9%	4.6%	4.6%	4.6%	4.5%	4.5%	4.5%
Propellor	0.7%	0.9%	0.8%	0.6%	0.9%	0.7%	0.6%	0.7%	0.6%	0.6%	0.8%	0.7%
Airplane Design Group												
I	0.6%	0.6%	0.6%	0.4%	0.6%	0.5%	0.4%	0.4%	0.4%	0.4%	0.6%	0.5%
II	0.4%	0.6%	0.5%	0.4%	0.6%	0.5%	0.4%	0.6%	0.5%	0.4%	0.6%	0.5%
III	90.2%	90.4%	90.3%	90.4%	90.4%	90.4%	90.6%	90.8%	90.7%	90.4%	90.3%	90.3%
IV	3.9%	3.7%	3.8%	4.0%	3.7%	3.9%	3.8%	3.5%	3.6%	3.6%	3.5%	3.5%
V	4.7%	4.7%	4.7%	4.6%	4.6%	4.6%	4.6%	4.6%	4.6%	5.0%	5.0%	5.0%
VI	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Market Segment												
Domestic	89.9%	89.6%	89.8%	89.8%	89.4%	89.7%	89.8%	89.6%	89.7%	89.4%	89.2%	89.3%
International	5.1%	5.1%	5.1%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%	5.4%	5.4%	5.4%
Precleared	5.0%	5.3%	5.1%	4.9%	5.2%	5.0%	4.9%	5.1%	5.0%	5.2%	5.4%	5.3%

Notes: Includes all AAD operations, including passenger, air cargo, and general aviation. Peak hours are based on rolling hour profiles with 1-minute intervals.

Source: LeighFisher analysis of LeighFisher AAD DDFS.

2.3 Experiment Design

The framework of the Environmental Review Airside Modeling effort was designed to enable comparison of the No Action and the Proposed Action alternatives for the DBO (2027) and the DBO + 5 years (2032). The No Action alternative included no physical improvements to the Airport from the SAMP NTP, but included projects that were recently completed or will be completed by the time the EA is complete—including the International Arrivals Facility (IAF) in Concourse A and the North Satellite Redevelopment Program (NorthSTAR). These projects were also included with the Proposed Action. The Proposed Action alternative assumed the No Action layout and the SAMP near-term projects listed in Section 1.

The effort assumed that the 2016 calibration remained valid, or that any changes in airfield operations between 2016 and 2019 were negligible[1]. Consequently, the five operating scenarios used in the previous modeling effort were retained, which are described below[2].

- South flow, Visual Meteorological Conditions (South VMC): Aircraft primarily arrive and depart from Runways 16L, 16C, and 16R. The Airport has a cloud ceiling of at least 5,000 feet and visibility of at least 5 miles.
- South flow, Marginal Meteorological Conditions (South MMC): Aircraft primarily arrive and depart from Runways 16L, 16C, and 16R. The Airport has a cloud ceiling below 5,000 feet but at least 3,000 feet or visibility less than 5 miles but at least 3 miles.
- South flow, Instrument Meteorological Conditions (South IMC): Aircraft primarily arrive and depart from Runways 16L, 16C, and 16R. The Airport has a cloud ceiling below 3,000 feet or visibility less than 3 miles.
- North flow, Visual Meteorological Conditions (North VMC): Aircraft primarily arrive and depart from Runways 34L, 34C, and 34R. The Airport has a cloud ceiling of at least 5,000 feet and visibility of at least 5 miles.
- North flow, Instrument Meteorological Conditions (North IMC): Aircraft primarily arrive and depart from Runways 34L, 34C, and 34R. The Airport has a cloud ceiling below 5,000 feet or visibility less than 5 miles.

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[1] To validate the use of the previously calibrated models, LeighFisher analyzed data from the FAA's ASPM Taxi Times Report for SEA from 2016 to 2019 to confirm historical runway use. The analysis showed that historical runway use in each of the five operating scenarios was largely consistent from 2016 to 2019. Runway use statistics from 2018 were skewed because Runway 16L-34R was minimally or not used from September 10 through November 29, 2018 due to a runway maintenance project.

[2] Per guidance from the FAA Air Traffic Control Tower (ATCT) staff at SEA during the SAMP planning process, the percentage of time that SEA operates in North flow, Marginal Meteorological Conditions is negligible. Therefore, the North MMC operating scenario was excluded from the modeling effort.

Using the Taxi Times Report from the FAA's Aviation Systems Performance Metrics (ASPM) database and hourly weather observations from the National Oceanic and Atmospheric Administration's National Climatic Data Center (NOAA NCDC), LeighFisher estimated the relative frequency of each of the five operating scenarios between January 1, 2016 and December 31, 2019. These frequencies were used to estimate composite simulated, or annualized, airfield performance using a weighted average. Table 3 presents the relative frequencies of each operating scenario.

Table 3
Relative Frequencies of Operating Scenarios
Seattle-Tacoma International Airport

Operating Scenario	Relative Frequency (%)
South VMC	37.94
South MMC	12.85
South IMC	20.05
North VMC	26.12
North IMC	3.04
TOTAL	100.00

Source: LeighFisher analysis of hourly ASPM and NOAA NCDC data, January 2016—December 2019.

LeighFisher created one model for each combination of operating scenario, demand level, and layout alternative. Thus, 20 TAAM models in total were created. The model parameters, including rules, from the pre-NEPA 2027 models were initially assumed and were adjusted as necessary to accommodate the updated airfield layouts and flight schedules.

2.4 Operational Efficiency Gains

Future changes in airfield and airspace standards, procedures, or technologies could enhance airfield performance in the future. No single standard, procedure, or technology is guaranteed at SEA, nor are the benefits to airfield capacity certain. Therefore, for simulation purposes, LeighFisher modeled enhanced airfield performance by permitting approximately a 5% increase in hourly runway throughput (generally 3-5 operations/hour) over the calibrated runway throughput, which could represent the effects of one or more future changes.

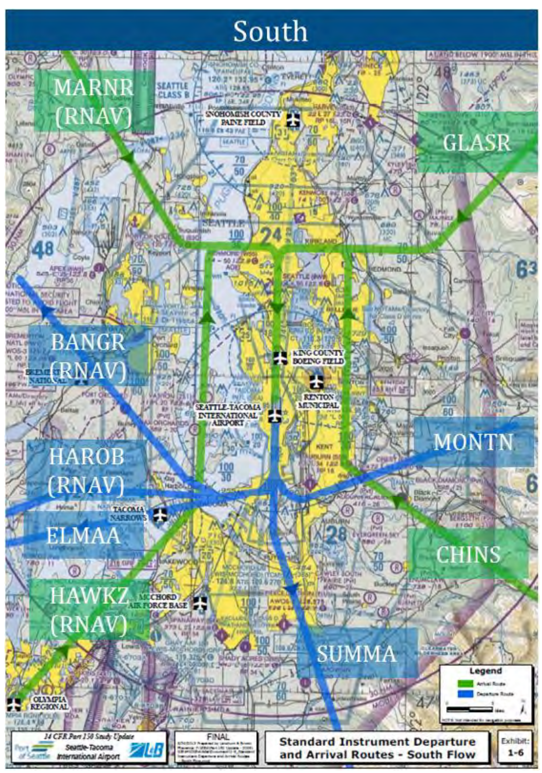
This modeling approach had been employed in the SAMP and pre-NEPA airfield simulation. It was coordinated, verified, and validated with FAA staff and was deemed appropriate for long-range planning efforts for SAMP and this modeling used for the NEPA analysis. However, this approach should not be considered replicable in subsequent airfield capacity or simulation studies without prior FAA coordination.

3 KEY INPUT ASSUMPTIONS

3.1 Airspace Structure

Airspace operations were simulated within the terminal airspace area around SEA. Outside the terminal area, simulated flights traveled directly to their destination airport or from their origin airport. Flights in the schedule were assigned to arrival fixes (Standard Terminal Arrival Routes, or STAR's) and departure fixes (Standard Instrument Departures, or SID's) based primarily on the airport of origin or destination. Four STAR's were used: MARNR for arrivals from the northwest, GLASR for arrivals from the northeast, CHINS for arrivals from the southeast, and HAWKZ for arrivals from the southwest. The SID's used included BANGR for departures to the northwest, MONTN for departures to the northeast, SUMMA for departures to the southeast, and HAROB for departures to the southwest. In South flow, the additional SID ELMAA was used for some departures to the southwest. In North flow, the additional SID's KTSAP and KMORE were used for some departures to the northwest and the northeast, respectively. The airspace routes for South flow and North flow are shown in Figures 5 and 6, respectively.

Figure 5
Simulated South Flow Arrival and Departure Routes
Seattle-Tacoma International Airport



Sources: Part 150 Noise Compatibility Study, Seattle-Tacoma International Airport (October 2013); LeighFisher analysis of published STAR's and SID's (May 2015).

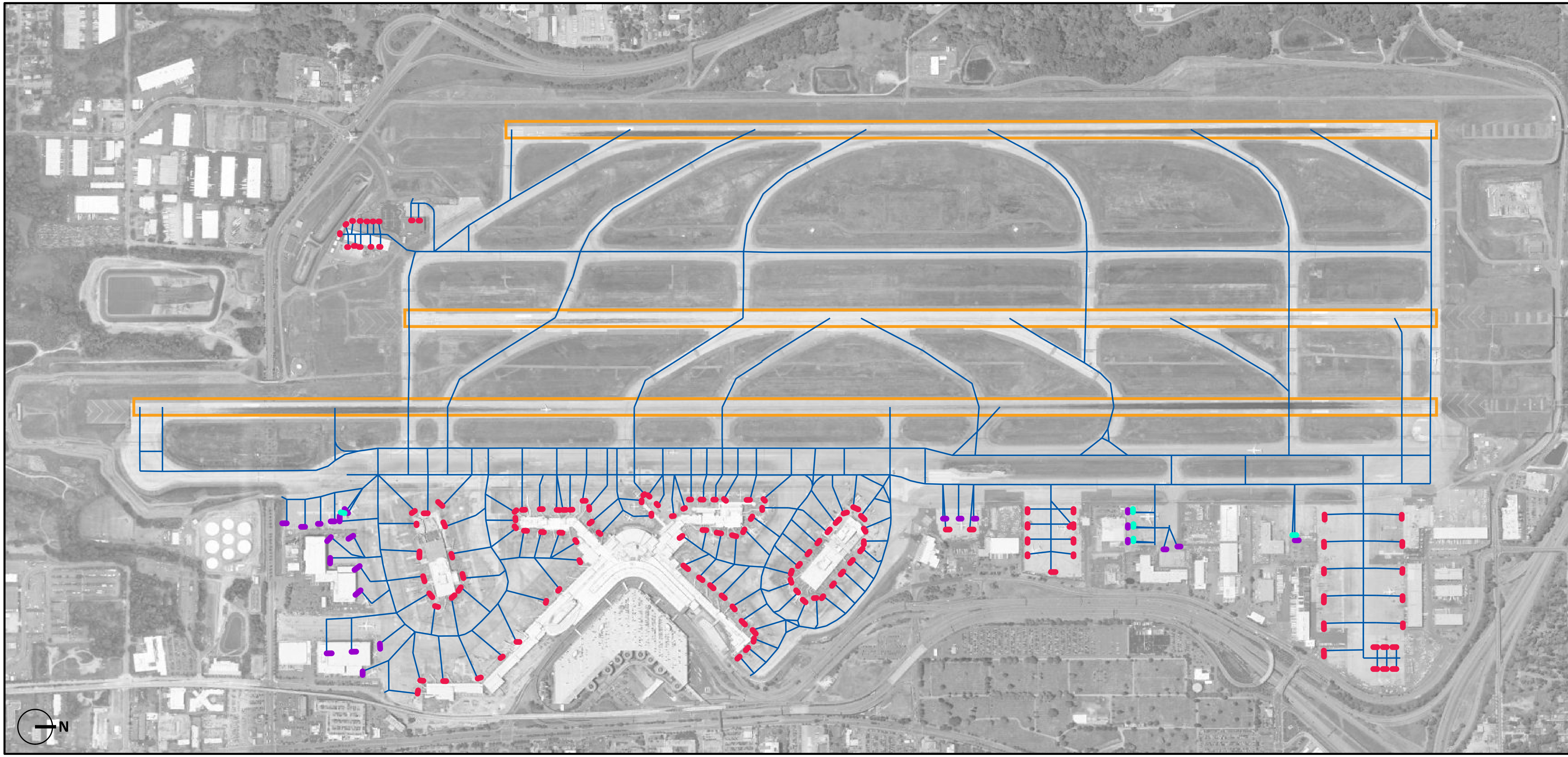
Figure 6
Simulated North Flow Arrival and Departure Routes
Seattle-Tacoma International Airport

Sources: Part 150 Noise Compatibility Study, Seattle-Tacoma International Airport (October 2013); LeighFisher analysis of published STAR's and SID's (May 2015).

Jet noise-abatement procedures confine departures to narrow corridors in both North flow and South flow. The FAA, in cooperation with the SEA Airport and local communities, established the procedures to take advantage of existing geographical and compatible land use conditions wherever possible. Both conventional (land-based) and area navigation (RNAV) SID's require all jet departures to converge on a single departure fix, regardless of the departure runway used. As a result, successive jet departures from parallel runways were dependent because jets must maintain the required separation until they could diverge onto different departure paths. Turboprop aircraft departures were exempt from passing over the single waypoint and could make an immediate, divergent turn.

3.2 Airfield Layout

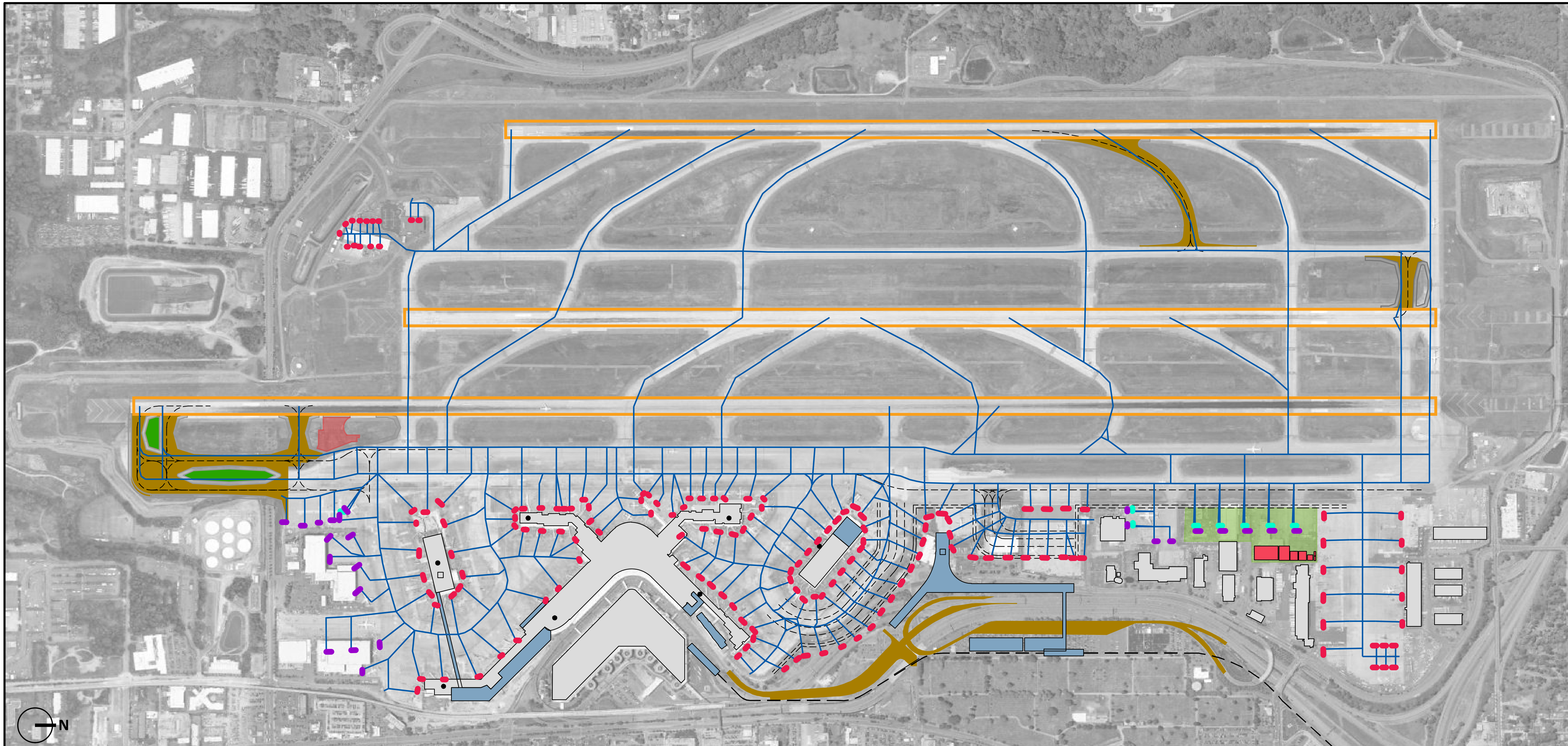
Subsequent pages depict the airfield layouts simulated in TAAM overlaid on a satellite image of SEA. Figure 7 shows the No Action layout, and Figure 8 shows the Proposed Action layout.



Gates
Long-term parking positions
Stand-off positions

Figure 7
Simulated No Action Airfield Layout
Seattle-Tacoma International Airport

TAAM layout overlay not to scale.
Source: LeighFisher; satellite imagery from Google Earth, January 2021



- Gates
- Long-term parking positions
- Stand-off positions

Figure 8
Simulated Proposed Action Airfield Layout
Seattle-Tacoma International Airport

CAD layout overlay included for reference. Received from Port of Seattle, October 2017.
TAAM layout overlay and CAD overlay not to scale.
Source: LeighFisher; satellite imagery from Google Earth, January 2021

3.3 Runway Use

Simulated aircraft were assigned to runways in TAAM based on pre-defined rules. These rules, developed during previous modeling efforts, were consistent across demand levels (2027 and 2032) and layout alternatives (No Action and Proposed Action) for each of the five operating scenarios.

Tables 4 and 5 summarize the input assumptions used for runway assignment in TAAM for the South flow and North flow models, respectively. "Heavy jet" aircraft are those which have maximum take-off weight (MTOW) capabilities of at least 300,000 pounds.

Table 4
South Flow Runway Use Input Assumptions
Seattle-Tacoma International Airport

	Arrival			Departure		
	16L	16C	16R	16L	16C	16R
VMC						
Heavy jet	75%		25%	100%		
Other			100%	40%	60%	
MMC						
Heavy jet	75%		25%	100%		
Other			100%	75%	25%	
IMC						
Heavy jet	75%		25%	100%		
Other			100%	100%		

Note: In VMC and MMC, all general aviation departures used 16C.
Source: LeighFisher, based on input from SEA ATCT staff (January 2017).

Table 5
North Flow Runway Use Input Assumptions
Seattle-Tacoma International Airport

	Arrival			Departure		
	34R	34C	34L	34R	34C	34L
VMC						
Heavy jet	75%		25%	100%		
Other			100%	100%		
IMC						
Heavy jet	25%		75%	100%		
Other			100%	100%		

Source: LeighFisher, based on input from SEA ATCT staff (January 2017).

Historically, when SEA operated in South IMC, approximately 15% of departures used Runway 16C. ATCT staff occasionally assign departures to Runway 16C in South IMC during specific operating conditions, such as a temporary closure of Runway 16L. During South IMC, ATCT staff would ordinarily avoid assigning departures to Runway 16C because it would introduce a dependency between departures on Runway 16C and arrivals on Runway 16R or Runway 16L, potentially resulting in departure delays. These conditions do not occur frequently enough to notably change the results of the overall simulation results.

Similarly, when SEA operated in North VMC, approximately 4% of departures used Runway 34C. As in South IMC, ATCT staff occasionally assign departures to Runway 34C in North VMC during specific operating conditions, such as a temporary closure of Runway 34R. During North VMC, departures on Runway 34C would not introduce a dependency with arrivals on parallel runways. However, aircraft departing from the passenger terminal and cargo areas assigned to Runway 34C would be required to cross the active Runway 34R. Departing aircraft waiting to cross Runway 34R to reach Runway 34C could block the Runway 34R departure queue, potentially resulting in departure delays.

In the South IMC and North VMC TAAM models, departures were not assigned to Runway 16C-34C primarily due to the dependency, taxiing, and queueing challenges described above. Additionally, the conditions under which ATCT might assign departures to Runway 16C-34C during South IMC or North VMC are not reliably replicated in TAAM. Specifically, TAAM is limited in its ability to make runway assignments based on conditions such as facilities closures or periods of low demand. Therefore, to avoid the risk of producing potentially misrepresentative results, departures were not assigned to Runway 16C-34C in the South IMC or North VMC models.

When an aircraft arrives on Runway 16L-34R (the inboard runway) at SEA, ATCT staff indicated that the arrival's runway occupancy time occupies the capacity to serve approximately 3-4 departures on that runway. The arrival must decelerate to taxiing speed on the inboard runway and use a distant runway exit to prevent back-taxiing on the parallel Taxiway B, resulting in high runway occupancy times and the consequent loss of departure capacity. Most arrivals on the inboard runway are heavy jet aircraft, but this loss of capacity also applies when non-heavy jets arrive on the inboard runway.

Because TAAM instantaneously selects a runway exit upon simulated arrival touchdown and adjusts its deceleration speed accordingly, it cannot simulate an aircraft traveling at taxiing speed on a runway. Therefore, the following rules were imposed when an inboard arrival occurred in the models:

- Hold the arrival at its runway exit for 100 seconds, after which it may continue taxiing
- Release the next departure on the inboard runway 120 seconds after the arrival began its hold at its exit
- Separate consecutive arrivals to the inboard runway by a minimum of 11.0 nautical miles (nmi)

The models only simulated heavy jet arrivals on the inboard runway.

3.4 Runway Dependencies

The following runway dependencies were assumed in the models:

- South VMC models
  - Visual approaches are independent of each other
  - Departures on 16L are independent of arrivals on 16R
  - Departures on 16C are independent of arrivals on 16R and 16L
  - Jet departures from 16L and 16C are fully dependent on each other
  - Mixed operations runway
    - A departure on 16L cannot begin its takeoff run if the next 16L arrival is within the capture distance of 2 nmi
    - A departure on 16L cannot begin its takeoff run until the previous arrival has cleared that runway

- South MMC models
  - Arrivals to 16L and 16R are dependent and must maintain a minimum 1.0 nmi diagonal separation
  - Departures on 16L are independent of arrivals on 16R
  - Departure on 16C are independent of arrivals on 16R and 16L (no "2-increasing-to-3" rule)
  - Jet departures from 16L and 16C are fully dependent on each other
  - Mixed operations runway
    - A departure on 16L cannot begin its takeoff run if the next 16L arrival is within the capture distance of 2 nmi
    - A departure on 16L cannot begin its takeoff run until the previous arrival has cleared that runway

- South IMC models
  - Arrivals to 16L and 16R are dependent and must maintain a minimum 1.0 nmi diagonal separation
  - Departures on 16L are independent of arrivals on 16R
  - Mixed operations runway
    - A departure on 16L cannot begin its takeoff run if the next 16L arrival is within the capture distance of 2 nmi
    - A departure on 16L cannot begin its takeoff run until the previous arrival has cleared that runway

- North VMC models
  - Visual approaches are independent of each other
  - Departures on 34R are independent of arrivals on 34L
  - Mixed operations runway
    - A departure on 34R cannot begin its takeoff run if the next 34R arrival is within the capture distance of 2 nmi

        - A departure on 34R cannot begin its takeoff run until the previous arrival has cleared that runway

- North IMC models
    - Arrivals to 34R and 34L are dependent and must maintain a minimum 1.0 nmi diagonal separation
    - Because of the adverse stagger between the two runways, departures on 34R are dependent on arrivals to 34L
        - A departure on 34R must begin its takeoff run before the next 34L arrival reaches the capture distance of 2 nmi plus the 3,401-foot runway stagger
        - A departure on 34R may begin its takeoff run after the preceding arrival on 34L has touched down
    - Mixed operations runway
        - A departure on 16L cannot begin its takeoff run if the next 16L arrival is within the capture distance of 2 nmi
        - A departure on 16L cannot begin its takeoff run until the previous arrival has cleared that runway

3.5 Taxiway Use

Figures 9 through 12 on subsequent pages depict the taxiway flow patterns that were simulated for the South flow No Action, North flow No Action, South flow Proposed Action, and North flow Proposed Action models.

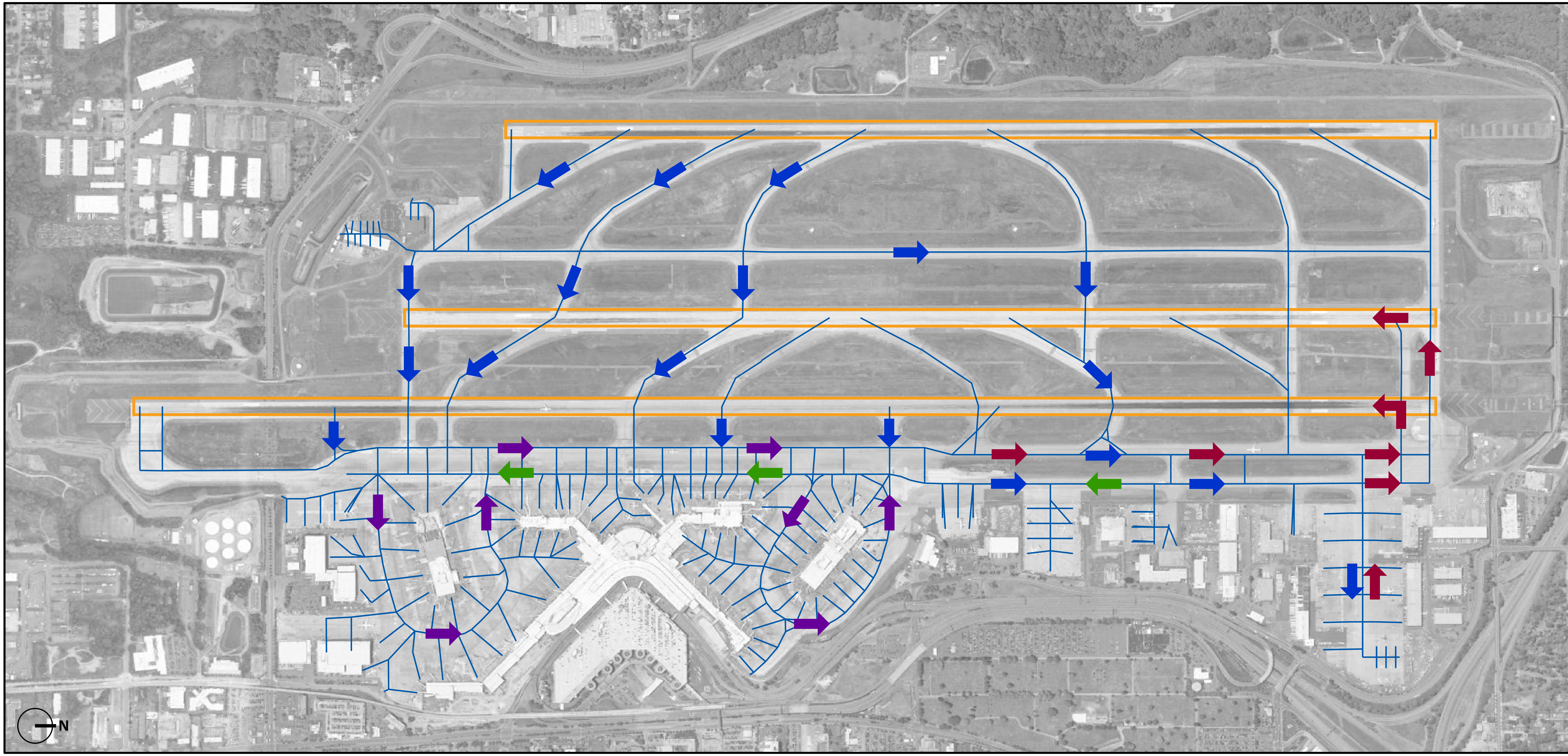
3.6 Taxiway Speeds and Restrictions

Consistent with previous modeling efforts, LeighFisher set simulated aircraft taxiing speeds according to the different airfield areas where taxiing occurs or the different types of taxiing activity. West of Runway 16L-34R, aircraft taxied at 20 knots; east of the runway, aircraft taxied at 15 knots in the movement areas and 7 knots in the non-movement (i.e., apron) areas. Aircraft pushed back from the gates at 3 knots and towed at 5 knots.

Due to required aircraft wingspan clearances from aircraft parked at adjacent gates, certain aircraft types were restricted from using Taxilane W. North of Taxiway N, aircraft with wingspans greater than 135 feet (i.e., larger than a Boeing 757-300 with winglets) were not permitted. South of Taxiway N, aircraft with wingspans greater than 167 feet (i.e., larger than a Boeing 767-300 with winglets) were not permitted. Furthermore, aircraft with a wingspan greater than 118 feet (i.e., Airplane Design Group [ADG] III) on Taxiway B cannot pass an aircraft pushing back on Taxilane W with a wingspan greater than 167 feet.

In TAAM, the “pushback time” input is defined as the time between the completion of pushback and the forward motion of an aircraft during which the tug is detached, flaps are checked, and pilots perform other pre-flight checks. For B747, B777, and B787 aircraft, the pushback time was set at 210 seconds; for other wide-body aircraft, 180 seconds; for B757 aircraft, 120 seconds; and for all other aircraft, the default value of 90 seconds.

The "runway crossing time" input is defined as the "start-up" time it takes for an aircraft before it moves forward to cross an active runway. For wide-body aircraft, the runway crossing time was set at 14 seconds; for B757 aircraft, 10 seconds; for ADG III aircraft, 6 seconds; and for smaller aircraft, 2-4 seconds.



Arrivals
Departures
Tows
Mixed operations

Figure 9
South Flow No Action Taxi Routes
Seattle-Tacoma International Airport

TAAM layout overlay not to scale.
Source: LeighFisher; satellite imagery from Google Earth, January 2021

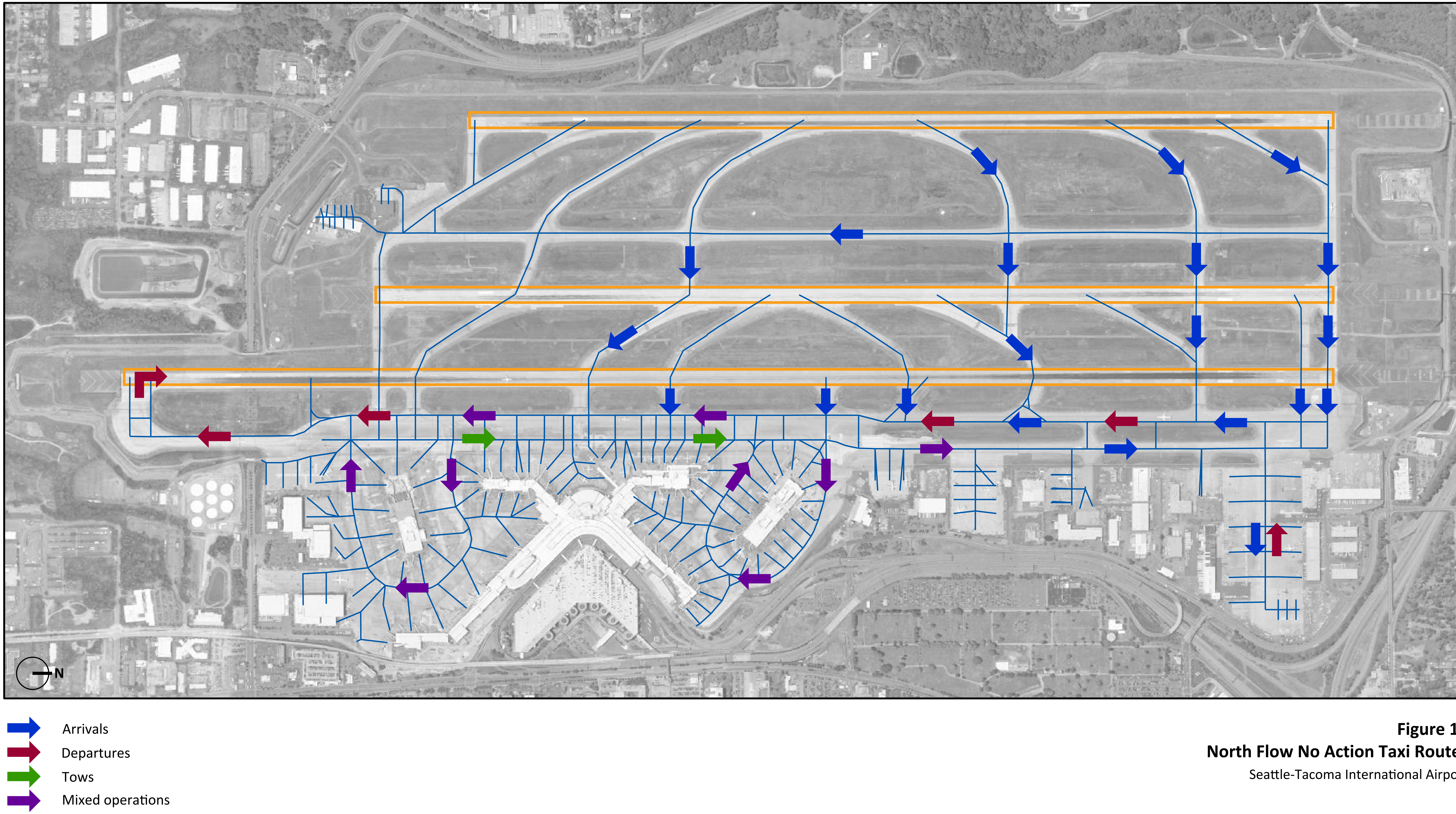
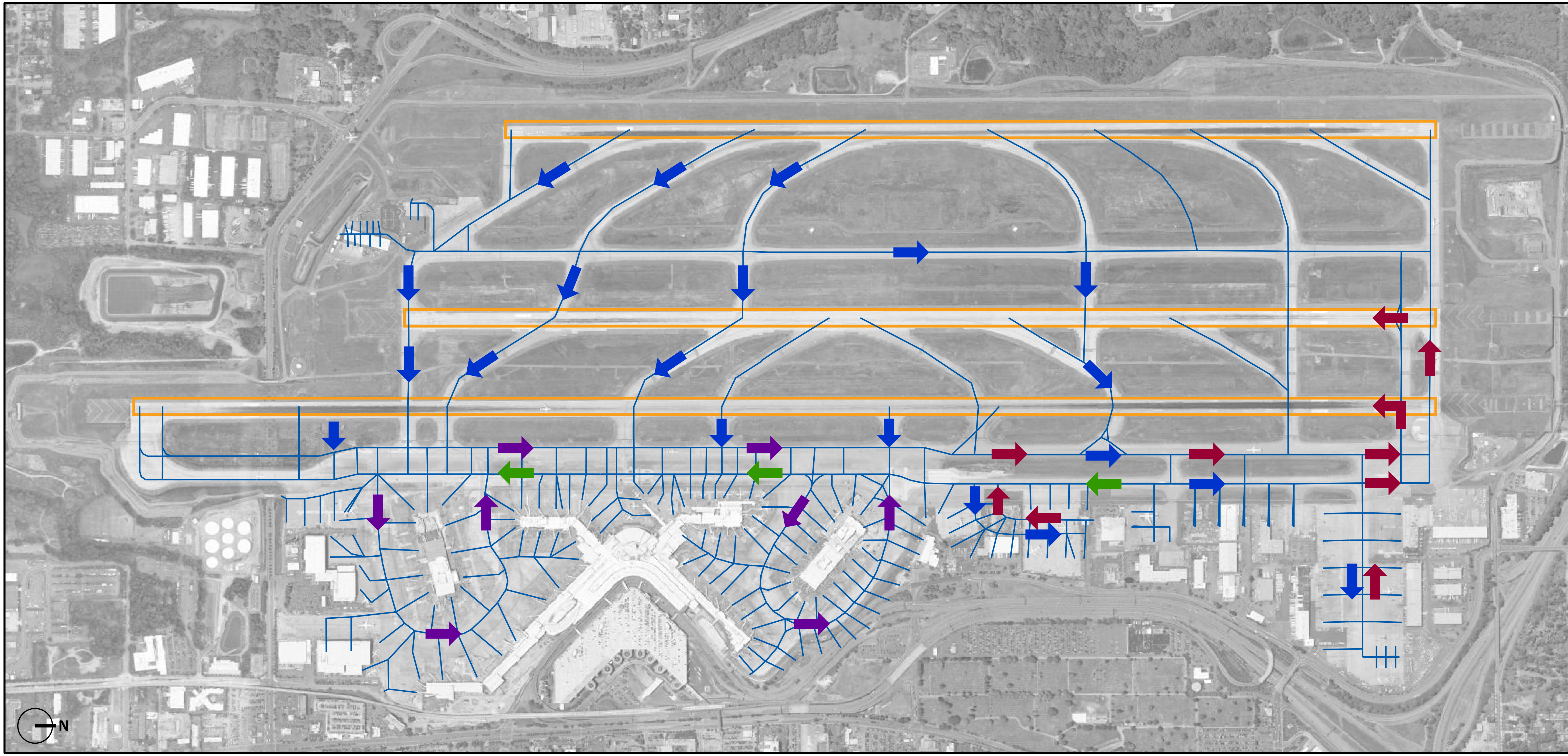


Figure 10
North Flow No Action Taxi Routes
Seattle-Tacoma International Airport

TAAM layout overlay not to scale.
Source: LeighFisher; satellite imagery from Google Earth, January 2021



Arrivals
Departures
Tows
Mixed operations

Figure 11
South Flow Proposed Action Taxi Routes
Seattle-Tacoma International Airport

TAAM layout overlay not to scale.
Source: LeighFisher; satellite imagery from Google Earth, January 2021

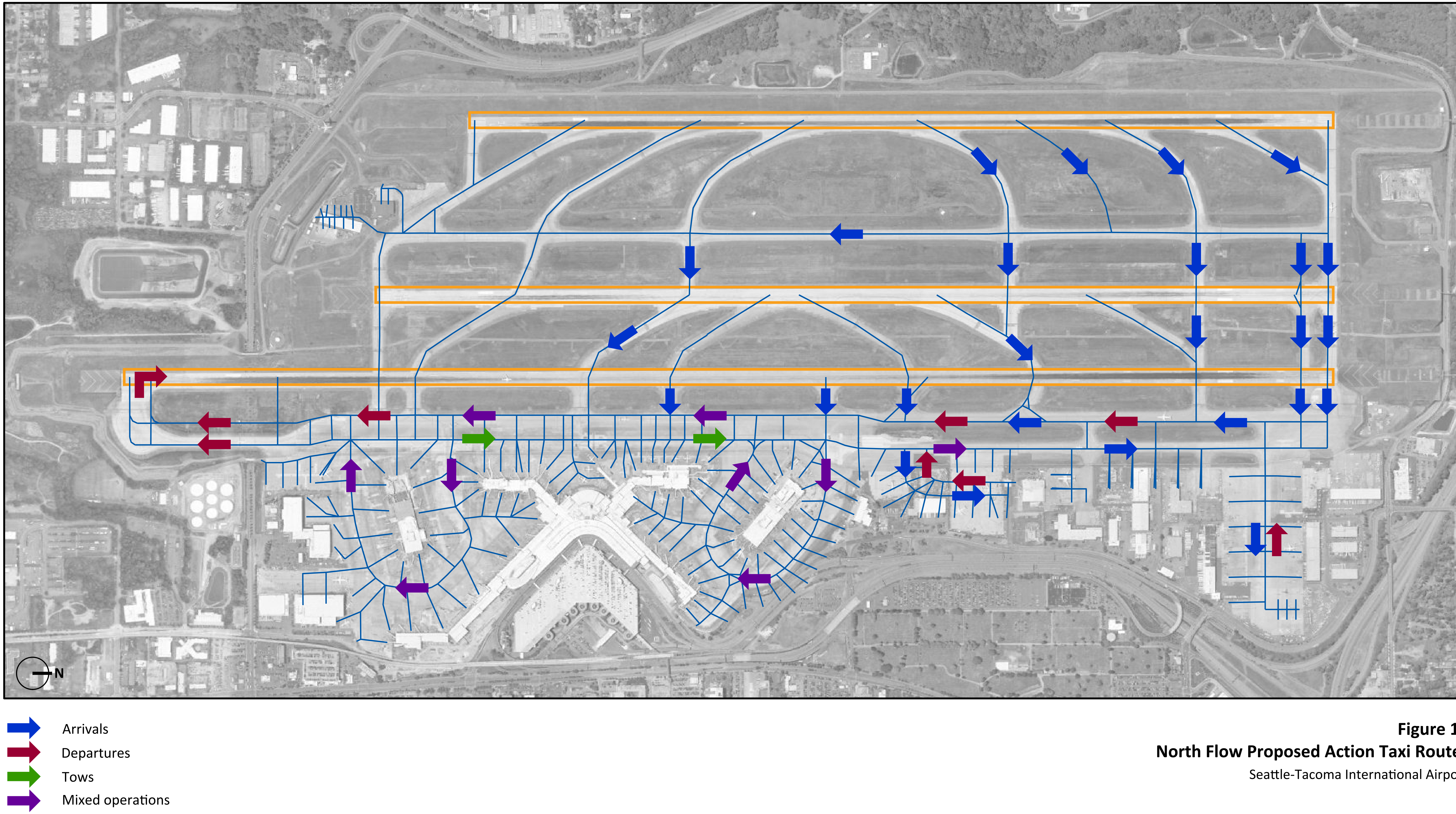


Figure 12
North Flow Proposed Action Taxi Routes
Seattle-Tacoma International Airport

TAAM layout overlay not to scale.
Source: LeighFisher; satellite imagery from Google Earth, January 2021

3.7 Departure Sequencing

TAAM contains a parameter to identify when a departing aircraft is entered into the departure queue and is sequenced for departure. If the parameter is set to "Early", an aircraft is sequenced for departure when it reaches the runway hold line or when it stops taxiing behind another aircraft which has been sequenced for departure, whichever occurs first. If the parameter is set to "At runway hold line", an aircraft is always sequenced for departure when it reaches the runway hold line. This setting primarily affects how TAAM accounts for taxi-out delay versus queueing delay.

In the Environmental Review Airside Modeling, this parameter was set to, "At runway hold line" because it was more favorable for runway crossings for arrivals. Under this setting, departure queueing delay may be underreported while taxi-out delay may be equivalently overreported.

3.8 Gate and Remote Overnight Use

Because the TAAM models simulated future years with facilities that do not yet exist, the modeling team made high-level assumptions regarding airline gate use. TAAM assigned aircraft to available gates subject to rules based on airline and/or aircraft type. These rules were informed by present-day airline allocations and size restrictions and, where appropriate, the intended users of future facilities. Tables 6 and 7 summarize the gate assignments for the No Action and the Proposed Action alternatives.

Several additional aircraft parking positions were available as remain overnight (RON) positions. In TAAM, these were used as either long-term parking positions or as stand-offs (i.e., a staging position for an arrival while it awaits a gate) at which passengers were not assumed to enplane or deplane. Table 8 lists these parking areas, how many parking positions were available at each in the No Action and Proposed Action, and which carriers were permitted to use each.

Table 6
No Action Gate Use
Seattle-Tacoma International Airport

Airline	Aircraft Class	Primary Location(s)	Secondary Location(s)	Permitted to use Non-Contact Gates
Air Canada	Narrow-body jet, turboprop	South Satellite	Gates B01—B07 (odd)	Yes
Alaska	Regional jet, turboprop	Concourse C	North Satellite; Gates D01—D05	Yes
Alaska	Narrow-body jet	North Satellite; Concourse C; Gates D01—D05	N/A	Yes
American	Narrow-body jet, regional jet	Gates D07-D11	Concourse D; Concourse C	Yes
Delta	Regional jet	Gates B09, B11, B15, B14	South Satellite; Concourse A	Yes
Delta	Narrow-body jet	Gates A01, A02, B09, B11, B15, B14; South Satellite	Concourse A	Yes
Delta	Wide-body jet	South Satellite	Concourse A	No*
Frontier	Narrow-body jet	N/A	N/A	Yes
Hawaiian	Wide-body jet	Concourse A; South Satellite	N/A	No
jetBlue	Narrow-body jet	N/A	N/A	Yes
Southwest	Narrow-body jet	Gates B04—B12 (even)	Concourse B	Yes
Spirit	Narrow-body jet	N/A	N/A	Yes
Sun Country	Narrow-body jet	N/A	N/A	Yes
United	Narrow-body jet, wide-body jet, regional jet	Gates B01—B07 (odd)	Concourse B	Yes
Foreign Flags	Narrow-body jet, wide-body jet	Concourse A (except Gates A01, A02)	South Satellite	No
Cargo Carriers	Wide-body jet, turboprop	Cargo Ramp	N/A	Yes
General Aviation	Regional jet, turboprop	FBO	N/A	No

*Note: One Delta wide-body jet was permitted to use the remote hardstands in the North IMC 2032 No Action model.

Source: LeighFisher.

Table 7
Proposed Action Gate Use
Seattle-Tacoma International Airport

Airline	Aircraft Class	Primary Location(s)	Secondary Location(s)	Permitted to use Non-Contact Gates
Air Canada	Narrow-body jet, turboprop	New Terminal	N/A	Yes
Alaska	Regional jet, turboprop	Concourse C	North Satellite; Gates D01—D05	Yes
Alaska	Narrow-body jet	North Satellite; Concourse C; Gates D01—D05	New Terminal	Yes
American	Narrow-body jet, regional jet	Gates D07-D11	Concourse D; Concourse C; New Terminal	Yes
Delta	Regional jet	Concourse B	N/A	Yes
Delta	Narrow-body jet	Concourse B; Gates A01, A02	South Satellite; Concourse A	Yes
Delta	Wide-body jet	South Satellite	Concourse A	No
Frontier	Narrow-body jet	New Terminal	N/A	Yes
Hawaiian	Wide-body jet	Concourse A; South Satellite	N/A	No
jetBlue	Narrow-body jet	New Terminal	N/A	Yes
Southwest	Narrow-body jet	New Terminal	N/A	Yes
Spirit	Narrow-body jet	New Terminal	N/A	Yes
Sun Country	Narrow-body jet	New Terminal	N/A	Yes
United	Narrow-body jet, wide-body jet, regional jet	New Terminal	N/A	Yes
Foreign Flags	Narrow-body jet, wide-body jet	Concourse A (except Gates A01, A02)	South Satellite	No
Cargo Carriers	Wide-body jet, turboprop	Cargo Ramp	N/A	Yes
General Aviation	Regional jet, turboprop	FBO	N/A	No

Source: LeighFisher.

Table 8
Remain Overnight Positions
Seattle-Tacoma International Airport

Area	Number of Positions (No Action)	Number of Positions (Proposed Action)	Permitted Air Carrier(s)
Alaska Maintenance Hangar	5 narrow-body	5 narrow-body	Alaska mainline
Delta Maintenance Hangar	4 narrow-body	4 narrow-body	Delta mainline
Cargo 7 Ramp	5 narrow-body and 1 wide-body	5 narrow-body and 1 wide-body	Any
Cargo 6 Ramp	3 narrow-body	N/A	Any
Cargo 4 Ramp	5 narrow-body	4 narrow-body	Any
Maintenance Ramp	1 wide-body	5 wide-body	Any (except foreign flags)

Source: LeighFisher.

3.9 Wake Turbulence Standards and Aircraft Separations

Controllers must maintain minimum distance-based and/or time-based radar separations between consecutive aircraft on arrival or departure paths to protect for wake turbulence. Consistent with previous modeling efforts, the minimum wake turbulence separations assumed in the models were based on FAA Order JO 7110.65W, which classified aircraft as “Heavy” (aircraft with MTOW capabilities of at least 300,000 pounds and the B757), “Large” (aircraft with MTOW capabilities between 41,000 pounds and 300,000 pounds), and “Small” (aircraft with MTOW capabilities less than 41,000 pounds). Tables 9 and 10 provide the minimum distance-based and time-based aircraft separations assumed, respectively.

Table 9
Assumed Minimum Distance-Based Aircraft Separations
Seattle-Tacoma International Airport

		Trailing Aircraft		
		Heavy	Large	Small
Leading Aircraft	Heavy	4.0 nmi	5.0 nmi	6.0 nmi
	Large	2.5 nmi	2.5 nmi	4.0 nmi
	Small	2.5 nmi	2.5 nmi	2.5 nmi

Source: Adapted from FAA Order JO 7110.65W.

Table 10
Assumed Minimum Time-Based Aircraft Separations
Seattle-Tacoma International Airport

		Trailing Aircraft		
		Heavy	Large	Small
Leading Aircraft	Heavy	90 sec	120 sec	120 sec
	Large	60 sec	60 sec	90 sec
	Small	60 sec	60 sec	60 sec

Source: Adapted from FAA Order JO 7110.65W.

Under visual conditions, controllers may grant pilots a visual approach clearance. When a pilot accepts responsibility to maintain separation under this clearance, separations tend to compress below the minimum standards. Therefore, the minimum distance-based separations in Table 11 were assumed between arrivals in the South VMC and North VMC models.

Table 11
Assumed Minimum Distance-Based Aircraft Separations (VMC)
Seattle-Tacoma International Airport

		Trailing Aircraft		
		Heavy	Large	Small
Leading Aircraft	Heavy	2.7 nmi	3.6 nmi	4.5 nmi
	Large	1.9 nmi	1.9 nmi	2.7 nmi
	Small	1.9 nmi	1.9 nmi	1.9 nmi

Source: LeighFisher analysis.

Typically, controllers add a buffer on top of the minimum radar separations to reduce the risk of an operational error. The sizes of these buffers depend on the level of air traffic control equipment, technologies, procedures, and staff experience. Buffers may also be adjusted as a means of regulating runway throughput. For this modeling effort, the ~5% operational efficiency gains were primarily simulated by reducing the buffers on top of minimum aircraft separations. Table 12 lists the buffers assumed for both distance-based and time-based separations.

Table 12
Simulated Aircraft Separation Buffers
Seattle-Tacoma International Airport

	No Action			Proposed Action		
	Operating Scenario	Distance	Time	Operating Scenario	Distance	Time
2027	South VMC	+0.7 nmi	+0.0 min*	South VMC	+0.7 nmi	+0.0 min*
	South MMC	+0.5 nmi	+0.0 min*	South MMC	+0.5 nmi	+0.0 min*
	South IMC	+0.5 nmi	+0.1 min	South IMC	+0.5 nmi	+0.1 min
	North VMC	+0.6 nmi	+0.0 min*	North VMC	+0.5 nmi	+0.0 min*
	North IMC	+1.4 nmi	+0.0 min	North IMC	+1.25 nmi	+0.0 min
	Operating Scenario	Distance	Time	Operating Scenario	Distance	Time
2032	South VMC	+0.8 nmi	+0.0 min*	South VMC	+0.7 nmi	+0.0 min*
	South MMC	+0.5 nmi	+0.0 min*	South MMC	+0.5 nmi	+0.0 min*
	South IMC	+0.6 nmi	+0.1 min	South IMC	+0.6 nmi	+0.1 min
	North VMC	+0.7 nmi	+0.0 min*	North VMC	+0.5 nmi	+0.0 min*
	North IMC	+1.4 nmi	+0.0 min	North IMC	+1.25 nmi	+0.0 min

*Note: Buffer for time-based separation behind “Light” and “Medium Light” aircraft was -0.2 min in VMC models and -0.1 min in South MMC.
Source: LeighFisher.

FAA Order JO 7110.65W was the governing document for wake turbulence separation standards at SEA at the time of previous modeling efforts. At the time of the Environmental Review Airside Modeling, the governing document for such standards at SEA was Order JO 7110.126A. These updated standards classify aircraft according to nine types (“A” through “I”) instead of three. However, for the purposes of the Environmental Review Airside Modeling, the minimum wake turbulence separations were not updated for two reasons:

1. The previous model calibration was assumed to be valid
2. Changes in wake turbulence separation standards were assumed to be included in the ~5% operational efficiency gains

Indeed, based on a comparison between the minimum distance-based separation standards for the aircraft types in the design day flight schedules under JO 7110.65W and JO 7110.126A, most of the differences between the two sets of standards result in lower minimum separation standards under JO 7110.126A. Table 13 on the following page provides a summary of this comparison.

Table 13

Comparison of Minimum Aircraft Separation Standards Between JO 7110.65W and JO 7110.126A

Seattle-Tacoma International Airport

			Follower						
			A330/A340/A350/ B747/B777/B787	A306/B767/ DC10/MD11	B757	A220/A320/ B737/DH8D	CRJ/E175	CL30/FA50	BE99/Cessna/ PA31
			Heavy B	Heavy C	Heavy E	Large F	Large G	Small H	Small I
Leader	A330/A340/A350/ B747/B777/B787	Heavy B	4 / 3	4 / 4	4 / 5	5 / 5	5 / 5	6 / 5	6 / 6
Leader	A306/B767/ DC10/MD11	Heavy C	4 / 2.5	4 / 2.5	4 / 3.5	5 / 3.5	5 / 3.5	6 / 5	6 / 6
Leader	B757	Heavy E	4 / 2.5	4 / 2.5	4 / 2.5	5 / 2.5	5 / 2.5	6 / 2.5	6 / 4
Leader	A220/A320/ B737/DH8D	Large F	2.5 / 2.5	2.5 / 2.5	2.5 / 2.5	2.5 / 2.5	2.5 / 2.5	4 / 2.5	4 / 4
Leader	CRJ/E175	Large G	2.5 / 2.5	2.5 / 2.5	2.5 / 2.5	2.5 / 2.5	2.5 / 2.5	4 / 2.5	4 / 2.5
Leader	CL30/FA50	Small H	2.5 / 2.5	2.5 / 2.5	2.5 / 2.5	2.5 / 2.5	2.5 / 2.5	2.5 / 2.5	2.5 / 2.5
Leader	BE99/Cessna/ PA31	Small I	2.5 / 2.5	2.5 / 2.5	2.5 / 2.5	2.5 / 2.5	2.5 / 2.5	2.5 / 2.5	2.5 / 2.5

Note 1: Each 2x2 sub-matrix includes the minimum required separation for a given leader-follower pair of aircraft types. The upper left entry corresponds to the minimum aircraft wake turbulence separation required under JO 7110.65W; and the bottom right entry corresponds to the separation required under JO 7110.126A. The corresponding row and column headers indicate the aircraft wake turbulence classification under the respective Orders.

Note 2: Blue-highlighted 2x2 sub-matrices correspond to aircraft types in the DDFS for which the minimum required aircraft separation is greater in JO 7110.65W than in JO 7110.126A. That is, the modeled aircraft separation is more conservative than the current standard. Red-highlighted 2x2 sub-matrices correspond to aircraft types in the DDFS for which the minimum required aircraft separation is greater in JO 7110.126A than in JO 7110.65W.

Source: LeighFisher; adapted from FAA Order JO 7110.65W and FAA Order JO 7110.126A.

4 RESULTS

The following simulation metrics were produced for the purposes of the environmental analysis:

- Annualized average taxi-in times
  - Airport-wide, separated into unimpeded and ground delay components
  - Passenger arrivals
  - Passenger arrivals using the new north terminal
  - Passenger arrivals not using the new north terminal
  - Cargo arrivals
  - General aviation arrivals

- Annualized average taxi-out times
  - Airport-wide, separated into unimpeded, taxi-out delay, and queueing delay components
  - Passenger departures
  - Passenger departures using the new north terminal
  - Passenger departures not using the new north terminal
  - Cargo departures
  - General aviation departures

- Annualized average departure gate delay

- Annualized average taxi delay for each runway end and operation type (arrival/departure)

- Flights scheduled to occur in daytime hours (7:00 AM—9:59 PM) but were simulated to occur in nighttime hours (10:00 PM—6:59 AM)

- Flights scheduled to occur in nighttime hours but were simulated to occur in daytime hours

- Flights terminated

- Simulated runway use per operation type (arrival/departure)

A "terminated" flight is a flight in the schedule which TAAM cannot successfully simulate to completion. It is not equivalent to an airline cancelation of a flight. Flight cancelations were not simulated.

4.1 2027 No Action

The subsequent eight tables summarize the results of the 2027 No Action models. Table 14 presents the average taxi-in times, taxi-out times, and departure gate delay. Table 15 presents the average taxi delay per runway end. Table 16 presents the number of flights pushed from daytime to nighttime hours, pushed from nighttime to daytime hours, and terminated. Each of these tables contains the metrics for each of the five 2027 No Action models as well as the annualized metrics. Annualization was conducted using the weights shown in Table 3 of Section 2.3. Tables 17 through 21 present the input and output runway use for each 2027 No Action model.

Table 14
2027 No Action: Average Taxi-In Times, Taxi-Out Times, and Departure Gate Delay
Seattle-Tacoma International Airport

	South VMC	South MMC	South IMC	North VMC	North IMC	Annualized
Average Taxi-In						
Overall						
Unimpeded	5.48	5.37	5.41	6.54	6.59	5.76
Ground Delay	1.70	2.32	4.40	3.52	1.63	2.80
Total	7.18	7.69	9.81	10.06	8.23	8.56
Passenger						
Overall	7.14	7.71	9.68	10.19	8.27	8.55
New Terminal	N/A	N/A	N/A	N/A	N/A	N/A
Other	7.14	7.71	9.68	10.19	8.27	8.55
Cargo	8.84	8.06	14.63	7.56	7.66	9.53
General Aviation	3.85	3.90	3.50	5.57	4.99	4.27
Average Taxi-Out						
Overall						
Unimpeded	9.18	8.85	8.94	8.05	8.13	8.76
Taxi-Out Delay	3.83	4.14	11.25	7.12	12.07	6.47
Queueing Delay	1.21	1.09	1.69	1.39	2.67	1.38
Total	14.22	14.08	21.87	16.56	22.88	16.61
Passenger						
Overall	14.50	14.29	22.29	16.45	22.82	16.80
New Terminal	N/A	N/A	N/A	N/A	N/A	N/A
Other	14.50	14.29	22.29	16.45	22.82	16.80
Cargo	7.64	8.48	12.24	19.27	24.36	12.34
General Aviation	9.04	8.82	13.73	18.14	24.49	12.80
Average Departure Gate Delay	2.22	4.49	7.85	10.18	51.14	7.27

Note: All times are given in minutes.
Source: LeighFisher, April 2020.

Table 15

2027 No Action: Average Taxi Delay Per Runway End

Seattle-Tacoma International Airport

	16L	16C	16R	34R	34C	34L
South VMC						
Arrival	1.98		1.69			
Departure	5.63	4.63				
South MMC						
Arrival	1.88		2.35			
Departure	6.07	2.59				
South IMC						
Arrival	4.82		4.38			
Departure	12.94					
North VMC						
Arrival				2.32		3.60
Departure				8.51		
North IMC						
Arrival				3.36		1.60
Departure				14.75		
Annualized						
Arrival	1.96		1.82	0.71		0.99
Departure	5.51	2.09		2.67		

Note: All times are given in minutes.
Source: LeighFisher, April 2020.

Table 16
2027 No Action: Schedule Changes
Seattle-Tacoma International Airport

	Daytime pushed to Nighttime	Nighttime pushed to Daytime	Terminations
South VMC			
Arrival	8	0	0
Departure	4	1	
South MMC			
Arrival	11	1	0
Departure	8	2	
South IMC			
Arrival	10	1	0
Departure	12	3	
North VMC			
Arrival	6	0	0
Departure	6	3	
North IMC			
Arrival	57	1	0
Departure	73	3	
Annualized			
Arrival	9.8	0.4	0.0
Departure	8.7	2.1	

Note: "Daytime" is defined as 07:00 to 21:59; "Nighttime" is defined as after 22:00 or before 06:59.
Source: LeighFisher, April 2020.

Table 17
2027 South VMC No Action: Input and Output Runway Use
Seattle-Tacoma International Airport

	Input			Output			
	Heavy	Medium	Small	Heavy	Medium	Small	Total
Arrival							
16L	75%			70%			5%
16C							
16R	25%	100%	100%	30%	100%	100%	95%
Departures							
16L	100%	40%	40%	100%	37%	33%	41%
16C		60%	60%		63%	67%	59%
16R							

Note: "Heavy" aircraft have MTOW capabilities of at least 300,000 pounds. "Medium" aircraft have MTOW capabilities of at least 41,000 pounds and less than 300,000 pounds. "Small" aircraft have MTOW capabilities of less than 41,000 pounds.
Source: LeighFisher, April 2020.

Table 18
2027 South MMC No Action: Input and Output Runway Use
Seattle-Tacoma International Airport

	Input			Output			
	Heavy	Medium	Small	Heavy	Medium	Small	Total
Arrival							
16L	75%			70%			5%
16C							
16R	25%	100%	100%	30%	100%	100%	95%
Departures							
16L	100%	75%	75%	100%	75%	33%	76%
16C		25%	25%		25%	67%	24%
16R							

Note: "Heavy" aircraft have MTOW capabilities of at least 300,000 pounds. "Medium" aircraft have MTOW capabilities of at least 41,000 pounds and less than 300,000 pounds. "Small" aircraft have MTOW capabilities of less than 41,000 pounds.
Source: LeighFisher, April 2020.

Table 19
2027 South IMC No Action: Input and Output Runway Use
Seattle-Tacoma International Airport

	Input			Output			
	Heavy	Medium	Small	Heavy	Medium	Small	Total
Arrival							
16L	75%			70%			5%
16C							
16R	25%	100%	100%	30%	100%	100%	95%
Departures							
16L	100%	100%	100%	100%	100%	100%	100%
16C							
16R							

Note: "Heavy" aircraft have MTOW capabilities of at least 300,000 pounds. "Medium" aircraft have MTOW capabilities of at least 41,000 pounds and less than 300,000 pounds. "Small" aircraft have MTOW capabilities of less than 41,000 pounds.
Source: LeighFisher, April 2020.

Table 20
2027 North VMC No Action: Input and Output Runway Use
Seattle-Tacoma International Airport

	Input			Output			
	Heavy	Medium	Small	Heavy	Medium	Small	Total
Arrival							
34R	75%			80%			6%
34C							
34L	25%	100%	100%	20%	100%	100%	94%
Departures							
34R	100%	100%	100%	100%	100%	100%	100%
34C							
34L							

Note: "Heavy" aircraft have MTOW capabilities of at least 300,000 pounds. "Medium" aircraft have MTOW capabilities of at least 41,000 pounds and less than 300,000 pounds. "Small" aircraft have MTOW capabilities of less than 41,000 pounds.
Source: LeighFisher, April 2020.

Table 21
2027 North IMC No Action: Input and Output Runway Use
Seattle-Tacoma International Airport

	Input			Output			
	Heavy	Medium	Small	Heavy	Medium	Small	Total
Arrival							
34R	25%			32%			2%
34C							
34L	75%	100%	100%	68%	100%	100%	98%
Departures							
34R	100%	100%	100%	100%	100%	100%	100%
34C							
34L							

Note: "Heavy" aircraft have MTOW capabilities of at least 300,000 pounds. "Medium" aircraft have MTOW capabilities of at least 41,000 pounds and less than 300,000 pounds. "Small" aircraft have MTOW capabilities of less than 41,000 pounds.
Source: LeighFisher, April 2020.

4.2 2027 Proposed Action

The subsequent eight tables summarize the results of the 2027 Proposed Action models. Table 22 presents the average taxi-in times, taxi-out times, and departure gate delay. Table 23 presents the average taxi delay per runway end. Table 24 presents the number of flights pushed from daytime to nighttime hours, pushed from nighttime to daytime hours, and terminated. Each of these tables contains the metrics for each of the five 2027 Proposed Action models as well as the annualized metrics. Annualization was conducted using the weights shown in Table 3 of Section 2.3. Tables 25 through 29 present the input and output runway use for each 2027 Proposed Action model.

Table 22
2027 Proposed Action: Average Taxi-In Times, Taxi-Out Times, and Departure Gate Delay
Seattle-Tacoma International Airport

	South VMC	South MMC	South IMC	North VMC	North IMC	Annualized
Average Taxi-In						
Overall						
Unimpeded	5.63	5.54	5.54	6.41	6.47	5.83
Ground Delay	1.37	2.25	3.75	3.48	1.64	2.58
Total	7.00	7.79	9.29	9.89	8.11	8.41
Passenger						
Overall	6.97	7.79	9.24	10.00	8.15	8.42
New Terminal	7.49	8.16	9.33	9.00	7.91	8.40
Other	6.86	7.71	9.22	10.20	8.21	8.42
Cargo	8.26	8.64	11.63	7.74	7.46	8.89
General Aviation	3.41	3.28	3.28	5.95	4.69	4.09
Average Taxi-Out						
Overall						
Unimpeded	8.74	8.45	8.59	8.17	8.14	8.51
Taxi-Out Delay	3.40	4.63	9.71	8.62	16.39	6.58
Queueing Delay	1.19	1.10	1.61	1.49	2.98	1.40
Total	13.34	14.18	19.90	18.28	27.51	16.49
Passenger						
Overall	13.59	14.34	20.32	18.28	27.24	16.67
New Terminal	11.49	12.39	18.99	18.54	26.79	15.42
Other	14.02	14.70	20.57	18.22	27.34	16.92
Cargo	7.41	10.91	10.42	18.23	33.51	12.08
General Aviation	9.77	9.56	11.91	18.96	34.33	13.32
Average Departure Gate Delay	2.17	6.22	5.87	4.79	48.85	5.53

Note: All times are given in minutes.
Source: LeighFisher, April 2020.

Table 23
2027 Proposed Action: Average Taxi Delay Per Runway End
Seattle-Tacoma International Airport

	16L	16C	16R	34R	34C	34L
South VMC						
Arrival	1.95		1.34			
Departure	5.09	4.34				
South MMC						
Arrival	1.89		2.27			
Departure	6.29	3.98				
South IMC						
Arrival	3.04		3.79			
Departure	11.32					
North VMC						
Arrival				2.53		3.53
Departure				10.11		
North IMC						
Arrival				3.40		1.62
Departure				19.37		
Annualized						
Arrival	1.59		1.56	0.76		0.97
Departure	5.01	2.12		3.23		

Note: All times are given in minutes.
Source: LeighFisher, April 2020.

Table 24
2027 Proposed Action: Schedule Changes
Seattle-Tacoma International Airport

	Daytime pushed to Nighttime	Nighttime pushed to Daytime	Terminations
South VMC			
Arrival	8	0	0
Departure	4	3	
South MMC			
Arrival	11	0	0
Departure	6	2	
South IMC			
Arrival	9	0	0
Departure	7	3	
North VMC			
Arrival	6	1	0
Departure	7	4	
North IMC			
Arrival	54	1	0
Departure	86	6	
Annualized			
Arrival	9.5	0.3	0.0
Departure	8.1	3.2	

Note: “Daytime” is defined as 07:00 to 21:59; “Nighttime” is defined as after 22:00 or before 06:59.
Source: LeighFisher, April 2020.

Table 25
2027 South VMC Proposed Action: Input and Output Runway Use
Seattle-Tacoma International Airport

	Input			Output			
	Heavy	Medium	Small	Heavy	Medium	Small	Total
Arrival							
16L	75%			65%			5%
16C							
16R	25%	100%	100%	35%	100%	100%	95%
Departures							
16L	100%	40%	40%	100%	37%	33%	41%
16C		60%	60%		63%	67%	59%
16R							

Note: “Heavy” aircraft have MTOW capabilities of at least 300,000 pounds. “Medium” aircraft have MTOW capabilities of at least 41,000 pounds and less than 300,000 pounds. “Small” aircraft have MTOW capabilities of less than 41,000 pounds.
Source: LeighFisher, April 2020.

Table 26
2027 South MMC Proposed Action: Input and Output Runway Use
Seattle-Tacoma International Airport

	Input			Output			
	Heavy	Medium	Small	Heavy	Medium	Small	Total
Arrival							
16L	75%			71%			5%
16C							
16R	25%	100%	100%	29%	100%	100%	95%
Departures							
16L	100%	75%	75%	100%	75%	33%	76%
16C		25%	25%		25%	67%	24%
16R							

Note: “Heavy” aircraft have MTOW capabilities of at least 300,000 pounds. “Medium” aircraft have MTOW capabilities of at least 41,000 pounds and less than 300,000 pounds. “Small” aircraft have MTOW capabilities of less than 41,000 pounds.
Source: LeighFisher, April 2020.

Table 27
2027 South IMC Proposed Action: Input and Output Runway Use
Seattle-Tacoma International Airport

	Input			Output			
	Heavy	Medium	Small	Heavy	Medium	Small	Total
Arrival							
16L	75%			71%			5%
16C							
16R	25%	100%	100%	29%	100%	100%	95%
Departures							
16L	100%	100%	100%	100%	100%	100%	100%
16C							
16R							

Note: “Heavy” aircraft have MTOW capabilities of at least 300,000 pounds. “Medium” aircraft have MTOW capabilities of at least 41,000 pounds and less than 300,000 pounds. “Small” aircraft have MTOW capabilities of less than 41,000 pounds.
Source: LeighFisher, April 2020.

Table 28
2027 North VMC Proposed Action: Input and Output Runway Use
Seattle-Tacoma International Airport

	Input			Output			
	Heavy	Medium	Small	Heavy	Medium	Small	Total
Arrival							
34R	75%			73%			5%
34C							
34L	25%	100%	100%	27%	100%	100%	95%
Departures							
34R	100%	100%	100%	100%	100%	100%	100%
34C							
34L							

Note: "Heavy" aircraft have MTOW capabilities of at least 300,000 pounds. "Medium" aircraft have MTOW capabilities of at least 41,000 pounds and less than 300,000 pounds. "Small" aircraft have MTOW capabilities of less than 41,000 pounds.
Source: LeighFisher, April 2020.

Table 29
2027 North IMC Proposed Action: Input and Output Runway Use
Seattle-Tacoma International Airport

	Input			Output			
	Heavy	Medium	Small	Heavy	Medium	Small	Total
Arrival							
34R	25%			23%			2%
34C							
34L	75%	100%	100%	77%	100%	100%	98%
Departures							
34R	100%	100%	100%	100%	100%	100%	100%
34C							
34L							

Note: "Heavy" aircraft have MTOW capabilities of at least 300,000 pounds. "Medium" aircraft have MTOW capabilities of at least 41,000 pounds and less than 300,000 pounds. "Small" aircraft have MTOW capabilities of less than 41,000 pounds.
Source: LeighFisher, April 2020.

4.3 2032 No Action

The subsequent eight tables summarize the results of the 2032 No Action models. Table 30 presents the average taxi-in times, taxi-out times, and departure gate delay. Table 31 presents the average taxi delay per runway end. Table 32 presents the number of flights pushed from daytime to nighttime hours, pushed from nighttime to daytime hours, and terminated. Each of these tables contains the metrics for each of the five

2032 No Action models as well as the annualized metrics. Annualization was conducted using the weights shown in Table 3 of Section 2.3. Tables 33 through 37 present the input and output runway use for each 2032 No Action model.

Table 30
2032 No Action: Average Taxi-In Times, Taxi-Out Times, and Departure Gate Delay
Seattle-Tacoma International Airport

	South VMC	South MMC	South IMC	North VMC	North IMC	Annualized
Average Taxi-In						
Overall						
Unimpeded	5.55	5.44	5.45	6.59	6.53	5.82
Ground Delay	1.87	2.41	4.59	3.82	1.27	2.97
Total	7.42	7.86	10.04	10.40	7.81	8.79
Passenger						
Overall	7.38	7.87	9.92	10.52	7.84	8.79
New Terminal	N/A	N/A	N/A	N/A	N/A	N/A
Other	7.38	7.87	9.92	10.52	7.84	8.79
Cargo	9.16	8.29	14.59	7.87	7.50	9.75
General Aviation	3.33	3.31	3.31	4.96	4.71	3.79
Average Taxi-Out						
Overall						
Unimpeded	9.16	8.86	8.94	8.09	8.12	8.77
Taxi-Out Delay	4.14	3.79	12.18	6.94	11.64	6.67
Queueing Delay	1.20	1.04	1.62	1.36	2.86	1.35
Total	14.50	13.69	22.74	16.39	22.63	16.79
Passenger						
Overall	14.77	13.89	23.20	16.32	22.58	16.96
New Terminal	N/A	N/A	N/A	N/A	N/A	N/A
Other	14.77	13.89	23.20	16.32	22.58	16.99
Cargo	7.53	8.33	10.97	18.63	23.77	11.71
General Aviation	9.70	10.40	13.61	14.78	23.95	12.33
Average Departure Gate Delay	2.68	4.59	11.81	10.16	46.73	8.05

Note: All times are given in minutes.
Source: LeighFisher, April 2020.

Table 31
2032 No Action: Average Taxi Delay Per Runway End
Seattle-Tacoma International Airport

	16L	16C	16R	34R	34C	34L
South VMC						
Arrival	2.27		1.85			
Departure	6.08	4.80				
South MMC						
Arrival	1.78		2.45			
Departure	5.61	2.38				
South IMC						
Arrival	4.12		4.61			
Departure	13.80					
North VMC						
Arrival				2.09		3.92
Departure				8.30		
North IMC						
Arrival				4.11		1.21
Departure				14.50		
Annualized						
Arrival	1.91		1.94	0.67		1.06
Departure	5.79	2.31		2.61		

Note: All times are given in minutes.
Source: LeighFisher, April 2020.

Table 32
2032 No Action: Schedule Changes
Seattle-Tacoma International Airport

	Daytime pushed to Nighttime	Nighttime pushed to Daytime	Terminations
South VMC			
Arrival	7	0	0
Departure	4	2	
South MMC			
Arrival	12	0	0
Departure	6	1	
South IMC			
Arrival	13	0	0
Departure	11	3	
North VMC			
Arrival	6	1	0
Departure	7	3	
North IMC			
Arrival	70	1	0
Departure	78	3	
Annualized			
Arrival	10.5	0.3	0.0
Departure	8.7	2.4	

Note: "Daytime" is defined as 07:00 to 21:59; "Nighttime" is defined as after 22:00 or before 06:59.
Source: LeighFisher, April 2020.

Table 33
2032 South VMC No Action: Input and Output Runway Use
Seattle-Tacoma International Airport

	Input			Output			
	Heavy	Medium	Small	Heavy	Medium	Small	Total
Arrival							
16L	75%			69%			5%
16C							
16R	25%	100%	100%	31%	100%	100%	95%
Departures							
16L	100%	40%	40%	100%	37%	50%	42%
16C		60%	60%		63%	50%	58%
16R							

Note: "Heavy" aircraft have MTOW capabilities of at least 300,000 pounds. "Medium" aircraft have MTOW capabilities of at least 41,000 pounds and less than 300,000 pounds. "Small" aircraft have MTOW capabilities of less than 41,000 pounds.
Source: LeighFisher, April 2020.

Table 34
2032 South MMC No Action: Input and Output Runway Use
Seattle-Tacoma International Airport

	Input			Output			
	Heavy	Medium	Small	Heavy	Medium	Small	Total
Arrival							
16L	75%			73%			5%
16C							
16R	25%	100%	100%	27%	100%	100%	95%
Departures							
16L	100%	75%	75%	100%	75%	33%	76%
16C		25%	25%		25%	67%	24%
16R							

Note: “Heavy” aircraft have MTOW capabilities of at least 300,000 pounds. “Medium” aircraft have MTOW capabilities of at least 41,000 pounds and less than 300,000 pounds. “Small” aircraft have MTOW capabilities of less than 41,000 pounds.
Source: LeighFisher, April 2020.

Table 35
2032 South IMC No Action: Input and Output Runway Use
Seattle-Tacoma International Airport

	Input			Output			
	Heavy	Medium	Small	Heavy	Medium	Small	Total
Arrival							
16L	75%			69%			5%
16C							
16R	25%	100%	100%	31%	100%	100%	95%
Departures							
16L	100%	100%	100%	100%	100%	100%	100%
16C							
16R							

Note: “Heavy” aircraft have MTOW capabilities of at least 300,000 pounds. “Medium” aircraft have MTOW capabilities of at least 41,000 pounds and less than 300,000 pounds. “Small” aircraft have MTOW capabilities of less than 41,000 pounds.
Source: LeighFisher, April 2020.

Table 36
2032 North VMC No Action: Input and Output Runway Use
Seattle-Tacoma International Airport

	Input			Output			
	Heavy	Medium	Small	Heavy	Medium	Small	Total
Arrival							
34R	75%			80%			6%
34C							
34L	25%	100%	100%	20%	100%	100%	94%
Departures							
34R	100%	100%	100%	100%	100%	100%	100%
34C							
34L							

Note: “Heavy” aircraft have MTOW capabilities of at least 300,000 pounds. “Medium” aircraft have MTOW capabilities of at least 41,000 pounds and less than 300,000 pounds. “Small” aircraft have MTOW capabilities of less than 41,000 pounds.
Source: LeighFisher, April 2020.

Table 37
2032 North IMC No Action: Input and Output Runway Use
Seattle-Tacoma International Airport

	Input			Output			
	Heavy	Medium	Small	Heavy	Medium	Small	Total
Arrival							
34R	25%			33%			2%
34C							
34L	75%	100%	100%	67%	100%	100%	98%
Departures							
34R	100%	100%	100%	100%	100%	100%	100%
34C							
34L							

Note: “Heavy” aircraft have MTOW capabilities of at least 300,000 pounds. “Medium” aircraft have MTOW capabilities of at least 41,000 pounds and less than 300,000 pounds. “Small” aircraft have MTOW capabilities of less than 41,000 pounds.
Source: LeighFisher, April 2020.

4.4 2032 Proposed Action

The subsequent eight tables summarize the results of the 2032 Proposed Action models. Table 38 presents the average taxi-in times, taxi-out times, and departure gate delay. Table 39 presents the average taxi delay per runway end. Table 40 presents the number of flights pushed from daytime to nighttime hours, pushed from nighttime to daytime hours, and terminated. Each of these tables contains the metrics for each of the five 2032 Proposed Action models as well as the annualized metrics. Annualization was conducted using the weights shown in Table 3 of Section 2.3. Tables 41 through 45 present the input and output runway use for each 2032 Proposed Action model.

Table 38
2032 Proposed Action: Average Taxi-In Times, Taxi-Out Times, and Departure Gate Delay
Seattle-Tacoma International Airport

	South VMC	South MMC	South IMC	North VMC	North IMC	Annualized
Average Taxi-In						
Overall						
Unimpeded	5.69	5.56	5.81	6.42	6.52	5.91
Ground Delay	1.78	2.20	4.50	3.90	1.61	2.93
Total	7.48	7.76	10.31	10.32	8.13	8.84
Passenger						
Overall	7.44	7.76	9.88	10.39	8.17	8.76
New Terminal	7.61	8.27	9.86	9.56	7.51	8.65
Other	7.40	7.65	9.88	10.57	8.31	8.79
Cargo	9.16	8.45	24.01	9.15	7.70	12.00
General Aviation	3.79	3.28	3.28	5.88	4.69	4.19
Average Taxi-Out						
Overall						
Unimpeded	8.74	8.46	8.53	8.15	8.22	8.50
Taxi-Out Delay	3.68	4.34	13.56	11.80	15.89	8.24
Queueing Delay	1.16	1.16	1.83	1.65	2.90	1.48
Total	13.59	13.96	23.92	16.32	27.01	18.21
Passenger						
Overall	13.81	14.18	24.24	21.43	26.78	18.33
New Terminal	11.97	11.99	22.51	21.68	28.18	17.49
Other	14.18	14.62	24.59	23.10	26.47	18.50
Cargo	8.36	8.49	16.37	21.06	32.38	15.62
General Aviation	9.13	9.51	16.24	27.13	32.28	14.04
Average Departure Gate Delay	2.58	5.66	18.73	19.56	50.99	11.28

Note: All times are given in minutes.
Source: LeighFisher, April 2020.

Table 39
2032 Proposed Action: Average Taxi Delay Per Runway End
Seattle-Tacoma International Airport

	16L	16C	16R	34R	34C	34L
South VMC						
Arrival	2.07		1.77			
Departure	5.51	4.34				
South MMC						
Arrival	2.02		2.22			
Departure	6.40	2.75				
South IMC						
Arrival	5.00		4.48			
Departure	15.38					
North VMC						
Arrival				3.34		3.94
Departure				13.45		
North IMC						
Arrival				2.22		1.60
Departure				18.79		
Annualized						
Arrival	2.05		1.85	0.94		1.08
Departure	6.00	2.00		4.08		

Note: All times are given in minutes.
Source: LeighFisher, April 2020.

Table 40
2032 Proposed Action: Schedule Changes
Seattle-Tacoma International Airport

	Daytime pushed to Nighttime	Nighttime pushed to Daytime	Terminations
South VMC			
Arrival	7	0	0
Departure	5	4	
South MMC			
Arrival	16	0	1
Departure	10	4	
South IMC			
Arrival	16	0	1
Departure	17	4	
North VMC			
Arrival	6	0	0
Departure	11	5	
North IMC			
Arrival	72	1	0
Departure	95	6	
Annualized			
Arrival	11.7	0.0	0.3
Departure	12.4	4.3	

Note: "Daytime" is defined as 07:00 to 21:59; "Nighttime" is defined as after 22:00 or before 06:59.
Source: LeighFisher, April 2020.

Table 41
2032 South VMC Proposed Action: Input and Output Runway Use
Seattle-Tacoma International Airport

	Input			Output			
	Heavy	Medium	Small	Heavy	Medium	Small	Total
Arrival							
16L	75%			72%			5%
16C							
16R	25%	100%	100%	28%	100%	100%	95%
Departures							
16L	100%	40%	40%	100%	39%	33%	43%
16C		60%	60%		61%	67%	57%
16R							

Note: "Heavy" aircraft have MTOW capabilities of at least 300,000 pounds. "Medium" aircraft have MTOW capabilities of at least 41,000 pounds and less than 300,000 pounds. "Small" aircraft have MTOW capabilities of less than 41,000 pounds.
Source: LeighFisher, April 2020.

Table 42
2032 South MMC Proposed Action: Input and Output Runway Use
Seattle-Tacoma International Airport

	Input			Output			
	Heavy	Medium	Small	Heavy	Medium	Small	Total
Arrival							
16L	75%			75%			6%
16C							
16R	25%	100%	100%	25%	100%	100%	94%
Departures							
16L	100%	75%	75%	100%	74%	22%	75%
16C		25%	25%		26%	78%	25%
16R							

Note: "Heavy" aircraft have MTOW capabilities of at least 300,000 pounds. "Medium" aircraft have MTOW capabilities of at least 41,000 pounds and less than 300,000 pounds. "Small" aircraft have MTOW capabilities of less than 41,000 pounds.
Source: LeighFisher, April 2020.

Table 43
2032 South IMC Proposed Action: Input and Output Runway Use
Seattle-Tacoma International Airport

	Input			Output			
	Heavy	Medium	Small	Heavy	Medium	Small	Total
Arrival							
16L	75%			72%			5%
16C							
16R	25%	100%	100%	28%	100%	100%	95%
Departures							
16L	100%	100%	100%	100%	100%	100%	100%
16C							
16R							

Note: "Heavy" aircraft have MTOW capabilities of at least 300,000 pounds. "Medium" aircraft have MTOW capabilities of at least 41,000 pounds and less than 300,000 pounds. "Small" aircraft have MTOW capabilities of less than 41,000 pounds.
Source: LeighFisher, April 2020.

Table 44
2032 North VMC Proposed Action: Input and Output Runway Use
Seattle-Tacoma International Airport

	Input			Output			
	Heavy	Medium	Small	Heavy	Medium	Small	Total
Arrival							
34R	75%			79%			6%
34C							
34L	25%	100%	100%	21%	100%	100%	94%
Departures							
34R	100%	100%	100%	100%	100%	100%	100%
34C							
34L							

Note: "Heavy" aircraft have MTOW capabilities of at least 300,000 pounds. "Medium" aircraft have MTOW capabilities of at least 41,000 pounds and less than 300,000 pounds. "Small" aircraft have MTOW capabilities of less than 41,000 pounds.
Source: LeighFisher, April 2020.

Table 45
2032 North IMC Proposed Action: Input and Output Runway Use
Seattle-Tacoma International Airport

	Input			Output			
	Heavy	Medium	Small	Heavy	Medium	Small	Total
Arrival							
34R	25%			22%			2%
34C							
34L	75%	100%	100%	78%	100%	100%	98%
Departures							
34R	100%	100%	100%	100%	100%	100%	100%
34C							
34L							

Note: "Heavy" aircraft have MTOW capabilities of at least 300,000 pounds. "Medium" aircraft have MTOW capabilities of at least 41,000 pounds and less than 300,000 pounds. "Small" aircraft have MTOW capabilities of less than 41,000 pounds.
Source: LeighFisher, April 2020.

5 COMPARISON OF NO ACTION AND PROPOSED ACTION

The key simulation metrics for the EA—taxi-in and taxi-out times—differ for the four scenarios simulated. Multiple factors may influence simulated taxi times, including the point-to-point taxi paths taken, the volume of aircraft taxiing, interactions between taxiing aircraft, and departure queue length limitations, among other factors. Combinations of these factors may also be dependent on each other, interacting to jointly influence taxi times.

Taxi paths taken. The Proposed Action scenario contains additional infrastructure that changes aircraft taxi flow patterns, including the new north terminal, a new high-speed exit, an additional runway crossing point, and the Taxiway A/B extension. By changing taxi flow patterns, this infrastructure affects taxi times. The effects of the new north terminal are perhaps the most influential on taxi times, as suggested by the simulated unimpeded taxi times. In all South flow models, average unimpeded taxi-in times were higher and average unimpeded taxi-out times were lower in the Proposed Action scenario. Similarly, in all North flow models, average unimpeded taxi-in times were lower and average unimpeded taxi-out times were higher in the Proposed Action scenario. These relationships are expected given the new north terminal's location relative to arrival runway exits and departure runway entrances.

Volume of aircraft taxiing. The 2027 Proposed Action models accommodated an AAD flight schedule with 25 more operations than the 2027 No Action models (approximately 1.8% more activity). The 2032 Proposed Action models accommodated an AAD flight schedule with 51 more operations than the 2032 No Action models (approximately 3.6% more activity). These increased volumes of airport demand affected the number of aircraft simultaneously taxiing on the airfield, resulting in increased interactions between taxiing aircraft.

Interactions between taxiing aircraft. If more aircraft are simultaneously taxiing on similar areas of the airfield, the likelihood of higher taxi times increases due to more frequent yielding or stopping-and-starting. Similarly, with fewer aircraft simultaneously taxiing, the likelihood of higher taxi times decreases.

Departure queue length limitations. In all models, the maximum number of aircraft permitted to simultaneously taxi for departure was limited. This was done to ensure that the physical length of the departure queue would not block aircraft gates or movement areas. A higher maximum could result in longer taxi-out times, as aircraft joining the departure queue would have more aircraft ahead of them in the queue. However, a higher maximum could also cause other effects that are not captured by taxi time statistics, such as lower gate hold times and consequently higher gate availability. The possible effects of the limits on departure queue length are evident in the North flow models, where the maximum departure queue length was higher in the Proposed Action scenario due to the Taxiway A/B extension.

Qualitatively, the Proposed Action scenario overall improves the operational flexibility of the airfield. It enables more space for aircraft in the departure queue, greater diversity in use of arrival runway exits, and lesser use of stand-off positions while an aircraft waits for a gate upon arrival. These improvements allow for the Airport to accept more hourly arrivals, possibly resulting in more aircraft taxiing on the ground simultaneously. While this is likely to increase taxi times, other effects of this increased upstream arrival capacity may not be captured by taxi time statistics, such as lower airspace delay.

6 HYBRID TERMINAL ALTERNATIVE

The EA also considered a "Hybrid Terminal" alternative in approximately the same location on the Airport as the new North Terminal in the Proposed Action. The Hybrid Terminal alternative included a different layout of the new 19 contact gates and the hardstand positions as compared to the Proposed Action. This option was not subjected to the same analysis as the Proposed Action alternative, including airfield simulation. While taxi times would likely have differed between the Proposed Action and the Hybrid Terminal alternatives, the Hybrid Terminal alternative was not simulated because the environmental and planning teams agreed it was unlikely to result in meaningful differences in the air quality and noise analyses.

TECHNICAL MEMORANDUM

AVIATION ACTIVITY FORECAST UPDATE

Seattle-Tacoma International Airport

Prepared for

Port of Seattle
Seattle, Washington

August 2019

Sustainable
Airport Master Plan
Seattle-Tacoma International Airport

CONTENTS

1.0 INTRODUCTION

The Sustainable Airport Master Plan (SAMP) forecasts for Seattle-Tacoma International Airport (SEA or the Airport) were completed in 2015 using 2014 as the base year. Since then, actual passenger traffic at SEA has exceeded the SAMP forecasts, reflecting strong economic growth, decreases in domestic airfares, airline competition, the continued development of Delta's hub, and strong growth in both origin-destination (O&D) and connecting passengers. Given faster than forecast economic and passenger traffic growth, the Port of Seattle (the Port) asked LeighFisher to review the key industry issues and trends that drive aviation activity in the Seattle Primary Area.

The objective of this technical memorandum is to:

- Review recent aviation trends at SEA for the period since the SAMP forecasts were prepared (between 2014 and 2018) and the factors contributing to faster than forecast growth
- Evaluate short-term trends in airline service based on advanced OAG schedules and input on potential changes in airline service from the Port of Seattle's airline service department
- Review the long-term trends in the SAMP forecasts, in light of economic conditions and airline industry changes
- Prepare updated forecasts of enplaned passengers, air cargo, and aircraft operations in 2027, 2032, and 2035
- Compare the 2018 updated aviation activity forecasts with the FAA's 2018 Terminal Area Forecast (TAF)

The 2018 updated aviation activity forecasts are "unconstrained" and, therefore, do not include specific assumptions about physical, regulatory, environmental or other impediments to aviation activity growth. Forecasts are presented for enplaned passengers, air cargo, and aircraft operations, including operations for passenger and all-cargo airlines and general aviation and military aircraft.

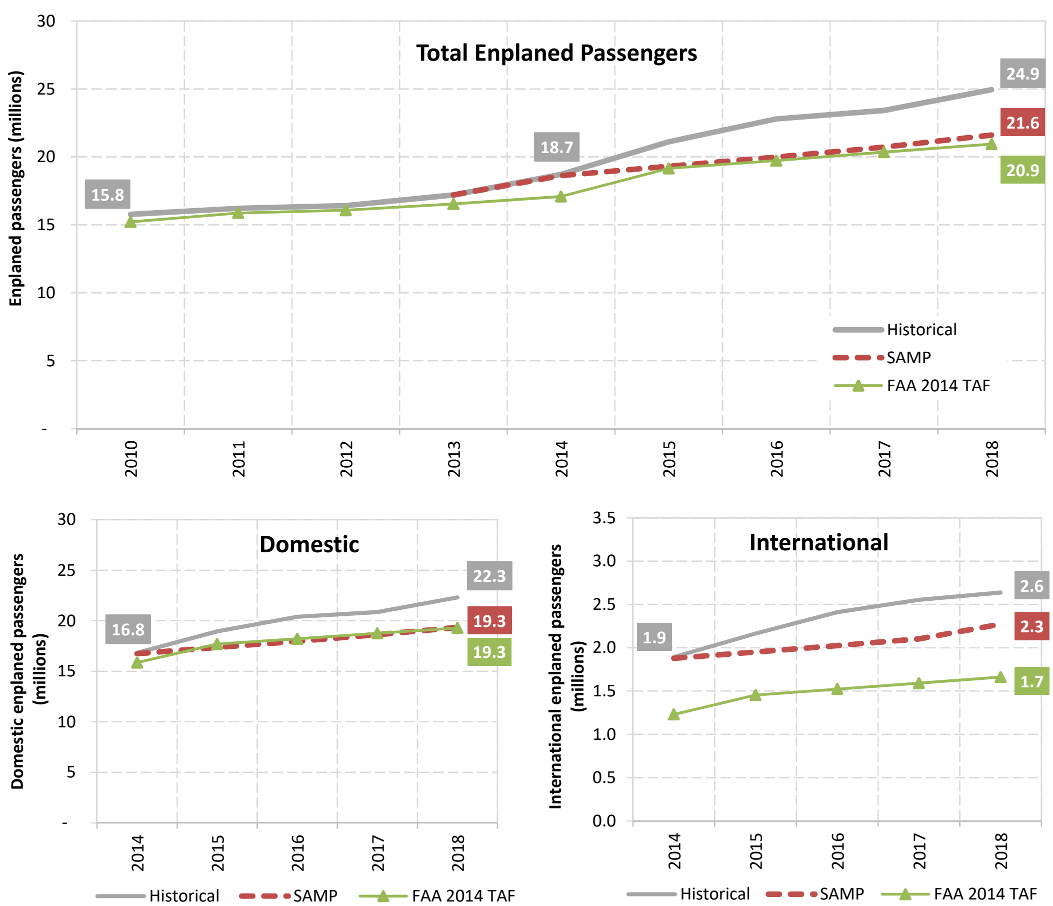
2.0 REVIEW OF RECENT AVIATION TRENDS

This section presents a review of actual and forecast aviation activity between 2014 and 2018 using the SAMP forecasts and the FAA 2014 TAF as a basis for comparison. In 2015, the FAA 2014 TAF was used to evaluate the completed SAMP forecasts. A summary of the factors contributing to faster than forecast growth since 2014 is also presented.

2.1 Enplaned Passengers

In 2018, the number of enplaned passengers totaled 24.9 million, approximately 3.3 million greater than the SAMP forecast of 21.6 million (a difference of 15%), as shown on Figure 2-1. Domestic passengers at SEA accounted for most of the increase between 2014 and 2018, although international passenger traffic increased an average of more than 8% per year during this period.

Figure 2-1
HISTORICAL AND FORECAST ENPLANED PASSENGERS: 2010-2018
Seattle-Tacoma International Airport



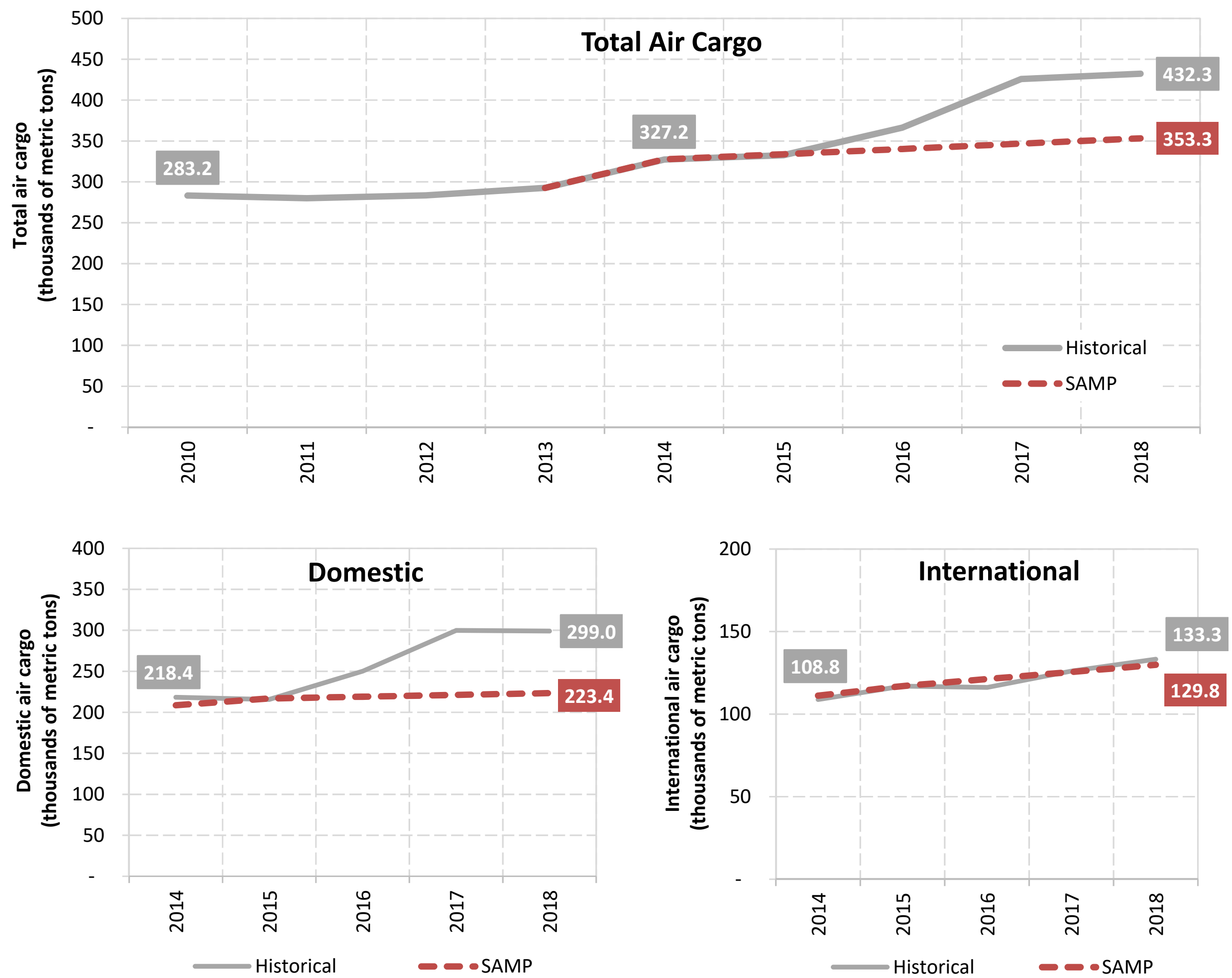
Note: Data are for domestic and international enplaned passengers.
The SEA SAMP forecasts were prepared on a calendar year basis and the FAA 2014 TAF was prepared on a U.S. government fiscal year basis (October through September) and exclude nonrevenue passengers.

Sources: *Historical*—Seattle-Tacoma International Airport records. *Forecast*—SAMP Forecast, LeighFisher, 2014. FAA 2014 Forecast, Federal Aviation Administration, www.faa.gov, accessed February 2015.

2.2 Air Cargo

In 2018, total air cargo (freight and mail) totaled 432,315 metric tons, approximately 79,000 metric tons greater than the SAMP forecast of 353,300 (a difference of 22%), as shown on Figure 2-2. Domestic air cargo at SEA accounted for most of the increase between 2014 and 2018, while international air cargo tonnage increased more slowly than forecast (a difference of 3%).

Figure 2-2
HISTORICAL AND FORECAST TOTAL AIR CARGO: 2010-2018
Seattle-Tacoma International Airport



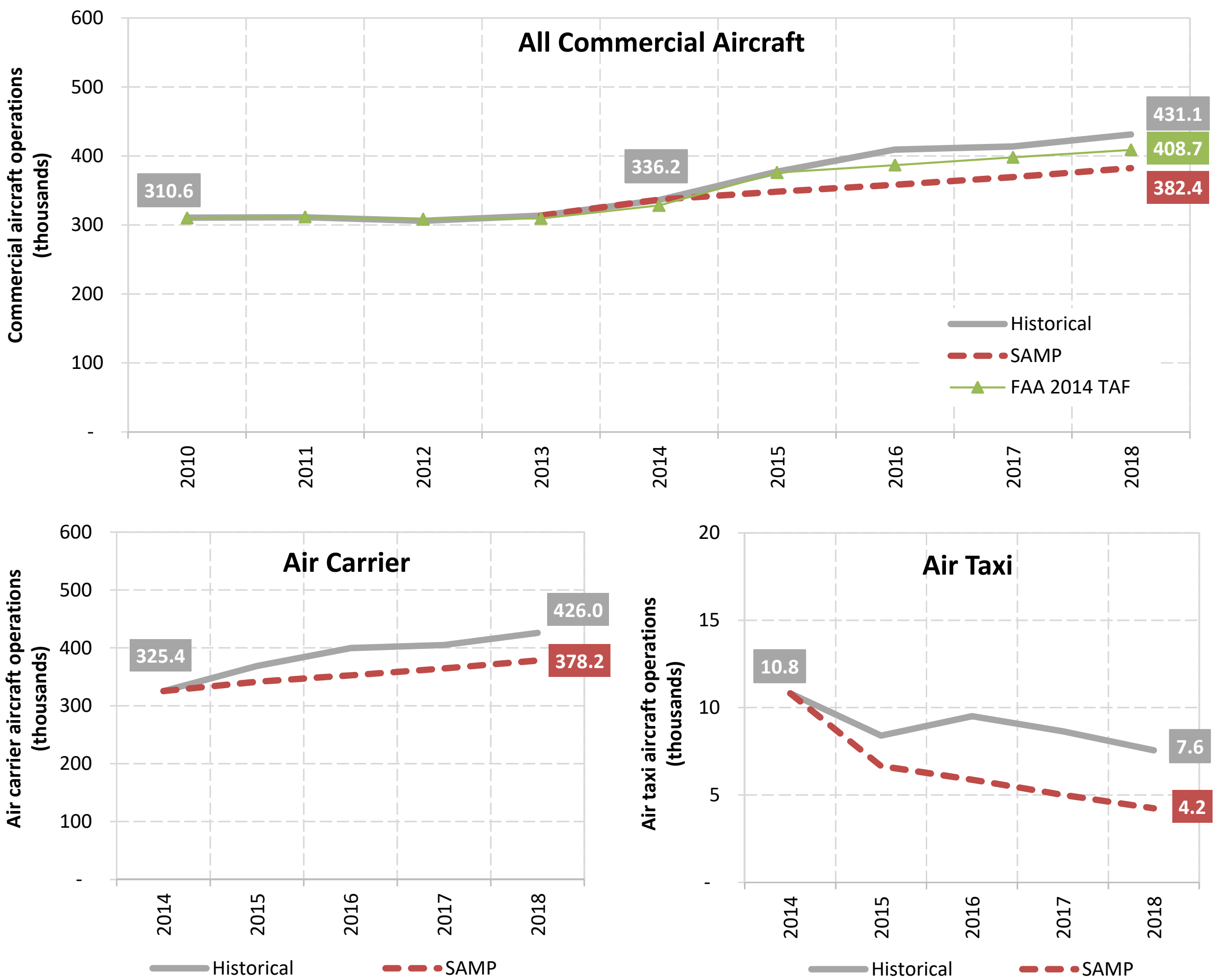
Note: Data includes enplaned and deplaned air freight and mail on domestic and international flights.

Sources: *Historical*—Seattle-Tacoma International Airport records. *Forecast*—SAMP Forecast, LeighFisher, 2014. FAA 2014 and 2017 Forecast, Federal Aviation Administration, www.faa.gov, accessed February 2015 and 2018.

2.3 Aircraft Operations

In 2018, the number of commercial aircraft operations totaled 431,137, approximately 48,700 operations greater than the SAMP forecast of 382,400 (a difference of 13%), as shown on Figure 2-3. Air carrier aircraft operations at SEA accounted for most of the increase between 2014 and 2018 and also offset the decrease in air taxi operations during this period.

Figure 2-3
HISTORICAL AND FORECAST COMMERCIAL AIRCRAFT OPERATIONS: 2010-2018
Seattle-Tacoma International Airport



Note: Data are for air carrier and air taxi and commuter operations, including passenger and all-cargo airlines and unscheduled air taxis.

Sources: *Historical*—Seattle-Tacoma International Airport records. *Forecast*—SAMP Forecast, LeighFisher, 2014.

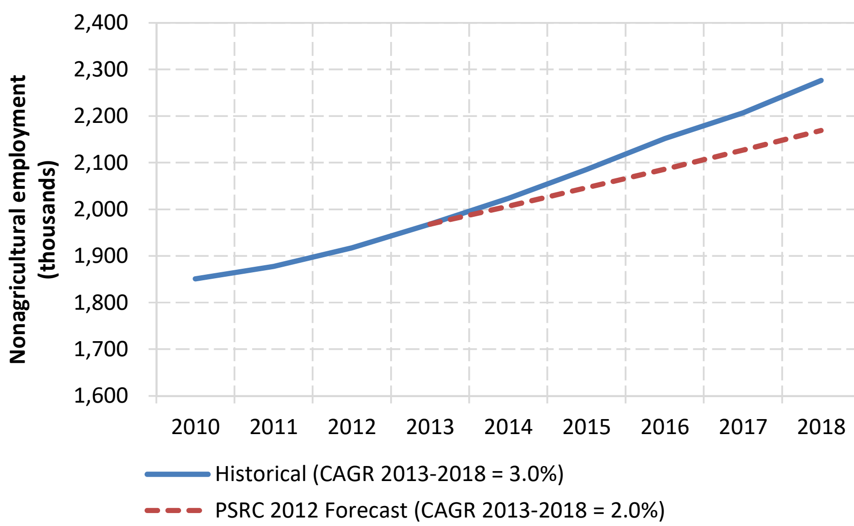
2.4 Factors Contributing to Faster than Forecast Growth

A number of factors contributed to faster than forecast growth between 2014 and 2018, including strong economic growth, decreases in domestic airfares, airline competition, the continued development of Delta's hub, and strong growth in both origin-destination (O&D) and connecting passengers.

2.4.1 Economic Growth

Strong economic growth in the Seattle Primary Area between 2014 and 2018 is reflected in the data for nonagricultural employment and per capita personal income. As shown on Figure 2-4, nonagricultural employment in the Seattle Primary Area increased an average of 3.0% per year between 2013 and 2018, faster than the 2.0% per year growth forecast by the Puget Sound Regional Council (PSRC) in its 2013 report used as a basis for the SAMP forecasts. In comparison, nonagricultural employment in the State of Washington and the United States increased an average increase of 2.8% and 1.8% per year, respectively, between 2013 and 2018. Strong growth in nonagricultural employment contributed to strong growth in passenger traffic at the Airport.

Figure 2-4
HISTORICAL AND FORECAST NONAGRICULTURAL EMPLOYMENT
Seattle Primary Area



CAGR = Compound annual growth rate

Note: The Seattle Primary Area includes King, Kitsap, Pierce, Snohomish, and Thurston counties.

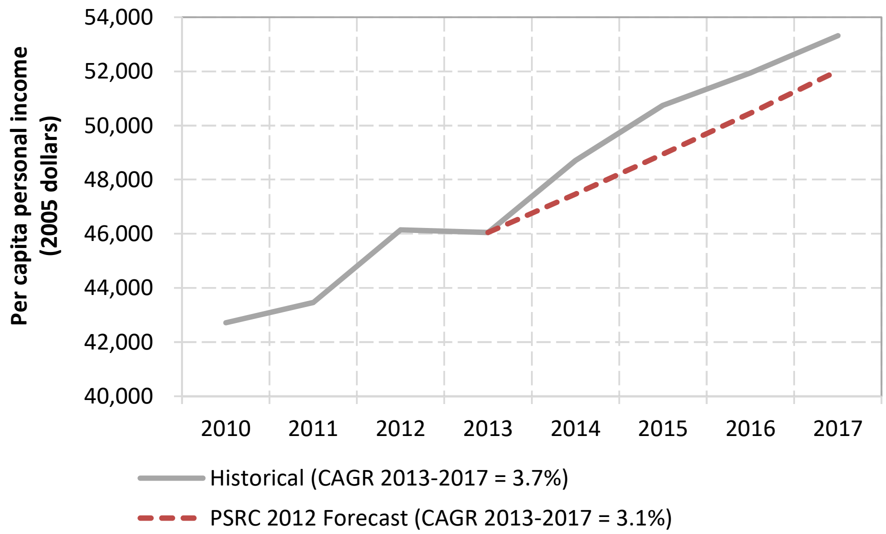
Sources: Historical— U.S. Department of Commerce, Bureau of the Census, www.census.gov, U.S. Department of Labor, Bureau of Labor Statistics, www.bls.gov, accessed January 2019. Forecast—Puget Sound Regional Council, 2012 Regional Macroeconomic Forecast, July 2013, www.psrc.org.

Unemployment rates* in the Seattle Primary Area also reflect strong economic growth since 2014, decreasing from 5.4% in 2014 to 4.0% in 2018. Unemployment rates in the State of Washington and the United States also decreased considerably between 2014 and 2018—from 6.1% to 4.5% in the State and from 6.2% to 3.9% in the nation as a whole.

*U.S. Department of Labor, Bureau of Labor Statistics, www.bls.gov, accessed January 2019. Unemployment rates are not seasonally adjusted.

Per capita personal income in the Seattle Primary Area, in 2016 dollars, increased an average of 3.7% per year between 2013 and 2017, faster than the 3.1% per year growth forecast by PRSC in its 2012 report, as shown on Figure 2-5. Per capita personal income was one of the two variables used in the econometric analysis of domestic O&D passengers used as a basis for the SAMP forecasts and is typically a key driver of passenger traffic at airports. In comparison, per capita personal income in the State of Washington and the United States increased an average increase of 3.3% and 2.3% per year, respectively, between 2013 and 2017. High average personal incomes in the Seattle Primary Area contributed to strong growth in passenger traffic at the Airport.

Figure 2-5
HISTORICAL AND FORECAST PER CAPITA PERSONAL INCOME
Seattle Primary Area



CAGR = Compound annual growth rate

Note: The Seattle Primary Area includes King, Kitsap, Pierce, Snohomish, and Thurston counties.

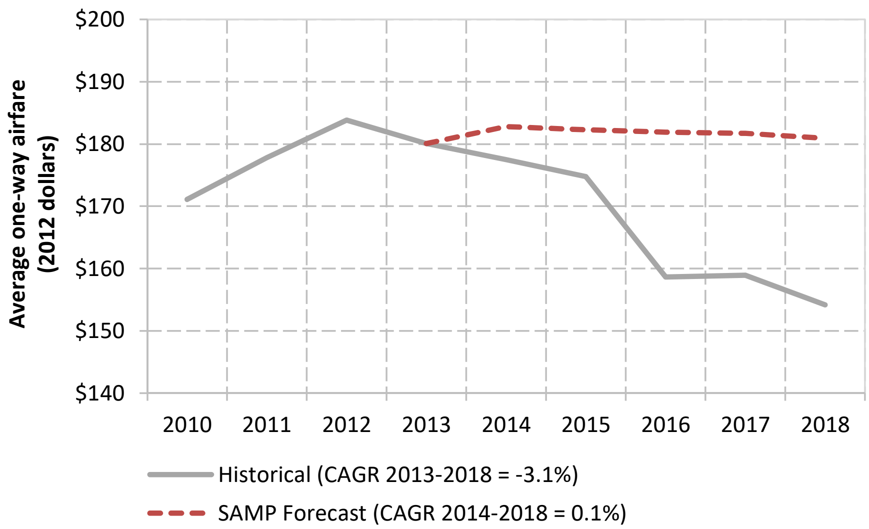
Sources: Historical—U.S. Department of Commerce, Bureau of Economic Analysis, www.bea.gov, accessed January 2019. Forecast—Puget Sound Regional Council, 2012 Regional Macroeconomic Forecast, July 2013, www.psrc.org.

2.4.2 Airfares

The cost of travel for a passenger is typically represented by airfare and airline yield data published by the U.S. Department of Transportation from its Origin-Destination Survey of Airline Passenger Traffic.* The cost of travel at SEA is represented by domestic one-way airfares, in 2016 dollars, which was one of the two variables used in the econometric analysis of domestic O&D passengers for the SAMP forecasts. As shown on Figure 2-6, SEA domestic airfares, in 2016 dollars, decreased an average of 3.1% per year, between 2013 and 2018, compared with a forecast increase of 0.1% per year based on the FAA's forecast of airline yield in its 2012 National Aerospace report. Passenger traffic and the cost of travel are inversely related; that is, passenger traffic typically increases in response to a decrease in airfares. Therefore, continued decreases in average airfares at the Airport contributed to strong passenger traffic growth between 2013 and 2018.

*Represents a 10% sample of all tickets issued by U.S. airlines.

Figure 2-6
HISTORICAL AND FORECAST DOMESTIC AIRFARES
Seattle-Tacoma International Airport



CAGR = Compound annual growth rate

Note: Airfare data for 2018 are for the first quarter.

Sources: Historical—U.S. Department of Transportation, Origin-Destination Survey of Airline Traffic, Domestic, online database, accessed January 2019. Forecast—Federal Aviation Administration, FAA Aerospace Forecast, Fiscal Years 2018-2038, March 2018, www.faa.gov.

2.4.3 Airline Competition

In 2013, Delta increased the number of scheduled departing seats at SEA by 15% (a total of 321,000 additional seats), marking the beginning of its hub development at the Airport. In response, Alaska provided an additional 400,000 scheduled departing seats in 2013. Between 2013 and 2018, the total number of scheduled departing seats at the Airport increased an average of 7.7% per year as Delta continued to develop its hub at SEA and Alaska competed with Delta's new service. Strong growth in seats during this 5-year period reflects average annual increases of 6.0% by Alaska, 22.6% by Delta, and 3.2% by all other airlines at SEA.

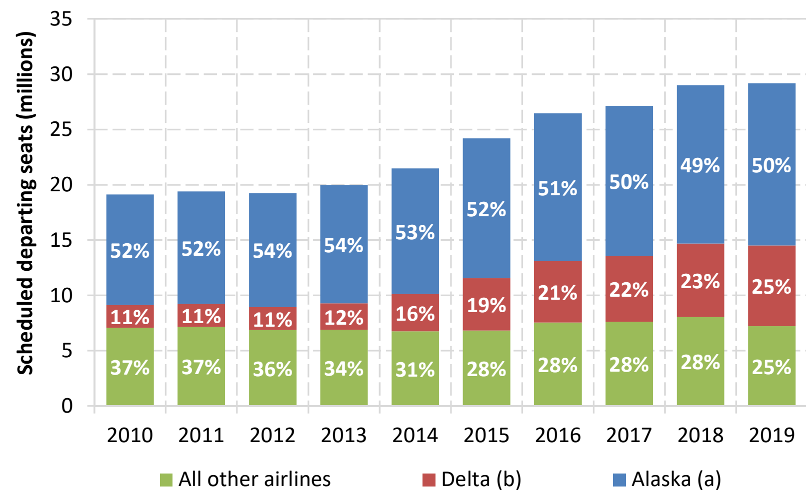
As shown on Figure 2-7, Alaska's share of total departing seats decreased from 54% in 2013 to 49% in 2018, while Delta's share nearly doubled—from 12% in 2013 to 23% in 2018. In 2019, the growth in scheduled departing seats at the Airport is expected to slow based on advance published schedules (an increase of about 1%).

2.4.4 Delta Hub Development

In 2013, Delta provided service from the Airport to a total of 16 destinations, including 9 domestic (7 Delta connecting hubs and 2 leisure destinations) and 7 international, as shown on Figure 2-8. Between 2013 and 2018, Delta added service to 33 domestic destinations for a total of 42 domestic destinations served in 2018, while Delta's international destinations served at the Airport doubled—from 7 in 2013 to 14 in 2018.

In 2019, based on advance published schedules, Delta is expected to serve approximately the same number of destinations from the Airport and provide an additional 660,000 scheduled departing seats (an increase of 10% between 2018 and 2019).

Figure 2-7
SCHEDULED DEPARTING SEATS: 2010-2019
Seattle-Tacoma International Airport

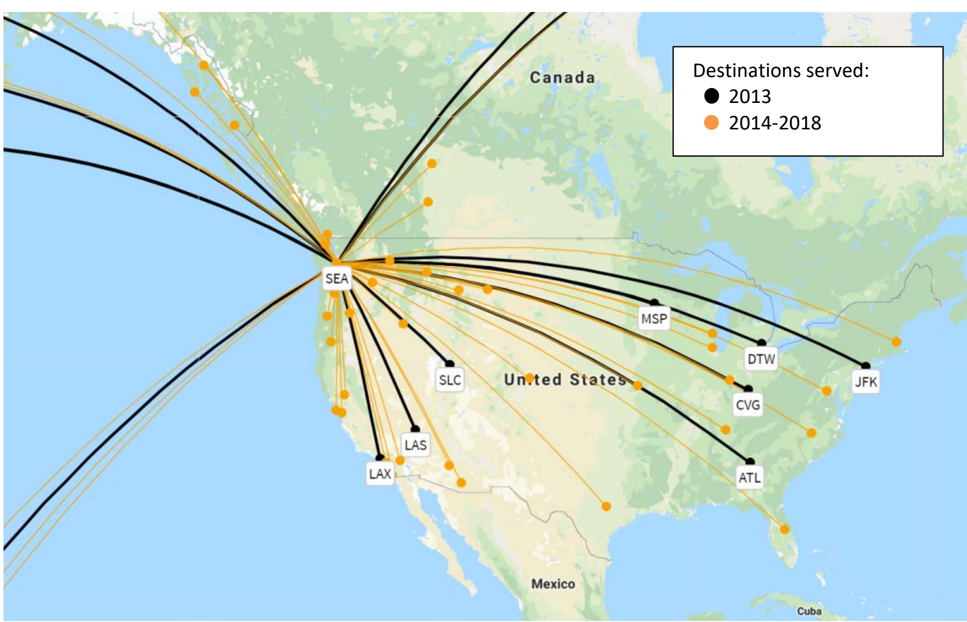


(a) Includes Virgin America (in 2010 through April 2018); Alaska merged with Virgin America in December 2016, received a single operating certificate from the FAA in January 2018 and moved to a single reservations system and rebranded as Alaska Airlines in April 2018.

(b) Includes Northwest Airlines (in 2010); Northwest merged with Delta in 2009.

Source: OAG Aviation Worldwide Ltd, OAG Analyser database, accessed January 2019. Advance airline schedules for 2019 are subject to change.

Figure 2-8
DELTA'S HUB DEVELOPMENT: 2013-2018
Seattle-Tacoma International Airport



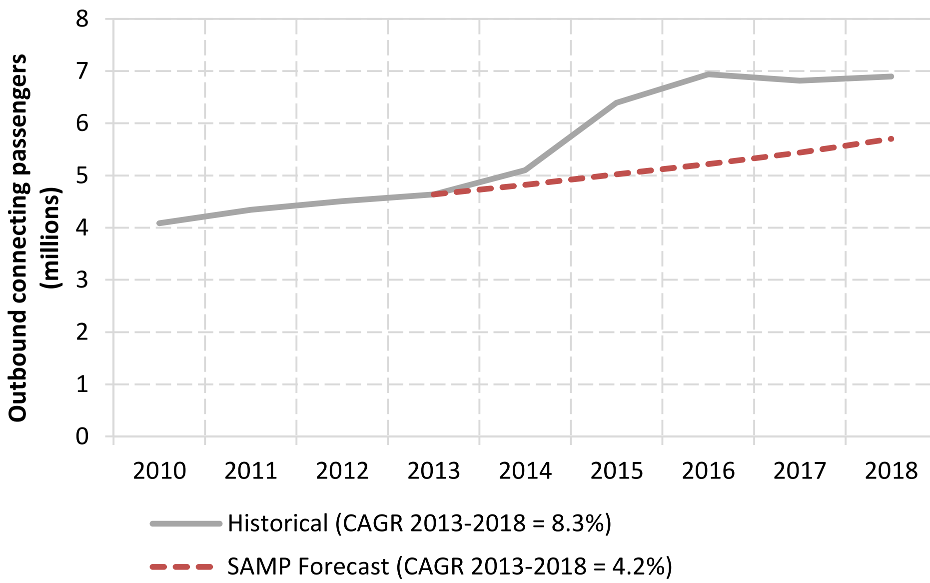
Note: Advance schedules are subject to change. International destinations, except Canada, are not shown.

Source: OAG Aviation Worldwide Ltd, OAG Mapper, accessed August 2018.

2.4.5 O&D and Connecting Passengers

Between 2013 and 2018, the number of outbound connecting passengers at SEA increased an average of 8.3% per year, nearly double the forecast growth rate of 4.2% per year in the SAMP forecast, as shown on Figure 2-9. Strong growth in connecting passengers reflects the continued development of Delta's hub at SEA. The percent of connecting passenger increased from 26% in 2014 to a high of 30% in 2015 and 2016 and moderated to 28% in 2018.

Figure 2-9
HISTORICAL AND FORECAST CONNECTING PASSENGERS: 2010-2018
Seattle-Tacoma International Airport



CAGR = Compound annual growth rate

Note: Data for 2018 are estimated based on data for January through June.

Source: Historical—U.S. Department of Transportation, Origin-Destination Survey of Airline Traffic, Domestic, online database, accessed January 2019. Forecast— LeighFisher, based on available data through September 2014.

3.0 UPDATED AVIATION ACTIVITY FORECASTS

This section presents updated forecasts of aviation activity at SEA for 2027 and 2035, including enplaned passengers, air cargo, and aircraft operations. The year 2027 was used to represent the "opening year" for the SAMP Near-Term Projects (in particular, the proposed north terminal); the year 2035 was used to encompass a 2032 "build plus 5 year" scenario for environmental analysis plus a buffer of 3 additional years. As discussed earlier, the forecasts presented in this memorandum are "unconstrained" and, therefore, do not include specific assumptions about physical, regulatory, environmental or other impediments to aviation activity growth.

3.1 Approach

A hybrid approach was used to develop the 2018 aviation activity forecast update for SEA based on the FAA 2018 TAF, a January 2018 Air Cargo Study, and bottom-up forecasts of commercial aircraft operations based on local factors, as outlined below.

- **FAA 2018 TAF of SEA Enplaned Passengers.** The FAA 2018 TAF, published in February 2019, provides an updated view of historical and forecast SEA enplaned passengers since the 2012 ADP forecast was prepared. The Port and the FAA agreed that the FAA 2018 TAF is appropriate to use for the purposes of environmental analysis as an approved third-party forecast. Therefore, based on this agreement and a review of recent aviation trends presented in Section 2.0, the FAA 2018 TAF will be used as the "preferred" enplaned passenger forecast in this memorandum.

- **Air Cargo Forecasts.** Air cargo forecasts prepared in January 2018 will provide an updated basis for developing cargo airline operation forecasts.* (Air cargo forecasts are not developed for the FAA TAF.) As discussed in Section 2.0, the growth in actual total air cargo at SEA exceeded the 2012 ADP forecast. In response to that growth, the Port commissioned air cargo industry experts to prepare a comprehensive air cargo market study. Completed in 2018, the study provides a market view of current conditions and a forecast based on expected industry trends and local factors and is therefore used as a basis for forecasting air cargo airline operations in this memorandum.

- **Local Profile Forecasts of Commercial Aircraft Operations.** Forecasts of commercial aircraft operations are prepared based on a bottom-up review of load factor, average seats per operation, air cargo tonnage per operation, and airline fleets and aircraft orders. Although the FAA 2018 TAF provides forecasts of SEA's commercial aircraft operations (air carrier and air taxi), the Port desired to use local factors for these assumptions and recent trends at SEA. FAA agreed with this approach.

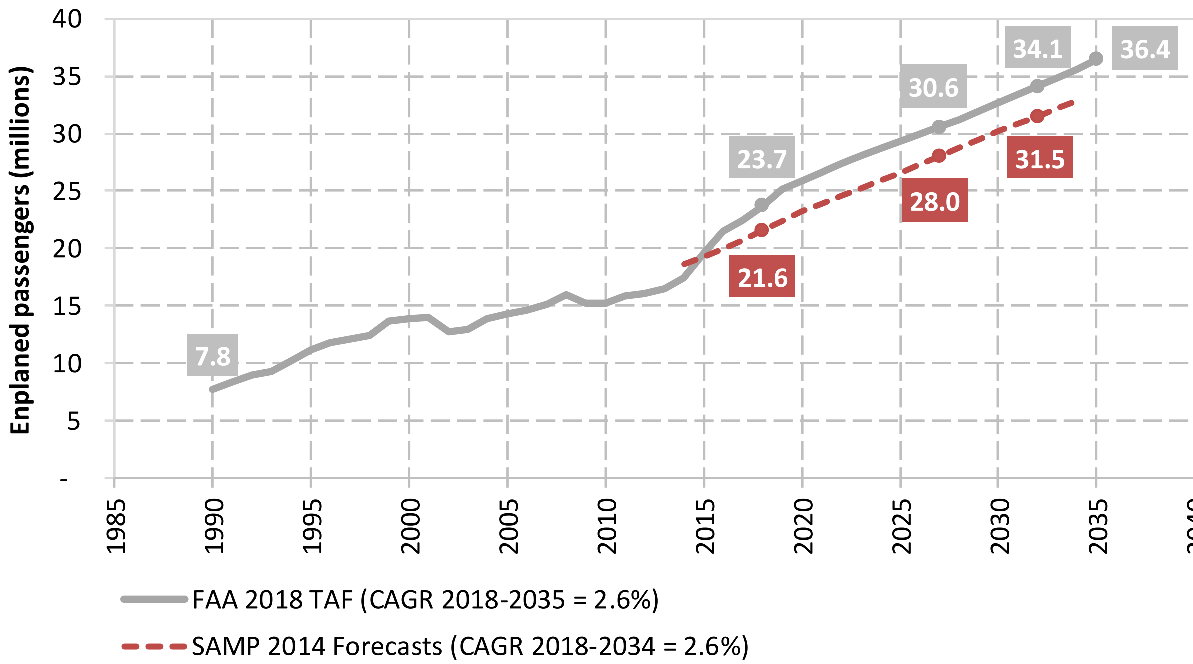
- **FAA 2018 TAF of General Aviation and Military Aircraft Operations.** In 2018, general aviation and military operations together accounted for 0.6% of total aircraft operations at the Airport. Given their relatively small share of SEA's total operations, it was considered appropriate to use the FAA 2018 TAF for forecasts of general aviation and military operations.

* Logistics, Capital & Strategy, Air Cargo Growth Potential and Facility Requirements Assessment, Seattle-Tacoma International Airport, January 31, 2018.

3.2 Enplaned Passengers

As shown on Figure 3-1 and in Table 3-1, based on the FAA 2018 TAF, the number of enplaned passengers at the Airport is forecast to increase from 24.9 million in 2018 to 30.6 million in 2027, 34.1 million in 2032, and 36.4 million in 2035 in the updated forecast. SEA enplaned passengers are forecast to increase an average of 2.9% per year between 2018 and 2027 and an average of 2.2% per year between 2027 and 2035. Domestic passengers are forecast to increase an average of 2.8% per year between 2018 and 2027 and 2.1% per year between 2027 and 2035. Stronger growth is forecast for international passengers—an average increase of 3.7% per year between 2018 and 2027 and 2.2% per year between 2027 and 2035.

Figure 3-1
HISTORICAL AND FORECAST ENPLANED PASSENGERS: 1990-2035
Seattle-Tacoma International Airport



CAGR = Compound annual growth rate

Note: Data are for domestic and international enplaned passengers for Federal Fiscal Years ended September 30 except for the SAMP Forecasts.

Sources: SAMP Forecast, LeighFisher, 2014. Federal Aviation Administration, FAA 2018 TAF, www.faa.gov, accessed February 2019.

Table 3-1
AVIATION ACTIVITY FORECASTS
Seattle-Tacoma International Airport

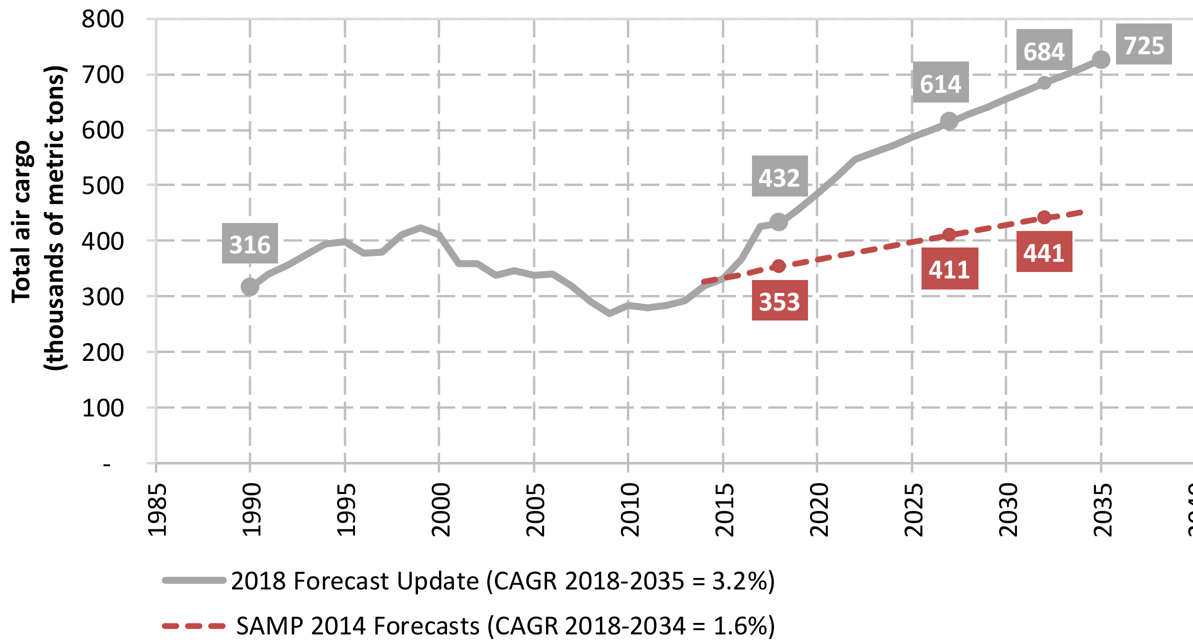
	Historical	Forecast			Compound annual percent increase (decrease)			
	2018	2027	2032	2035	2018-2027	2027-2032	2032-2035	2018-2035
Enplaned passengers								
Domestic								
Air carrier	17,747,944	22,771,303	25,198,453	26,826,986	2.8%	2.0%	2.1%	2.5%
Commuter	3,348,894	4,186,916	4,658,612	4,969,581	2.5	2.2	2.2	2.3
Domestic total	21,096,838	26,958,219	29,857,065	31,796,567	2.8	2.1	2.1	2.4
International								
Air carrier	1,949,470	2,799,856	3,383,006	3,735,415	4.1	3.7	3.4	3.9
Commuter	654,140	799,948	857,222	893,616	2.3	1.4	1.4	1.9
International total	2,603,610	3,599,804	4,240,228	4,629,031	3.7	3.2	3.0	3.4
Total enplaned passengers	23,700,448	30,558,023	34,097,293	36,425,598	2.9	2.2	2.2	2.6
Total air cargo	432,315	613,755	683,650	736,200	4.0	2.3	2.0	3.2
Total aircraft operations								
Commercial aircraft operations								
Air carrier								
Passenger airlines	403,132	493,300	530,400	558,800	2.3	1.5	1.8	1.9
Cargo airlines	11,662	15,500	15,600	15,600	3.2	0.1	0.0	1.7
Other	4,404	3,600	3,600	3,600	(2.2)	0.0	0.0	(1.2)
Total air carrier	419,198	512,400	549,600	578,000	2.3	1.4	1.7	1.9
Air taxi								
Passenger airlines	7,228	40	40	30	(43.9)	0.0	(9.1)	(27.6)
Cargo airlines	3,472	2,900	2,800	2,700	(2.0)	(0.7)	(1.2)	(1.5)
Other	1,239	700	700	700	(6.1)	0.0	0.0	(3.3)
Total air taxi	11,939	3,640	3,540	3,430	(12.4)	(0.6)	(1.0)	(7.1)
Total commercial aircraft operations	431,137	516,040	553,140	581,430	2.0	1.4	1.7	1.8
General aviation	2,546	3,220	3,300	3,350	2.6	0.5	0.5	1.6
Military	95	100	100	100	0.6	0.0	0.0	0.3
Total aircraft operations	433,778	519,360	556,540	584,880	2.0	1.4	1.7	1.8
Forecast assumptions								
Load factor	83.0%	84.5%	85.3%	85.8%	0.2	0.2	0.2	0.2
Average seats per operation	139.2	145.3	148.5	150.3	0.5	0.4	0.4	0.5

Note: Data are for Federal Fiscal Years ended September 30.
Sources: Federal Aviation Administration, FAA 2018 TAF, www.faa.gov, accessed February 2019. Logistics, Capital & Strategy, Air Cargo Growth Potential and Facility Requirements Assessment, Seattle-Tacoma International Airport, January 31, 2018. LeighFisher, April 2019.

3.3 Air Cargo

As shown in Table 3-1 and on Figure 3-2, based on the air cargo market study discussed earlier, total air cargo at the Airport is forecast to increase from 432,315 metric tons in 2018 to 613,755 metric tons in 2027, 683,650 metric tons in 2032, and 736,200 metric tons in 2035 in the updated forecast. SEA total air cargo is forecast to increase an average of 4.0% per year between 2018 and 2027 and an average of 2.3% per year between 2027 and 2035.

Figure 3-2
HISTORICAL AND FORECAST AIR CARGO: 1990-2035
Seattle-Tacoma International Airport



CAGR = Compound annual growth rate

Note: Data are for domestic and international enplaned and deplaned freight and mail for Federal Fiscal Years ended September 30 except for the SAMP Forecasts.

Sources: *Historical*—Seattle-Tacoma International Airport records. *Forecast*—SAMP Forecast, LeighFisher, 2014. Logistics, Capital & Strategy, Air Cargo Growth Potential and Facility Requirements Assessment, Seattle-Tacoma International Airport, January 31, 2018.

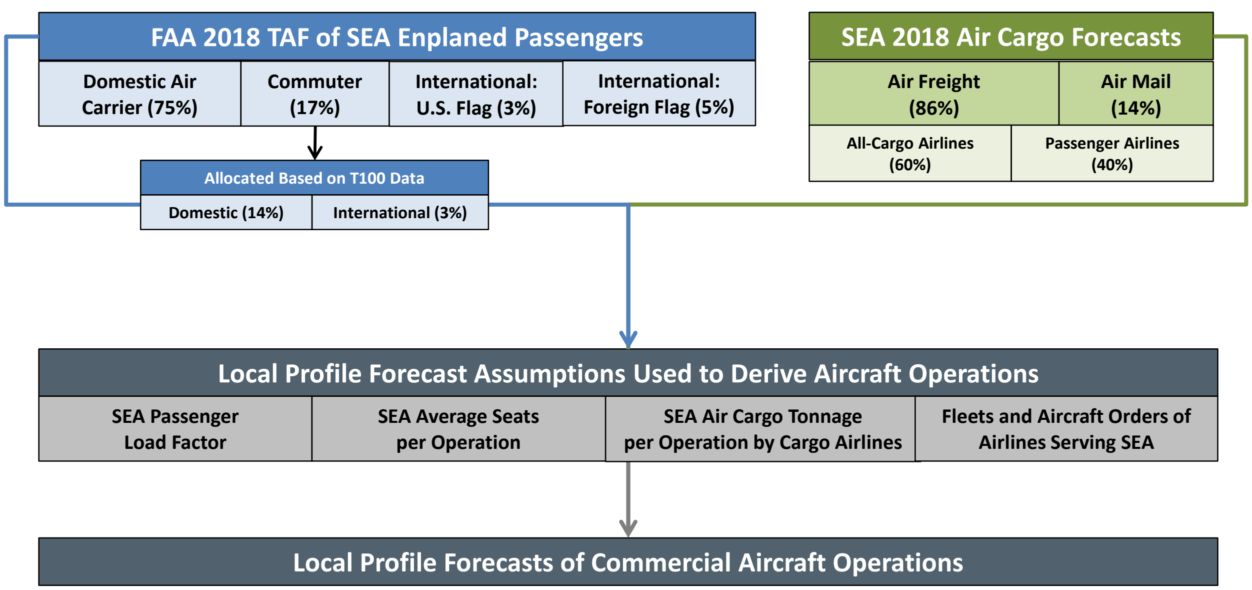
3.4 Local Profile of Aircraft Operations

As discussed in Section 3.1 and shown on Figure 3-3, the forecasts of commercial aircraft operations at the Airport were derived from forecasts of passenger and air cargo demand prepared by the FAA (the FAA 2018 TAF for SEA) and air cargo industry experts. The locally-derived operation forecasts for SEA presented in this technical memorandum are directly related to the FAA 2018 TAF for SEA because both forecasts reflect:

1. Current conditions using 2018 as the base year
2. The current market segmentation of passenger traffic, i.e., domestic and international, and the mix of airlines providing service
3. The current distribution of air carrier and commuter activity and the aircraft specific to SEA used to transport passengers and air cargo

The forecasts of commercial aircraft operations at the Airport were based on a bottom-up review of local factors specific to SEA, including load factor, average seats per operation, air cargo tonnage per operation, and airline fleets and aircraft orders, as discussed in the following sections.

Figure 3-3
APPROACH FOR LOCAL PROFILE FORECASTS OF COMMERCIAL AIRCRAFT OPERATIONS
Seattle-Tacoma International Airport



Note: Percentages are based on 2018 data for a Federal Fiscal Year ended September 30.

Sources: Seattle-Tacoma International Airport records. Federal Aviation Administration, FAA 2018 Terminal Area Forecasts (TAF), February 2019. USDOT T100 data

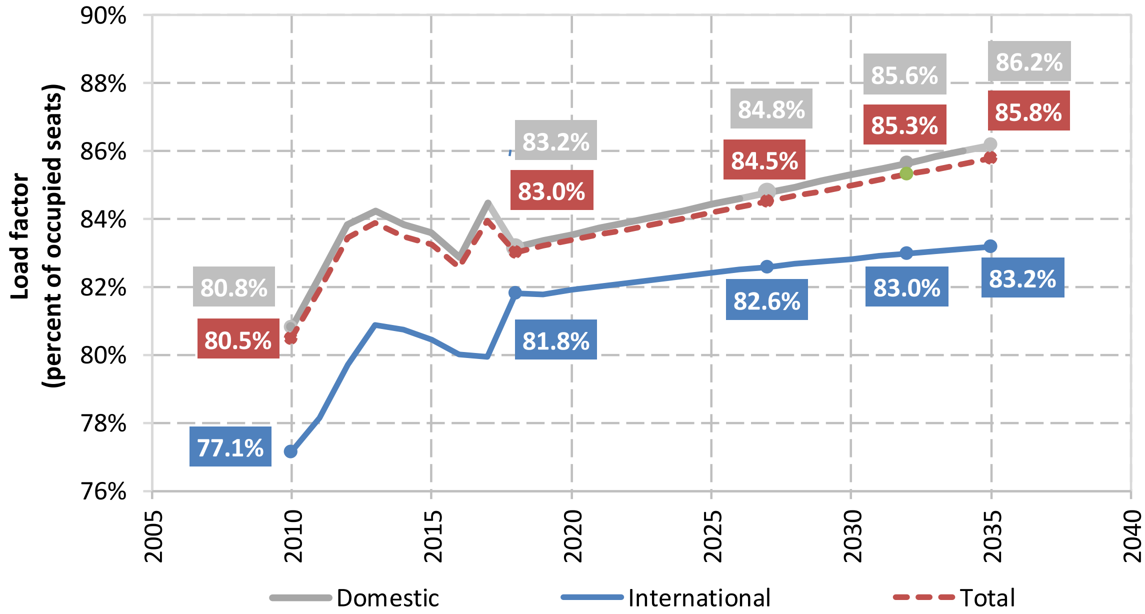
3.4.1 Load Factors

As shown on Figure 3-4, SEA's load factors (the percent of occupied seats) for total enplaned passengers increased from 80.5% in 2010 to 83.0% in 2018 (an average increase of 0.4% per year), amid annual fluctuations in overall seat capacity related to the development of Delta's hub at SEA and the competitive reaction of Alaska and other airlines in terms of additional seats and lower average airfares. The historical trends in load factor for the Airport closely follow SEA's domestic load factors reflecting the large share of domestic passengers (89% in 2018).

- SEA load factors for the Airport as a whole are forecast to increase an average of 0.2% per year (slower than historical trends), increasing from 83.0% in 2018 to 84.5% in 2027, 85.3% in 2032, and 85.8% in 2035, reflecting the continued expansion of international service at SEA with load factors lower than the Airport average.
- Domestic load factors are forecast to increase from 83.2% in 2018 to 84.8% in 2027, 85.6% in 2032, and 86.2% in 2035, somewhat slower than the FAA's Aerospace forecast for the nation as a whole—from 84.7% in 2018 to 86.1% in 2027 and 86.5% in 2035, reflecting the continued addition of seat capacity at SEA in support of hub development by Alaska and Delta, particularly to new markets where load factors tend to be lower until the additional capacity is absorbed and to markets served by commuter aircraft with generally lower than average load factors.
- International load factors are forecast to increase from 81.8% in 2018 to 82.6% in 2027, 83.0% in 2032, and 83.2% in 2035, somewhat faster than the FAA's Aerospace forecast for the nation as a whole—81.1% in 2018 through 2035, reflecting SEA's increasing role as an international gateway.*

* Federal Aviation Administration, FAA Aerospace Forecast, Fiscal Years 2018-2038, March 2018, www.faa.gov. Includes U.S. Mainline and Regional Air Carriers.

Figure 3-4
HISTORICAL AND FORECAST LOAD FACTORS: 2010-2035
Seattle-Tacoma International Airport



CAGR = Compound annual growth rate

Note: Data are for Federal Fiscal Years ended September 30.

Sources: *Historical*—Seattle-Tacoma International Airport records and OAG Worldwide Aviation Ltd, online database, accessed April 2019.
Forecast—LeighFisher, April 2019.

3.4.2 *Aircraft Gauge*

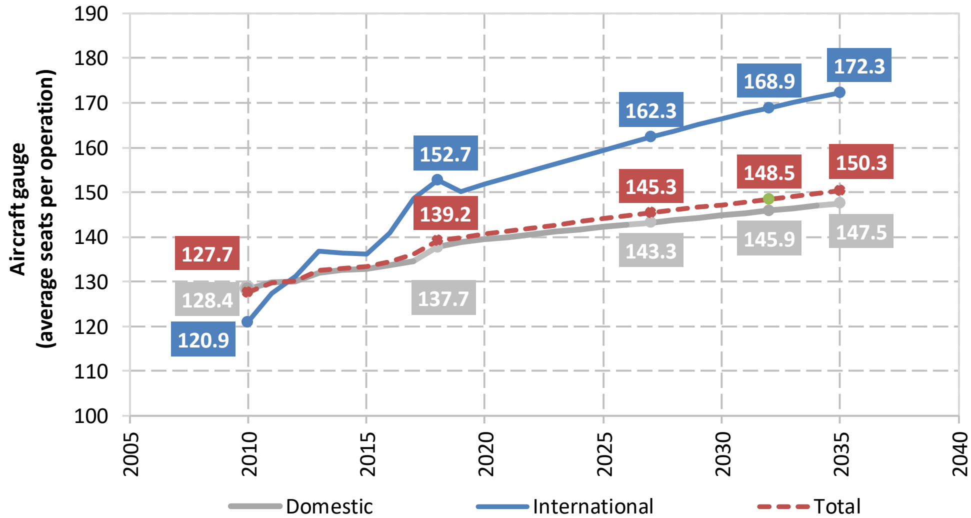
As shown on Figure 3-4, SEA's average aircraft gauge, in terms of the average number of seats per operation, increased from 127.7 in 2010 to 139.2 in 2018 (an average increase of 0.5% per year). Similar to the trends in load factors, the average number of seats per operation at the Airport as a whole closely follows SEA's domestic seats per operation.

- The average number of seats per operation at SEA is forecast to increase an average of 0.5% per year, increasing from 139.2 in 2018 to 145.3 in 2027, 148.5 in 2032, and 150.3 in 2035.

- Domestic seats per operation at SEA are forecast to increase from 137.7 in 2018 to 143.3 in 2027, 145.9 in 2032, and 147.5 in 2035, somewhat less than the FAA's Aerospace forecast for the nation as a whole—from 139.3 in 2018 to 145.2 in 2027 and 149.3 in 2035—reflecting the large share of passenger airline operations by Alaska Airlines (51% in 2018) with a predominantly narrowbody fleet (averaging 131 seats at SEA in 2018) and the increasing number of regional jet operations related to the continued development of the Airport as a connecting hub (increasing an average of 3.7% per year between 2010 and 2018).

- International seats per operation are forecast to increase from 152.7 in 2018 to 162.3 in 2027, 168.9 in 2032, and 172.3 in 2035, less than the FAA's Aerospace forecast for the nation as a whole—from 216.8 in 2018 to 221.0 in 2027 and 223.4 in 2035—reflecting the large share of short-haul Canadian operations (31% of total passenger airline operations in 2018 compared with 13% for the nation as a whole) served primarily with regional jet aircraft as well as the predominant share of small widebody aircraft flown from SEA to Asia (82% of Asia operations in 2018) and the predominant share of small narrowbody aircraft flown from SEA to Mexico (68% of Mexico operations in 2018).

Figure 3-5
HISTORICAL AND FORECAST AIRCRAFT GAUGE: 2010-2035
Seattle-Tacoma International Airport

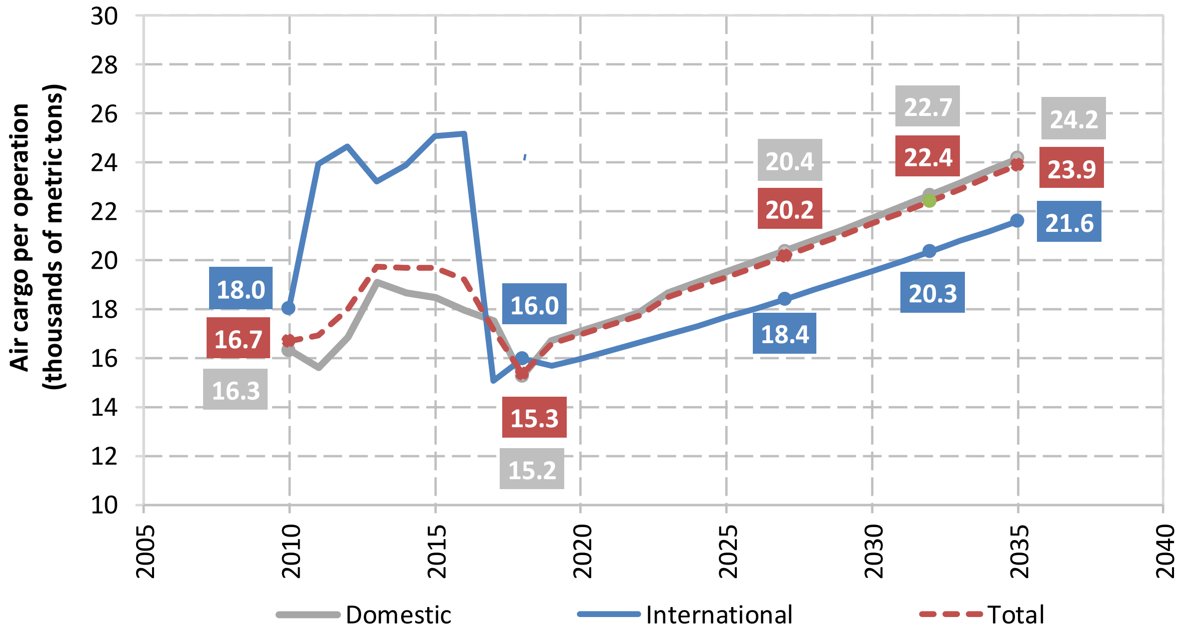


CAGR = Compound annual growth rate
Note: Data are for Federal Fiscal Years ended September 30.
Sources: *Historical*—OAG Worldwide Aviation Ltd, online database, accessed April 2019. *Forecast*—LeighFisher, April 2019.

3.4.3 *Cargo Airline Average Air Cargo Tonnage Per Operation*

Air cargo tonnage handled by cargo airlines was evaluated to derive the number of cargo airline operations. Since the number of passenger airline operations is derived from the forecasts of enplaned passengers and assumptions for load factor and average seats per operation, the air cargo tonnage carried by passenger airlines as belly cargo is separated from total air cargo. As shown on Figure 3-6, SEA's average air cargo tonnage per operation (in metric tons) by cargo airlines decreased from 16,700 metric tons in 2010 to 15,300 in 2018 amid considerable annual fluctuations reflecting an increase in operations by integrators (FedEx and ABX Air), combi-airlines (Asiana, Eva, and Korean Airlines), and freighters (Atlas Air and Air Transport International) between 2011 and 2016. Average air cargo tonnage per operation by cargo airlines at SEA is forecast to increase an average of 2.6% per year, increasing from 15,300 metric tons in 2018 to 20,200 metric tons in 2027, 22,400 metric tons in 2032, and 23,900 metric tons in 2035.

Figure 3-6
HISTORICAL AND FORECAST AVERAGE AIR CARGO TONNAGE PER OPERATION: 2010-2035
Seattle-Tacoma International Airport



CAGR = Compound annual growth rate

Note: Data are for Federal Fiscal Years ended September 30.

Sources: *Historical*— Seattle-Tacoma International Airport records and U.S. Department of Transportation, Schedule T100, online database, accessed April 2019. *Forecast*—LeighFisher, April 2019.

3.4.4 Airline Aircraft Operation Forecasts by Sector, Aircraft Type, and Equipment

Table 3-2 presents forecasts of aircraft operations at SEA for passenger and cargo airlines by sector (domestic and international), type of operation (air carrier and commuter), and equipment type through the forecast period. Assumptions regarding likely changes in fleet mix over the forecast period were based on the following:

- A 2018 distribution of airline operations by aircraft type using U.S. Department of Transportation T100 data
- A review of the current fleets of airlines serving SEA, including the mix of aircraft and their average age, and aircraft orders using airline filings with the U.S. Security and Exchange Commission
- An aircraft's useful life is assumed to average 25 years. For example, Alaska Airlines' Q400 aircraft averaged 11 years in 2018 (as indicated in Alaska's 2019 10-K SEC filing shown in Table 3-3); therefore, it is assumed, for the purposes of this forecast, that the Q400 will decrease in number and be removed from the passenger airline fleet by 2035.
- Deliveries of new aircraft are assumed to allow for the retirement of older, less fuel-efficient aircraft
- Older aircraft will be replaced by new aircraft of similar size, i.e., a small narrowbody aircraft (100-150 seats) will be replaced by next generation small narrowbody aircraft. For example, in 2018, jetBlue placed orders for 60 130-seat A220-300 aircraft to replace its aging 100-seat E190 aircraft (with options to convert to the A220-100 with 109 seats). Although the A220-300 has 30% more seats than the E190, jetBlue expects that its lower operating costs on a per seat basis will make up for lower load factors in markets that previously only supported E190 service.
- The upgauging of aircraft will be gradual and consistent with an airline's known practices. For example, the CRJ200 50-seat aircraft was replaced by Delta and other mainline airlines with larger regional jets with a 2-class configuration (i.e., CRJ700, CRJ900, and EMB175).

Alaska Airlines accounted for 51% of passenger airline aircraft operations at SEA in 2018, followed by Delta with 25%, Southwest with 6%, and American and United each with 5%. As shown in Table 3-3, the B737 aircraft accounted for nearly half of Alaska Airlines' fleet of 330 aircraft in 2018 and 59% of Alaska's operations at SEA. In addition to the changes in its fleet summarized in Table 3-3, Alaska has options to acquire up to 37 additional B737 aircraft with deliveries from 2021 through 2024 and 30 E175 aircraft with deliveries from 2021 to 2023. Alaska contracts with Skywest Airlines to operate 32 E175 aircraft and has options to add regional capacity by having SkyWest operate up to eight more E175 aircraft. As shown in Table 3-3, Alaska plans to reduce its Q400 fleet from 39 aircraft in 2018 to 23 aircraft in 2020.

Table 3-3

ALASKA AIRLINES AIRCRAFT FLEET AND OPERATIONS AT SEA

	Average age (years)	Number of aircraft in fleet 2018	2019	2020	SEA 2018 operations
Mainline fleet					
B737 Freighters	18	3	3	3	100
B737 NextGen (a)	8	159	**166**	**168**	118,700
A319/A320	9	63	63	**61**	7,300
A321neo	1	8	**9**	9	--
Total mainline fleet		233	241	241	126,100
Mainline fleet					
Regional fleet					
Q400	11	39	**31**	**23**	57,700
E175	1				
Operated by Horizon Air		26	**30**	30	11,100
Operated by Skywest Airlines		32	32	32	7,100
Total regional fleet		97	93	85	75,900
Total fleet	7	330	334	326	202,000

Note: Bold font indicates changes in fleet.

(a) Includes B737-700, -800, -900, -900ER aircraft.

Sources: U.S. Department of Transportation, Schedule T100, online database, accessed January 2019. Alaska Air Group, Inc., Form 10-K, filed with the U.S. Securities and Exchange Commission on February 15, 2019.

Table 3-2
COMMERCIAL AIRLINE AIRCRAFT OPERATIONS FORECASTS BY SECTOR, AIRCRAFT TYPE, AND EQUIPMENT
Seattle-Tacoma International Airport

	Aircraft operations				Percent of total operations				Average seats per operation			
	Historical	Forecast			Historical	Forecast			Historical	Forecast		
Sector/Aircraft type/Equipment	2018	2027	2032	2035	2018	2027	2032	2035	2018	2027	2032	2035
PASSENGER AIRLINES												
DOMESTIC												
Air carrier												
Narrow-Body (Large)												
A321	11,526	14,970	18,890	23,220	2.8%	3.0%	3.6%	4.2%	188	188	188	188
A321NEO	508	2,610	10,900	14,830	0.1%	0.5%	2.1%	2.7%	185	185	185	185
B737-9	20,496	25,850	22,590	15,790	5.0%	5.2%	4.3%	2.8%	178	178	178	178
B737-9ER	78,086	96,190	110,000	118,820	19.0%	19.5%	20.7%	21.3%	178	178	178	178
B757-200	10,560	--	--	--	2.6%	0.0%	0.0%	0.0%	193	--	--	--
B757-300	2,676	--	--	--	0.7%	0.0%	0.0%	0.0%	230	--	--	--
Narrow-Body (Large) Total	**123,852**	**139,620**	**162,380**	**172,660**	**30.2%**	**28.3%**	**30.6%**	**30.9%**	**182**	**179**	**180**	**180**
Narrow-Body (Small)												
A220-100	--	16,420	23,050	35,350	0.0%	3.3%	4.3%	6.3%	--	109	109	109
A220-300	--	14,930	26,920	46,900	0.0%	3.0%	5.1%	8.4%	--	130	130	130
A319	13,882	12,360	--	--	3.4%	2.5%	0.0%	0.0%	134	134	--	--
A320-1/2	15,178	4,470	--	--	3.7%	0.9%	0.0%	0.0%	156	156	--	--
A320NEO	256	18,720	31,030	32,560	0.1%	3.8%	5.8%	5.8%	186	186	186	186
B717-200	8,448	--	--	--	2.1%	0.0%	0.0%	0.0%	110	--	--	--
B737-400	86	--	--	--	0.0%	0.0%	0.0%	0.0%	145	--	--	--
B737-700	22,000	22,200	--	--	5.4%	4.5%	0.0%	0.0%	139	139	--	--
B737-8	66,702	76,410	79,980	66,980	16.3%	15.5%	15.1%	12.0%	162	162	162	162
B737-MAX 8	230	10,730	21,300	24,050	0.1%	2.2%	4.0%	4.3%	175	175	175	175
MD-90	8	--	--	--	0.0%	0.0%	0.0%	0.0%	158	--	--	--
Narrow-Body (Small) Total	**126,790**	**176,240**	**182,280**	**205,840**	**30.9%**	**35.7%**	**34.4%**	**36.8%**	**151**	**153**	**156**	**151**
Wide-Body (Large)												
B747-400	6	--	--	--	0.0%	0.0%	0.0%	0.0%	376	--	--	--
Wide-Body (Small)												
A330-200	1,530	1,860	--	--	0.4%	0.4%	0.0%	0.0%	279	279	--	--
A330-300	44	--	--	--	0.0%	0.0%	0.0%	0.0%	293	--	--	--
B767-3/R	314	--	--	--	0.1%	0.0%	0.0%	0.0%	220	--	--	--
B767-400	42	--	--	--	0.0%	0.0%	0.0%	0.0%	244	--	--	--
B777-2	14	--	--	--	0.0%	0.0%	0.0%	0.0%	301	--	--	--
B787-8	--	500	1,080	1,700	0.0%	0.1%	0.2%	0.3%	--	270	270	270
B787-9	2	500	1,080	1,700	0.0%	0.1%	0.2%	0.3%	252	252	252	252
Wide-Body (Small) Total	**1,946**	**2,860**	**2,160**	**3,400**	**0.5%**	**0.6%**	**0.4%**	**0.6%**	**269**	**273**	**261**	**261**

Table 3-2 (page 2 of 6)

COMMERCIAL AIRLINE AIRCRAFT OPERATIONS FORECASTS BY SECTOR, AIRCRAFT TYPE, AND EQUIPMENT

Seattle-Tacoma International Airport

	Aircraft operations				Percent of total operations				Average seats per operation			
	Historical	Forecast			Historical	Forecast			Historical	Forecast		
Sector/Aircraft type/Equipment	2018	2027	2032	2035	2018	2027	2032	2035	2018	2027	2032	2035
PASSENGER AIRLINES (continued)												
DOMESTIC												
Air carrier												
Regional Jet (Large)												
EMB-175	54,034	68,020	83,820	103,220	13.2%	13.8%	15.8%	18.5%	76	76	76	76
EMB-190	--	--	--	--	0.0%	0.0%	0.0%	0.0%	--	--	--	--
RJ-700	1,750	2,120	--	--	0.4%	0.4%	0.0%	0.0%	69	69	--	--
RJ-900	2,984	5,110	--	--	0.7%	1.0%	0.0%	0.0%	76	76	--	--
Regional Jet (Large) Total	**58,768**	**75,250**	**83,820**	**103,220**	**14.3%**	**15.3%**	**15.8%**	**18.5%**	**76**	**76**	**76**	**76**
Turboprop/Prop												
DHC8-400	49,952	48,970	37,580	--	12.2%	9.9%	7.1%	0.0%	76	76	--	--
Total air carrier	**361,314**	**442,940**	**468,220**	**485,120**	**88.0%**	**89.8%**	**88.3%**	**86.8%**	**139**	**140**	**138**	**146**
Air taxi/commuter												
Regional Jet (Small)												
BD-350	4	--	--	--	0.0%	0.0%	0.0%	0.0%	8	--	--	--
G150	2	--	--	--	0.0%	0.0%	0.0%	0.0%	7	--	--	--
GL5000	4	--	--	--	0.0%	0.0%	0.0%	0.0%	13	--	--	--
G-V	2	--	--	--	0.0%	0.0%	0.0%	0.0%	13	--	--	--
HAWKER 800	2	--	--	--	0.0%	0.0%	0.0%	0.0%	8	--	--	--
RJ-200/440	6,978	--	--	--	1.7%	0.0%	0.0%	0.0%	50	--	--	--
Regional Jet (Small) Total	**6,992**	**--**	**--**	**--**	**1.7%**	**0.0%**	**0.0%**	**0.0%**	**50**	**--**	**--**	**--**
Turboprop/Prop												
CARAVAN	6	--	--	--	0.0%	0.0%	0.0%	0.0%	9	--	--	--
Total air taxi/commuter	**6,998**	**--**	**--**	**--**	**1.7%**	**0.0%**	**0.0%**	**0.0%**	**50**	**--**	**--**	**--**
DOMESTIC TOTAL	**368,312**	**442,940**	**468,220**	**485,120**	**89.8%**	**89.8%**	**88.3%**	**86.8%**	**138**	**143**	**146**	**147**

Table 3-2 (page 3 of 6)

COMMERCIAL AIRLINE AIRCRAFT OPERATIONS FORECASTS BY SECTOR, AIRCRAFT TYPE, AND EQUIPMENT

Seattle-Tacoma International Airport

	Aircraft operations				Percent of total operations				Average seats per operation			
	Historical	Forecast			Historical	Forecast			Historical	Forecast		
Sector/Aircraft type/Equipment	2018	2027	2032	2035	2018	2027	2032	2035	2018	2027	2032	2035
PASSENGER AIRLINES (continued)												
INTERNATIONAL												
Air carrier												
Narrow-Body (Large)												
A321NEO	--	3,480	7,000	7,350	0.0%	0.7%	1.3%	1.3%	--	185	185	185
B737-9	368	--	--	--	0.1%	0.0%	0.0%	0.0%	178	--	--	--
B737-9ER	1,456	2,610	2,830	2,970	0.4%	0.5%	0.5%	0.5%	178	178	178	178
B757-200	864	--	--	--	0.2%	0.0%	0.0%	0.0%	183	--	--	--
Narrow-Body (Large) Total	**2,688**	**6,090**	**9,830**	**10,320**	**0.7%**	**1.2%**	**1.9%**	**1.8%**	**180**	**182**	**183**	**183**
Narrow-Body (Small)												
A220-300	--	4,980	11,310	20,340	0.0%	1.0%	2.1%	3.6%	--	130	130	130
A319	82	--	--	--	0.0%	0.0%	0.0%	0.0%	121	--	--	--
A320-1/2	926	--	--	--	0.2%	0.0%	0.0%	0.0%	150	--	--	--
A320NEO	244	3,280	4,090	4,290	0.1%	0.7%	0.8%	0.8%	180	180	180	180
B717-200	6	--	--	--	0.0%	0.0%	0.0%	0.0%	110	--	--	--
B737-700	104	--	--	--	0.0%	0.0%	0.0%	0.0%	124	--	--	--
B737-8	1,514	--	--	--	0.4%	0.0%	0.0%	0.0%	160	--	--	--
Narrow-Body (Small) Total	**2,876**	**8,260**	**15,400**	**24,630**	**0.7%**	**1.7%**	**2.9%**	**4.4%**	**156**	**150**	**143**	**139**
Wide-Body (Large)												
B747-400	950	--	--	--	0.2%	0.0%	0.0%	0.0%	333	--	--	--
B747-8	120	--	--	--	0.0%	0.0%	0.0%	0.0%	364	--	--	--
B777-3	2,092	2,540	--	--	0.5%	0.5%	0.0%	0.0%	327	327	--	--
B777-9	--	3,980	5,060	6,440	0.0%	0.8%	1.0%	1.2%	--	400	400	400
Wide-Body (Large) Total	**3,162**	**6,520**	**5,060**	**6,440**	**0.8%**	**1.3%**	**1.0%**	**1.2%**	**331**	**372**	**400**	**400**
Wide-Body (Small)												
A330-200	862	1,050	1,130	--	0.2%	0.2%	0.2%	0.0%	252	252	252	--
A330-300	1,276	2,540	2,750	2,890	0.3%	0.5%	0.5%	0.5%	289	289	289	289
A340-600	56	--	--	--	0.0%	0.0%	0.0%	0.0%	308	--	--	--
A359	122	500	1,080	1,130	0.0%	0.1%	0.2%	0.2%	306	306	306	306
B767-3/R	3,694	1,490	--	--	0.9%	0.3%	0.0%	0.0%	216	216	--	--
B767-400	2	--	--	--	0.0%	0.0%	0.0%	0.0%	246	--	--	--
B777-2	2,376	3,380	3,660	3,840	0.6%	0.7%	0.7%	0.7%	274	274	274	274
B787-8	588	1,710	1,850	1,940	0.1%	0.3%	0.3%	0.3%	213	213	213	213
B787-9	2,012	2,940	4,260	4,470	0.5%	0.6%	0.8%	0.8%	270	270	270	270
Wide-Body (Small) Total	**10,988**	**13,610**	**14,730**	**14,270**	**2.7%**	**2.8%**	**2.8%**	**2.6%**	**251**	**261**	**269**	**270**

Table 3-2 (page 4 of 6)

COMMERCIAL AIRLINE AIRCRAFT OPERATIONS FORECASTS BY SECTOR, AIRCRAFT TYPE, AND EQUIPMENT

Seattle-Tacoma International Airport

	Aircraft operations				Percent of total operations				Average seats per operation			
	Historical	Forecast			Historical	Forecast			Historical	Forecast		
Sector/Aircraft type/Equipment	2018	2027	2032	2035	2018	2027	2032	2035	2018	2027	2032	2035
PASSENGER AIRLINES (continued)												
INTERNATIONAL												
Air carrier												
Regional Jet (Large)												
EMB-175	9,828	14,410	17,200	18,050	2.4%	2.9%	3.2%	3.2%	76	76	76	76
EMB-190	58	--	--	--	0.0%	0.0%	0.0%	0.0%	97	--	--	--
RJ 705	200	--	--	--	0.0%	0.0%	0.0%	0.0%	75	--	--	--
RJ-700	562	--	--	--	0.1%	0.0%	0.0%	0.0%	69	--	--	--
RJ-900	1,248	1,510	--	--	0.3%	0.3%	0.0%	0.0%	76	76	--	--
Regional Jet (Large) Total	**11,896**	**15,920**	**17,200**	**18,050**	**2.9%**	**3.2%**	**3.2%**	**3.2%**	**76**	**76**	**76**	**76**
Turboprop/Prop												
DHC8-400	10,208	--	--	--	2.5%	0.0%	0.0%	0.0%	76	--	--	--
Total air carrier	**41,818**	**50,400**	**62,220**	**73,710**	**10.2%**	**10.2%**	**11.7%**	**13.2%**	**153**	**189**	**182**	**178**
Air taxi/commuter												
Regional Jet (Small)												
GL6000	4	--	--	--	0.0%	0.0%	0.0%	0.0%	14	--	--	--
LEAR75	2	--	--	--	0.0%	0.0%	0.0%	0.0%	9	--	--	--
RJ-200/440	8	--	--	--	0.0%	0.0%	0.0%	0.0%	50	--	--	--
Regional Jet (Small) Total	**14**	**--**	**--**	**--**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**34**	**--**	**--**	**--**
Turboprop/Prop												
DHC8-300	216	--	--	--	0.1%	0.0%	0.0%	0.0%	50	--	--	--
Total air taxi/commuter	**230**	**--**	**--**	**--**	**0.1%**	**0.0%**	**0.0%**	**0.0%**	**1**	**--**	**--**	**--**
INTERNATIONAL TOTAL	**42,048**	**50,400**	**62,220**	**73,710**	**10.2%**	**10.2%**	**11.7%**	**13.2%**	**153**	**173**	**164**	**151**
TOTAL PASSENGER AIRLINES	**410,360**	**493,340**	**530,440**	**558,830**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**139**	**145**	**148**	**150**

Table 3-2 (page 5 of 6)

COMMERCIAL AIRLINE AIRCRAFT OPERATIONS FORECASTS BY SECTOR, AIRCRAFT TYPE, AND EQUIPMENT

Seattle-Tacoma International Airport

	Aircraft operations				Percent of total operations			
	Historical	Forecast			Historical	Forecast		
Sector/Aircraft type/Equipment	2018	2027	2032	2035	2018	2027	2032	2035
ALL-CARGO AIRLINES								
DOMESTIC								
Air carrier								
Narrow-Body (Large)								
B757-200	510	620	520	470	3.4%	3.4%	2.8%	2.6%
Narrow-Body (Small)								
B727-200	2	--	--	--	0.0%	0.0%	0.0%	0.0%
B737-400	258	120	--	--	1.7%	0.7%	0.0%	0.0%
B737-700	1,594	2,250	2,370	2,450	10.5%	12.2%	12.9%	13.4%
B737-8	14	--	--	--	0.1%	0.0%	0.0%	0.0%
DC-9-30	2	--	--	--	0.0%	0.0%	0.0%	0.0%
Narrow-Body (Small) Total	**1,870**	**2,370**	**2,370**	**2,450**	**12.4%**	**12.9%**	**12.9%**	**13.4%**
Wide-Body (Large)								
B747-400	14	--	--	--	0.1%	0.0%	0.0%	0.0%
B747-8	16	--	--	--	0.1%	0.0%	0.0%	0.0%
B747F	172	260	300	300	1.1%	1.4%	1.6%	1.6%
B777-3	2	--	--	--	0.0%	0.0%	0.0%	0.0%
Wide-Body (Large) Total	**204**	**260**	**300**	**300**	**1.3%**	**1.4%**	**1.6%**	**1.6%**
Wide-Body (Small)								
A300-600	176	210	210	210	1.2%	1.1%	1.1%	1.1%
B767-2/R	1,798	2,570	2,570	2,560	11.9%	14.0%	14.0%	14.0%
B767-3/R	2,282	3,790	3,900	3,940	15.1%	20.6%	21.2%	21.5%
B777-F	662	1,590	1,800	1,900	4.4%	8.6%	9.8%	10.4%
DC-10-10	70	--	--	--	0.5%	0.0%	0.0%	0.0%
DC-10-30	536	--	--	--	3.5%	0.0%	0.0%	0.0%
IL-76/TD	2	--	--	--	0.0%	0.0%	0.0%	0.0%
MD-11	1,758	1,890	1,700	1,520	11.6%	10.3%	9.2%	8.3%
Wide-Body (Small) Total	**7,284**	**10,050**	**10,180**	**10,130**	**48.1%**	**54.6%**	**55.3%**	**55.4%**
Total air carrier	**9,868**	**13,300**	**13,370**	**13,350**	**65.2%**	**72.3%**	**72.7%**	**73.0%**
Air taxi/commuter								
Turboprop/Prop								
CARAVAN	3,468	2,830	2,740	2,640	22.9%	15.4%	14.9%	14.4%
HERCULES	4	--	--	--	0.0%	0.0%	0.0%	0.0%
Total air taxi/commuter	**3,472**	**2,830**	**2,740**	**2,640**	**22.9%**	**15.4%**	**14.9%**	**14.4%**
DOMESTIC TOTAL	**13,340**	**16,130**	**16,110**	**15,990**	**88.1%**	**87.7%**	**87.6%**	**87.4%**

Table 3-2 (page 6 of 6)

COMMERCIAL AIRLINE AIRCRAFT OPERATIONS FORECASTS BY SECTOR, AIRCRAFT TYPE, AND EQUIPMENT

Seattle-Tacoma International Airport

	Aircraft operations				Percent of total operations			
	Historical	Forecast			Historical	Forecast		
Sector/Aircraft type/Equipment	2018	2027	2032	2035	2018	2027	2032	2035
ALL-CARGO AIRLINES (continued)								
INTERNATIONAL								
Air carrier								
Wide-Body (Large)								
B747-400	36	--	--	--	0.2%	0.0%	0.0%	0.0%
B747-8	332	420	430	440	2.2%	2.3%	2.3%	2.4%
B747F	844	1,050	1,060	1,060	5.6%	5.7%	5.8%	5.8%
Wide-Body (Large) Total	**1,212**	**1,470**	**1,490**	**1,500**	**8.0%**	**8.0%**	**8.1%**	**8.2%**
Wide-Body (Small)								
A300-600	2	--	--	--	0.0%	0.0%	0.0%	0.0%
B767-2/R	156	190	190	190	1.0%	1.0%	1.0%	1.0%
B767-3/R	330	420	430	440	2.2%	2.3%	2.3%	2.4%
B777-F	84	120	120	120	0.6%	0.7%	0.7%	0.7%
IL-76/TD	4	--	--	--	0.0%	0.0%	0.0%	0.0%
MD-11	6	--	--		0.0%	0.0%	0.0%	0.0%
Wide-Body (Small) Total	**582**	**730**	**740**	**750**	**3.8%**	**4.0%**	**4.0%**	**4.1%**
Total air carrier	**1,794**	**2,200**	**2,230**	**2,250**	**11.9%**	**12.0%**	**12.1%**	**12.3%**
Air taxi/commuter								
Turboprop/Prop								
CARAVAN	--	70	60	60	0.0%	0.4%	0.3%	0.3%
INTERNATIONAL TOTAL	**1,794**	**2,270**	**2,290**	**2,310**	**11.9%**	**12.3%**	**12.4%**	**12.6%**
TOTAL CARGO AIRLINES	**15,134**	**18,400**	**18,400**	**18,300**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Note: Data are for Federal Fiscal Years ended September 30.
The classification of aircraft by sector and type is based on U.S. Department of Transportation T100 data.

(a) U.S. Security and Exchange Commission, Annual 10-K Filings and individual airline websites. OAG Worldwide Aviation Ltd, online database, accessed April 2019.

Sources: *Historical*—U.S. Department of Transportation, Schedule T100, online database, accessed January 2019. *Forecast*—LeighFisher, April 2019.

As shown in Table 3-4, the E175 aircraft accounted for 40% of Delta Air Lines' operations at SEA in 2018 but only 8% of its fleet of 1,316 aircraft, reflecting the continued development of Delta's hub at SEA. Delta's mainline fleet operated at SEA consists primarily of narrowbody aircraft (i.e., B737-800, B737-900ER, B757-200/300) used in domestic service and widebody aircraft (i.e., B-767-300ER, B-777-200ER, A330-200/300) used primarily in international service. Of U.S. network airlines, Delta operates the oldest mainline fleet with an average age of 17 years, as shown in Table 3-4, compared with American (11 years) and United (15 years). Delta expects to accept delivery of 80 aircraft in 2019 to replace aging aircraft such as the MD-88 and MD-90. Although Delta has not announced specific plans for the retirement of aircraft, it was assumed that aging aircraft such as the B-717-200 with an average age of 17 years in 2018 would be replaced gradually throughout the forecast period.

Table 3-4
DELTA AIR LINES AIRCRAFT FLEET AND OPERATIONS AT SEA

	Average	Number of aircraft in fleet					SEA 2018
	age (years)	2018	2019	2020	2021	After 2021	operations
Mainline fleet							
B-717-200	17	91					8,500
B-737-700	10	10					--
B-737-800	17	77					14,000
B-737-900ER	3	112	**130**	130	130	130	10,000
B-757-200	21	100					10,100
B-757-300	16	16					2,000
B-767-300	26	2					--
B-767-300ER	23	56					3,400
B-767-400ER	18	21					--
B-777-200ER	19	8					800
B-777-200LR	10	10					--
A220-100	0	4	**28**	**40**	40	40	--
A220-300	0	--	**--**	**6**	**18**	**50**	--
A319-100	17	57					6,300
A320-200	23	62					--
A321-200	1	65	**97**	**124**	**127**	127	--
A321-200neo	0	--	**--**	**16**	**52**	**100**	--
A330-200	14	11					600
A330-300	10	31					900
A330-900neo	0	--	**4**	**8**	**17**	**35**	--
A350-900	1	11	**13**	**15**	15	**25**	--
MD-88	28	84					--
MD-90	22	43					--
Total mainline fleet	17	871					56,600
Regional fleet							
CRJ-200	n.a.	119					--
CRJ-700	n.a.	47					1,700
CRJ-900	n.a.	157	**164**	**172**	172	172	3,500
Embraer 170	n.a.	21					--
Embraer 175	n.a.	101					41,600
Total regional fleet		445					46,800
Total fleet/ SEA operations		1,316					103,400

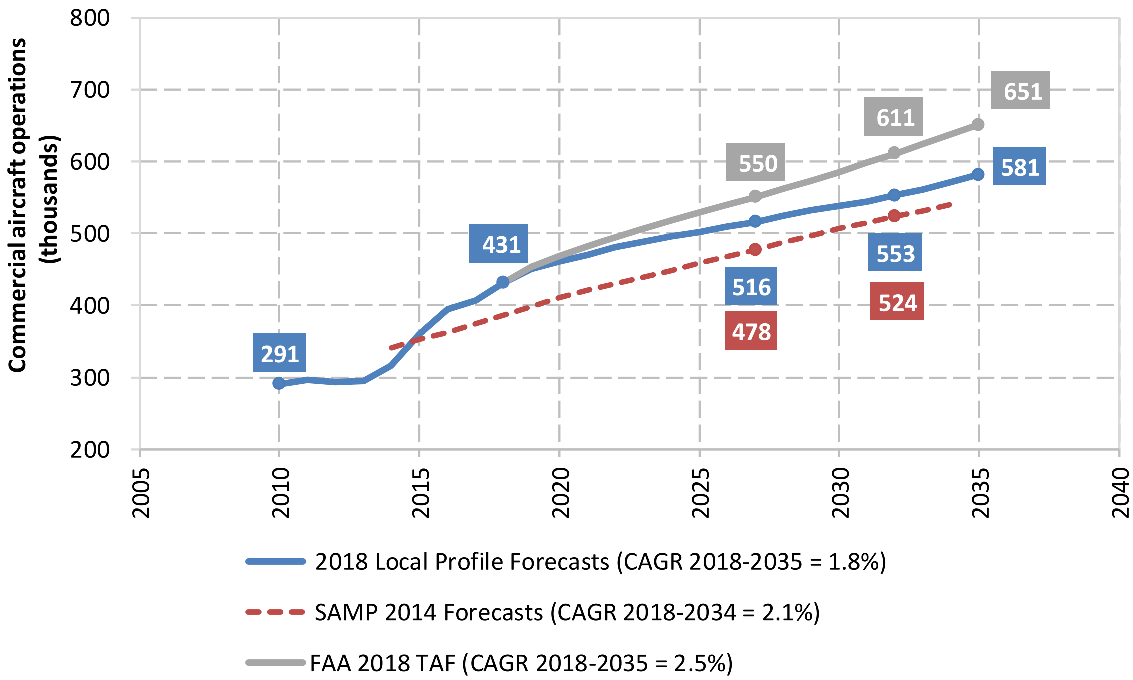
Note: Bold font indicates changes in fleet.
Delta's regional fleet at SEA was operated by Compass and Skywest airlines in 2018.

Sources: U.S. Department of Transportation, Schedule T100, online database, accessed January 2019. Delta Air Lines, Inc., Form 10-K, filed with the U.S. Securities and Exchange Comission on February 15, 2019.

3.4.5 *Commercial Aircraft Operations*

As shown on Figure 3-7 and Table 3-1, the number of commercial aircraft operations at the Airport is forecast to increase from 431,137 in 2018 to 516,040 in 2027, 553,140 in 2032, and 581,430 in 2035 in the updated forecast, an average increase of 1.8% per year. Air carrier aircraft operations are forecast to increase an average of 1.8% per year between 2018 and 2035, compared with an average decrease of 7.1% per year in air taxi operations reflecting the retirement and replacement of regional aircraft with less than 60 seats.

Figure 3-7
HISTORICAL AND FORECAST COMMERCIAL AIRCRAFT OPERATIONS: 2010-2035
Seattle-Tacoma International Airport



CAGR = Compound annual growth rate

Note: Data are for air carrier and air taxi operations for Federal Fiscal Years ended September 30 except for the SAMP Forecast.

Sources: SAMP Forecast, LeighFisher, 2014. Federal Aviation Administration, FAA 2018 TAF, www.faa.gov, accessed February 2019. LeighFisher, April 2019.

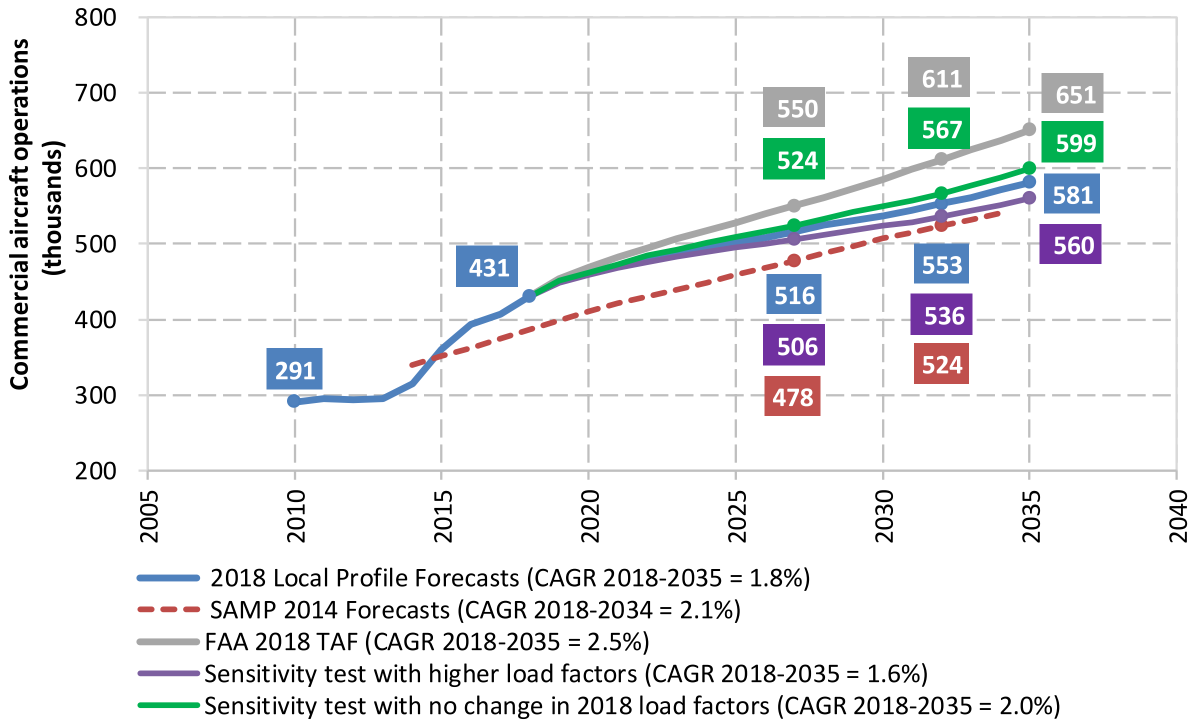
3.5 Sensitivity Tests of Passenger Airline Aircraft Operations

Two sensitivity tests of passenger airline aircraft operations were conducted to evaluate the impact of alternative load factor assumptions on commercial aircraft operations. For the purpose of these sensitivity tests, it was assumed that load factors at SEA:

1. Remain unchanged from 83.0% in 2018 through 2035
2. Increase from 83.0% in 2018 to 86.3% in 2027 and 89.2% in 2035 (an average increase of 0.4% per year compared with an increase of 0.2% in the updated forecasts)

As shown on Figure 3-8, when the load factor is assumed to remain unchanged at 83.0%, commercial aircraft operations total 506,000 in 2027 and 560,000 in 2035, lower than the updated forecast. In the second sensitivity test when load factors increase an average of 0.4% per year, commercial aircraft operations total 524,000 in 2027 and 599,000 in 2035, higher than the updated forecast.

Figure 3-8
SENSITIVITY TESTS OF COMMERCIAL AIRCRAFT OPERATIONS: 2010-2035
Seattle-Tacoma International Airport



CAGR = Compound annual growth rate

Note: Data are for air carrier and air taxi operations for Federal Fiscal Years ended September 30 except for the SAMP Forecast.

Sources: SAMP Forecast, LeighFisher, 2014. Federal Aviation Administration, FAA 2018 TAF, www.faa.gov, accessed February 2019. LeighFisher, April 2019.

4.0 COMPARISON WITH THE FAA 2018 TAF

Table 4-1 presents a comparison of the updated aviation activity forecasts prepared for Seattle-Tacoma International Airport with the FAA 2018 TAF for the Airport. The forecasts are compared for the components of total enplaned passengers, commercial aircraft operations and total aircraft operations. As noted earlier, the 2018 TAF is the basis for updated forecasts of enplaned passengers as well as general aviation and military operations. Therefore, a comparison of the preferred forecasts and the FAA 2018 TAF will differ only in terms of commercial and total aircraft operations.

The format of Table 4-1 is based on the template provided by the FAA for the comparison of airport planning forecasts and the FAA TAF.* As required, the results are presented for the base year of 2018 and forecast horizons years which are equal to the base year, plus 1, 5, 10 and 15 years (2019, 2023, 2028, and 2033). The 2018 updated aviation activity forecasts have been compared graphically with the FAA 2018 TAF in the figures presented throughout this report, including Figures 3-1 and 3-3.

The key findings of the comparison of the updated aviation demand forecasts with the FAA 2018 TAF are:

- The forecast of enplaned passengers for SEA is equal to the 2018 TAF in each forecast year, as shown in Table 4-1.
- The forecast of commercial operations for SEA varies from the 2018 TAF by:
  - 4.5% in 2023
  - 7.3% in 2028

- The forecast of total aircraft operations for SEA varies from the FAA 2018 TAF by:
  - 3.5% in 2023
  - 6.6% in 2028

- Overall, the 2018 updated aviation activity forecasts are similar to the FAA 2018 TAF for the Airport and “differ by less than 10 percent in the 5-year forecast period, and 15 percent in the 10-year forecast period”, as stipulated in the FAA forecast guidance.

Table 4-2 presents a summary of the SAMP aviation activity forecasts using a second template provided by the FAA.

*U.S. Department of Transportation, Federal Aviation Administration, *Forecasting Aviation Activity by Airport*, July 2001, and *Review and Approval of Aviation Forecasts*, June 2008, http://www.faa.gov.

Table 4-1
FAA TAF FORECAST COMPARISON
Seattle-Tacoma International Airport
Aviation Activity Forecast Update
2018 – 2033

	Year *(a)*	SEA 2018 updated planning forecasts	FAA 2018 TAF	SEA 2018 updated forecasts vs. 2018 TAF (percent variance)
Passenger enplanements				
Base yr.	2018	23,700,448	23,700,448	0.0%
Base yr. + 5yrs.	2023	28,036,363	28,036,363	0.0%
	2027	30,558,023	30,558,023	0.0%
Base yr. + 10yrs.	2028	31,220,241	31,220,241	0.0%
	2032	34,097,293	34,097,293	0.0%
Base yr. + 15yrs.	2033	34,851,717	34,851,717	0.0%
Commercial operations *(a)*				
Base yr.	2018	431,137	431,137	0.0%
Base yr. + 5yrs.	2023	483,500	506,521	-4.5%
	2027	516,040	550,341	-6.2%
Base yr. + 10yrs.	2028	520,600	561,692	-7.3%
	2032	553,140	610,992	-9.5%
Base yr. + 15yrs.	2033	558,100	623,921	-10.5%
Total operations *(b)*				
Base yr.	2018	433,778	433,778	0.0%
Base yr. + 5yrs.	2023	491,800	509,767	-3.5%
	2027	519,360	553,651	-6.2%
Base yr. + 10yrs.	2028	527,570	565,018	-6.6%
	2032	556,540	614,385	-9.4%
Base yr. + 15yrs.	2033	564,950	627,331	-9.9%

Note: Data are for Federal Fiscal Years ended September 30.

(a) Commercial operations include operations by passenger airlines, all-cargo airlines, and air taxi operators.
(b) Total operations include commercial operations plus operations by general aviation and military.

Sources: Commercial Operations Forecasts—LeighFisher, April 2019.
FAA 2018 TAF for SEA—U.S. Department of Transportation, Federal Aviation Administration, www.faa.gov, accessed February 2019.

Table 4-2
SUMMARY OF SEA PLANNING FORECASTS USING FAA TEMPLATE
Seattle-Tacoma International Airport

		Forecast				Average annual compound growth rates			
	Base year 2018	Base year + 1 year 2019	Base year + 5 years 2023	Base year + 10 years 2028	Base year + 15 years 2033	Base year to +1 year 2018 - 2019	Base year to +5 years 2018 - 2023	Base year to +10 years 2018 - 2028	Base year to +15 years 2018 - 2033
Passenger enplanements									
Air carrier *(a)*	19,697,414	20,962,861	23,427,075	26,134,338	29,223,410	6.4%	3.5%	2.9%	2.7%
Commuter *(b)*	4,003,034	4,173,191	4,609,288	5,085,903	5,628,307	4.3%	2.9%	2.4%	2.3%
Total	23,700,448	25,136,052	28,036,363	31,220,241	34,851,717	6.1%	3.4%	2.8%	2.6%
Aircraft operations									
Itinerant									
Air carrier	419,198	442,000	483,500	520,600	558,100	5.4%	2.9%	2.2%	1.9%
Commuter/air taxi	11,939	8,290	5,050	3,640	3,430	-30.6%	-15.8%	-11.2%	-8.0%
Total commercial operations	431,137	450,290	488,550	524,240	561,530	4.4%	2.5%	2.0%	1.8%
General aviation	2,546	3,090	3,150	3,230	3,320	21.4%	4.3%	2.4%	1.8%
Military	95	100	100	100	100	5.3%	1.0%	0.5%	0.3%
Local									
General aviation	--	--	--	--	--	--	--	--	--
Military	--	--	--	--	--	--	--	--	--
Total operations	433,778	453,480	491,800	527,570	564,950	4.5%	2.5%	2.0%	1.8%
Cargo/mail (enplaned + deplaned tons)	432,315	457,800	560,000	627,700	697,600	5.9%	5.3%	3.8%	3.2%
Based Aircraft									
Single-engine (nonjet)	--	--	--	--	--	--	--	--	--
Multiengine (nonjet)	--	--	--	--	--	--	--	--	--
Jet engine	2	2	2	2	2	--	--	--	--
Helicopter	--	--	--	--	--	--	--	--	--
Other	--	--	--	--	--	--	--	--	--
Total	2	2	2	2	2	--	--	--	--
Operational factors									
Average aircraft size (seats)									
Air Carrier *(a)*	172	172	175	179	183				
Commuter *(b)*	75	75	76	77	78				
Average enplaning load factor									
Air Carrier *(a)*	84%	84%	85%	86%	86%				
Commuter *(b)*	78%	78%	79%	81%	82%				
GA operations per based aircraft	1,273	1,545	1,575	1,615	1,660				

Note: Data are for Federal Fiscal Years ended September 30.
(a) Includes mainline and charter airline activity as summarized in the previous tables in this report.
(b) Includes regional affiliate airline activity, which includes flights using regional aircraft with more than 60 seats.

Sources: FAA 2018 TAF for SEA—U.S. Department of Transportation, Federal Aviation Administration, www.faa.gov, accessed February 2019.

Appendix A

2014 SAMP Forecast Report

Sustainable Airport Master Plan – Near Term Projects

Constrained Operating Growth Scenarios

January 2020

PREPARED FOR
Port of Seattle
Seattle-Tacoma International Airport

PREPARED BY
Landrum & Brown, Incorporated

Seattle-Tacoma International Airport
Constrained Operating Growth Scenarios

The forecasts prepared as part of the Sustainable Airport Master Plan (SAMP) for the Seattle-Tacoma International Airport (SEA or Airport) were completed in 2015 using 2014 as the base year.[1] The SAMP used this forecast to develop and evaluate alternatives to satisfy activity associated with the 20-year unconstrained demand. The alternatives analysis resulted in a Long-Term Vision (LTV) for airport development. Modeling of the LTV airfield using Total Airport and Airspace Modeler (TAAM) software determined that, with no other changes to how the airfield/airspace is operated, simulated average aircraft delays at the Airport would exceed 20 minutes with activity forecast for 2029. FAA benefit cost and planning analysis has historically used 20 minutes of delay as an indicator of unacceptable levels of delay, whereby airlines would significantly reduce growth at that airport. The delay would be even greater in 2034, with projected delays of 37 minutes.[2] SAMP implementation planning determined that substantial gate, hardstand and terminal capacity could be constructed by 2027 to alleviate portions of the projected delay. Additional TAAM modeling of these improvements (included in the "Near-Term Projects" or NTPs) determined that, with an assumed medium level of efficiency improvement[3] to the airfield, average delay per aircraft operation would be 16.6 minutes in 2027. This level of average delay is considered to be within the range of what has been shown to be viable at congested airports in operation today. Consequently, without the NTPs, the 2027 projected aircraft operations demand could not be accommodated due to unsustainable levels of delay. The delay in the near term is primarily a result of a lack of aircraft gates and resulting congestion on the ramps. Delays due to departure procedure constraints and taxiway congestion will increase with traffic growth, but will remain secondary factors until gate capacity is increased.

As part of the initiation of the environmental review for the Proposed Action, the FAA and the Port of Seattle reviewed the SAMP forecasts for use in the studies. Since the SAMP forecasts were prepared, actual passenger traffic at SEA has exceeded the SAMP forecasts, reflecting strong economic growth, decreases in domestic airfares, airline competition, the continued development of Delta Air Lines' hub, and strong growth in both origin-destination and connecting passengers. The Port, in collaboration with the FAA, determined that an updated forecast was warranted given the faster than forecasted economic and passenger growth. The *Seattle-Tacoma International Airport Aviation Demand Forecast Update* (2019 Updated Forecast) was approved by FAA for use in the National Environmental Policy Act (NEPA) Environmental Assessment (EA)

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[1] Sustainable Airport Master Plan, Technical Memorandum 2, prepared by the Port of Seattle.
[2] Average delay per aircraft operation is determined by through annualized weighting values applied to models run to simulate specific airfield operating conditions. The weighting values represent the proportion of the year that the airport operates under the conditions simulated in the individual models.
[3] Medium level of efficiency improvement assumes that various future NextGen technologies will increase runway throughput by 3-4 additional operations per hour (roughly a 5% increase in throughputs) over the calibrated Maximum Sustainable Throughput (MST) (SAMP Technical Memorandum No. 6, Appendix G, page 56)

The analysis conducted to prepare the 2019 Updated Forecast indicated that the resulting level of aircraft operations could exceed the Airport's ability to accommodate the demand, even with implementation of the Proposed Action. As a result, the FAA and Port of Seattle decided to consider the activity levels that could be accommodated in 2027 and 2032 under both the No Action and Proposed Action cases.

The process for conducting this assessment included:

1. Considering the capability of the Airport to accommodate the updated forecast and at what point the constraints result in unacceptable aircraft operational delay (Section 2).[4]

2. Developing estimated annual growth rates for aircraft operations and passengers for the years beyond the point where the unsustainable aircraft operational delay would occur under No Action and Proposed Action conditions. This would include an evaluation of opportunities airlines and the Airport may reasonably undertake to support the annual growth rates for the constrained periods (Section 3).

3. Applying the annual growth rates and calculating constrained annual aircraft operations and passenger levels for use in the NEPA EA. This is particularly important for the assessment of environmental impacts for categories where the number of passengers and/or operations is a primary driver of the impacts. The categories where this is directly relevant include noise, air quality, climate, and traffic impact studies. Other categories, including Department of Transportation Section 4(F), environmental justice, and historical, architectural, archeological, and cultural resources, incorporate the results of these primary assessments directly or indirectly to determine impacts (Section 4).

The following describes the results of each of the steps in the process.

1. <u>2019 Updated Forecast Update</u>

The 2019 Updated Forecast identified quicker growth than the forecast prepared as part of the SAMP. The SAMP NTP environmental review will include a discussion on the 2019 Updated Forecasts. The table below compares the aircraft operating and passenger levels for 2027 and 2032 from both the SAMP forecast and the 2019 Updated Forecast.

[4] This analysis applied the 2019 Updated Forecast number of operations and passengers in 2027 to the SAMP analysis of 2027 conditions.

Table 1: Comparison of SAMP Forecast and 2019 Updated Forecast

	2027		2032	
	Aircraft Operations	Passengers	Aircraft Operations	Passengers
SAMP Forecast	477,000	56,000,000	527,000	63,000,000
2019 Updated Forecast	520,000	61,116,000	557,000	68,195,000
2018 TAF	554,000	61,116,000	614,000	68,195,000

Source: Sustainable Airport Master Plan, Technical Memorandum 7, page 2-1, prepared by Leigh Fisher for the Port of Seattle; Seattle-Tacoma International Airport Aviation Demand Forecast Update (2018), prepared by the Leigh Fisher for the Port of Seattle (2019) and referencing the 2018 FAA Terminal Area Forecast. March 2019.

2. Capability of Airport to Accommodate Demand

The SAMP included detailed simulation modeling of airport capacity and delay based on peak month average day activity levels. The peak month average day activity was converted to annual activity levels for future years to approximate annual activity levels for master planning purposes. Based on the simulation modeling of peak month average day activity and subsequent annualization of delay, the SAMP concluded that in order to accommodate the 2027 annual demand of approximately 477,000 aircraft operations and 56 million annual passengers (56 MAP), and to improve level of delay, the Airport would need to implement the NTPs. In addition to addressing the unsustainable level of delay, the NTPs are also anticipated to provide an improved level of service for these volumes. It should be noted that the annual activity levels (from which simulations of peak day activity are estimated) are approximations and should not be considered caps or maximum activity levels for an airport. Passengers and operations can continue to grow at capacity constrained airports, as evidenced by activity at other airports that continue to grow (e.g., DCA, JFK, and LGA).

Based on the 2019 Updated Forecast, those approximate annual activity levels identified in the SAMP are expected to occur in 2022 (aircraft operations) and 2023 (passengers). Above those activity levels, the assumption is that without additional capacity, airlines will significantly reduce additional service at the Airport because the expected delays will significantly impact their ability to maintain the rest of their network of flights reliably. For the purposes of this analysis, the forecast 2023 level of activity was identified as the point where substantially constrained growth for the number of flights would start occurring. For the years prior to 2023, it is assumed forecast demand can be accommodated at the Airport.

3. Annual Constrained Growth Rates

During periods where constrained growth is expected to occur there are strategies that airlines and the Airport can reasonably use to allow additional growth in passengers and aircraft operations. These strategies include:

Use of Additional Hardstands and Overnight Aircraft Parking Positions

Observations of other airports that experience constrained operating environments indicate that a small amount of growth in aircraft operations can be expected (See Table 2). When the constraint is related to lack of gates/aircraft parking positions, airports can take actions to provide additional capacity. Historically at SEA, these actions have included designating taxiways for parking aircraft overnight and designating cargo aircraft positions as passenger hardstands where bus loading/unloading can occur. In addition, airlines may choose to use a nearby airport to park aircraft overnight and fly the aircraft in early the next morning.

SEA has incorporated these approaches over the years as the situation has warranted and could do so again to accommodate some of the demand. For example, overnight aircraft have parked on Taxiway A near the terminal area. Other areas on the Airport that have been used for overnight passenger aircraft parking include: Taxiway T, the northern portion of Taxiway A (as noted above), various cargo parking positions, and the tri-taxilanes around the North Satellite. Using these areas for overnight parking would be at the expense of cargo operations, requiring increased operational coordination, and forcing cargo to be pushed back to non-peak times as their parking space would be overtaken by passenger operations. It is anticipated that using cargo parking spots for overnight parking would occur on a limited basis and would likely affect cargo operators that are not shipping next day packages. Overall, overnight parking on any movement area is not ideal due to complexities that occur from aircraft repositions, aircraft pushbacks onto taxiways, deicing, and general traffic flow north and south. While none of these areas are currently preferred overnight parking locations, if the situation warranted, they could be used again in the future.

Similarly, other areas on the Airport could be used for hardstand operations, including: various cargo parking positions, various general aviation parking positions, and the Alaska, Delta, and United Airlines maintenance areas. As with the overnight parking positions, these areas are not ideal from an operational perspective and would be used on a limited basis. The same types of tradeoffs in activities would occur as described above and would provide a poor level of service to passengers requiring bussing, ground boarding of the aircraft, and exposure to varying weather conditions. However, if the situation warranted, they could be used to provide additional hardstand capability.

Finally, airlines have at times used operational strategies such as using other airports as a place to park aircraft overnight prior to sending them to SEA for morning departures. . There were at least six occurrences in 2018 where empty aircraft were flown from SEA to other locations for overnight parking[5]. More recently, the airline scheduling strategy has been to add additional evening revenue flights to other nearby airports and flying those aircraft back to SEA in the morning.[6] It is acknowledged that these practices are not ideal for an airline due to operational inefficiencies; however, they are strategies that are possible as needed.

[5] Data provided by Port of Seattle, Airline Resources and Scheduling, October 2019
[6] Data provided by Port of Seattle, Airline Resources and Scheduling, October 2019

Table 2: Similarly Constrained Airport Activity

DCA

Enplanements					Operations					Local Operations			Total Operations	
Year	Air Carrier	Commuter	Total	Percent Growth	Air Carrier	Commuter	GA	Military	Total	Civil	Military	Total	Total OPS	Percent Growth
2010	5,860,238	2,678,537	8,538,775	N/A	174,353	88,716	5,151	2,040	270,260	0	0	0	270,260	N/A
2011	6,161,824	2,903,545	9,065,369	6.167%	194,831	84,268	5,099	601	284,799	0	0	0	284,799	5.380%
2012	6,227,743	3,074,409	9,302,152	2.612%	190,311	89,912	6,183	1,460	287,866	0	0	0	287,866	1.077%
2013	6,485,558	3,366,228	9,851,786	5.909%	195,295	92,624	5,435	2,082	295,436	0	0	0	295,436	2.630%
2014	6,482,557	3,393,224	9,875,781	0.244%	197,859	82,072	4,230	2,806	286,967	0	0	0	286,967	-2.867%
2015	7,828,412	3,170,011	10,998,423	11.368%	222,103	67,612	3,163	3,372	296,250	0	0	0	296,250	3.235%
2016	8,215,871	3,260,187	11,476,058	4.343%	230,188	62,950	3,261	3,500	299,899	0	0	0	299,899	1.232%
2017	7,993,630	3,483,109	11,476,739	0.006%	241,993	49,033	3,844	3,255	298,125	0	0	0	298,125	-0.592%
2010 - 2017 Compound Average Growth Rate:				**3.77%**										**1.23%**
2014 - 2017 Compound Average Growth Rate:				**3.83%**										**0.96%**

JFK

Enplanements					Operations					Local Operations			Total Operations	
Year	Air Carrier	Commuter	Total	Percent Growth	Air Carrier	Commuter	GA	Military	Total	Civil	Military	Total	Total OPS	Percent Growth
2010	21,003,452	1,566,765	22,570,217	N/A	327,598	68,158	7,013	325	403,094	0	0	0	403,094	N/A
2011	21,841,550	1,706,320	23,547,870	4.332%	341,874	63,390	7,506	310	413,080	0	0	0	413,080	2.477%
2012	22,900,922	1,564,623	24,465,545	3.897%	352,109	51,655	7,755	354	411,873	0	0	0	411,873	-0.292%
2013	23,305,418	1,433,101	24,738,519	1.116%	353,389	47,992	6,860	518	408,759	0	0	0	408,759	-0.756%
2014	24,326,331	1,574,357	25,900,688	4.698%	374,668	43,307	7,332	313	425,620	0	0	0	425,620	4.125%
2015	25,904,178	1,488,418	27,392,596	5.760%	401,737	32,782	7,462	649	442,630	0	0	0	442,630	3.997%
2016	27,262,869	1,734,087	28,996,956	5.857%	419,274	30,912	8,274	370	458,830	0	0	0	458,830	3.660%
2017	27,729,638	1,774,008	29,503,646	1.747%	414,743	30,829	8,224	403	454,199	0	0	0	454,199	-1.009%
2010 - 2017 Compound Average Growth Rate:				**3.41%**										**1.50%**
2014 - 2017 Compound Average Growth Rate:				**3.31%**										**1.64%**

LGA

Enplanements					Operations					Local Operations			Total Operations	
Year	Air Carrier	Commuter	Total	Percent Growth	Air Carrier	Commuter	GA	Military	Total	Civil	Military	Total	Total OPS	Percent Growth
2010	8,800,460	2,999,395	11,799,855	N/A	209,318	147,957	7,028	349	364,652	0	0	0	364,652	N/A
2011	8,911,019	3,111,017	12,022,036	1.883%	242,305	121,170	6,401	311	370,187	0	0	0	370,187	1.518%
2012	9,287,598	3,350,963	12,638,561	5.128%	265,301	104,339	6,535	344	376,519	0	0	0	376,519	1.710%
2013	9,509,944	3,730,246	13,240,190	4.760%	299,500	64,766	6,903	271	371,440	0	0	0	371,440	-1.349%
2014	9,410,339	4,020,193	13,430,532	1.438%	313,952	49,364	6,831	228	370,375	0	0	0	370,375	-0.287%
2015	10,232,320	3,835,472	14,067,792	4.745%	311,016	51,921	6,024	463	369,424	0	0	0	369,424	-0.257%
2016	10,546,044	4,236,488	14,782,532	5.081%	313,818	54,384	6,344	174	374,720	0	0	0	374,720	1.434%
2017	10,025,632	4,413,153	14,438,785	-2.325%	307,642	52,853	5,474	278	366,247	0	0	0	366,247	-2.261%
2010 - 2017 Compound Average Growth Rate:				**2.55%**										**0.05%**
2014 - 2017 Compound Average Growth Rate:				**1.83%**										**-0.28%**

SEA

Enplanements					Operations					Local Operations			Total Operations	
Year	Air Carrier	Commuter	Total	Percent Growth	Air Carrier	Commuter	GA	Military	Total	Civil	Military	Total	Total OPS	Percent Growth
2010	7,865,088	534,231	8,399,319	N/A	148,940	30,398	11,638	952	191,928	0	0	0	191,928	N/A
2011	7,990,632	454,160	8,444,792	0.541%	145,989	27,547	10,569	735	184,840	0	0	0	184,840	-3.693%
2012	8,227,182	453,330	8,680,512	2.791%	151,384	25,652	9,801	631	187,468	9	0	9	187,477	1.427%
2013	8,315,797	503,290	8,819,087	1.596%	154,655	23,465	9,499	602	188,221	6	1	7	188,228	0.401%
2014	8,674,503	515,819	9,190,322	4.209%	156,135	23,555	8,910	583	189,183	10	1	11	189,194	0.513%
2015	9,177,233	623,589	9,800,822	6.643%	162,315	22,306	9,628	732	194,981	0	0	0	194,981	3.059%
2016	9,625,678	628,062	10,253,740	4.621%	171,252	13,622	9,731	922	195,527	0	0	0	195,527	0.280%
2017	10,175,869	712,649	10,888,518	6.191%	184,409	10,329	9,534	745	205,017	0	0	0	205,017	4.854%
2010 - 2017 Compound Average Growth Rate:				**3.30%**										**0.83%**
2014 - 2017 Compound Average Growth Rate:				**4.33%**										**2.03%**

Source: FAA Terminal Area Forecast, accessed online 8/10/2019.

Upgauging of Aircraft

Airlines make choices about the size of aircraft and the overall number of seats available at an airport based on the demand, the capability of the airport to accommodate their activity, and the impact on the rest of their network. At airports with high demand but limited capability to accommodate more flights, airlines may quicken the pace at which they use larger aircraft at that airport. This is referred to as 'upgauging' and for SEA would include airlines replacing regional jet aircraft with narrowbody aircraft that offer more seats, as well as replacing smaller narrowbody aircraft with larger narrowbody aircraft that offer more seats.

SEA has experienced upgauging over the last five years and the 2019 Updated Forecast projects upgauging will continue to occur. Upgauging is not exclusively occurring at SEA. In fact, it is observed at most large hub airports as airlines are choosing to operate larger aircraft versus a greater number of smaller aircraft due to the financial performance of those aircraft. Some of the airlines at SEA, like Delta Air Lines, have the aircraft and the capability to quicken the pace at which they upgauge aircraft without unreasonably affecting their broader network. Other airlines at SEA, like Alaska Airlines, do not have the number of larger aircraft to notably upgauge their fleet at SEA without negatively impacting the rest of their network.

Increasing Load Factors

During periods when growth in aircraft operations is constrained, the demand for air travel is expected to continue to increase. One result of this situation is an increase in 'load factor' or the average percentage of an aircraft's seats that are filled by passengers. This results in fewer empty seats per aircraft, which allows for overall passenger growth even without additional aircraft operations.

SEA has experienced increasing load factors over the last five years and the 2019 Updated Forecast projects load factor increases will continue to occur. If passenger demand continues to grow as predicted in the 2019 Updated Forecast and if growth in aircraft operations and size of aircraft cannot provide the seat capacity, it is expected that the load factors will increase at a quicker pace during constrained growth periods. However, because SEA has relatively high load factors already, there is limited potential for this trend to result in a substantial increase in total passengers.[7]

Based on the strategies described above an estimate of aircraft operations and passenger annual growth rates for constrained growth periods at SEA was prepared. For the purposes of the constrained scenario analysis, it is assumed that the Airport could accommodate additional flights during constrained periods by utilizing all or some of the locations discussed above for overnight parking and hardstands. It should be noted that no increase in operations or passengers was assumed in this analysis based on the airline strategies because the Airport cannot control the airlines' decision-making. This growth is likely to occur in the non-peak periods during the day and applies to the period prior to and after the opening of the Near-Term Projects, as warranted.

Constrained Annual Growth Rates

Passenger – 0.89%

Aircraft Operations – 0.27%

These constrained growth rates were compared to several other airports that experience constrained operating environments (JFK, LGA, and DCA). While the constraints at each of these airports are unique to their situation, the growth rates offer the best examples of how activity changes in constrained operating environments. The table below shows the recent and average growth rates for these airports.

- Annual passenger growth rates ranged from 1.83 percent to 4.3 percent with an average growth rate from 2010 through 2017 of 3.26 percent.
- Annual aircraft operations growth rates ranged from -0.28 percent to 1.5 percent with an average growth rate from 2010 through 2017 of 0.91 percent.

[7] Berhof, Ralf. (April 2019). DLR Global Airport Capacity Model wrt. FESG Task 04.

Comparing these individual and average growth rates to the constrained growth rate scenarios for SEA indicates that the constrained growth rates for SEA are lower than the other constrained airports. This is a more conservative approach so as not to overestimate the capability of the Airport.

4. Resulting Constrained Growth Aircraft Operations and Passengers

No Action

The constrained growth rates were applied to the 2019 Updated Forecast level of activity from 2023 and beyond to calculate the annual aircraft operations and passengers for the 2027 and 2032 No Action scenario. The table below compares the unconstrained aircraft operations and passenger levels from the 2019 Updated Forecast to the constrained aircraft operations and passenger levels for the 2027 and 2032 No Action scenario. The resulting number of operations and passengers under the 2027 No Action scenario are higher than what the SAMP projected for 2027. While that level of activity can be accommodated, it comes at a lower level of service to passengers and airlines than what the Port of Seattle prefers to offer.

Table 3: No Action Aircraft Operations and Passengers

	2027		2032	
	Aircraft Operations	Total Passengers	Aircraft Operations	Total Passengers
SAMP Forecast (unconstrained)	477,000	56,000,000	527,000	63,000,000
2019 Updated Forecast (Unconstrained)	519,000	61,116,000	557,000	68,195,000
No Action Constrained Scenario	499,000	58,077,000	506,000	60,718,000
Unmet Demand (2019 Updated Forecast)	*20,000*	*3,039,000*	*51,000*	*7,477,000*

Proposed Action

Implementation of the Near-Term Projects, with full build-out completing in 2027, will increase the Airport's ability to accommodate increased aircraft operations and passenger activity at an acceptable level of delay, by adding aircraft gates and passenger processing facilities. As a result, it is assumed that after implementation, the number of aircraft operations and passengers will increase toward the projected unconstrained levels in the 2019 Updated Forecast. This higher growth rate is expected to occur for 18 to 24 months after implementation (2027 and 2028) as airlines adjust their schedules to the additional gate availability. However, because the growth in activity has occurred quicker than expected over the last five years at SEA, it is not anticipated that the Airport will be able to accommodate the projected unconstrained aircraft operations and passengers from the 2019 Updated Forecast, even with the implementation of the Near-Term Projects. Therefore, it is assumed that the Airport will again experience constrained growth rates between 2029 and 2032 as airfield and airspace capacity, exhibited through departure delay, then become the primary constraining factors. The table below compares the unconstrained aircraft operations and passenger levels from the 2019 Updated Forecast to the anticipated aircraft operations and passenger levels for the 2027 and 2032 Proposed Action scenario.

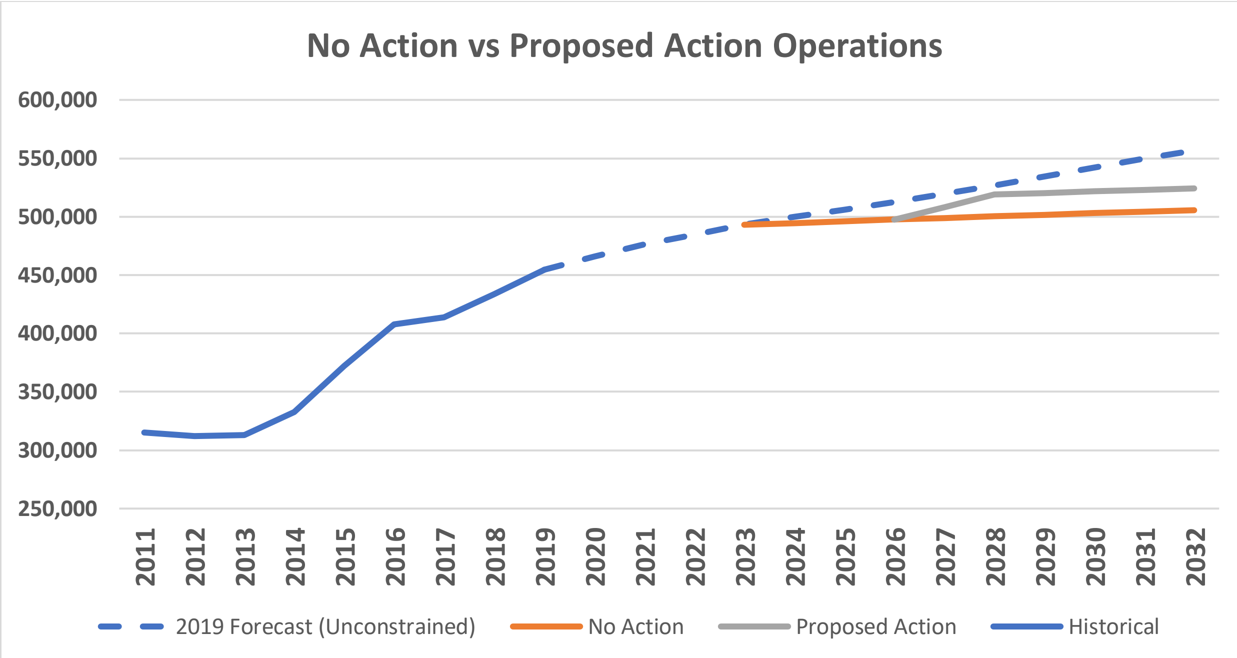
Table 4: Proposed Action Aircraft Operations and Passengers

	2027		2032	
	Aircraft Operations	Total Passengers	Aircraft Operations	Total Passengers
SAMP Forecast (unconstrained)	477,000	56,000,000	527,000	63,000,000
2019 Updated Forecast (Unconstrained)	519,000	61,116,000	557,000	68,195,000
Proposed Action Constrained Scenario	508,000	59,224,000	524,000	63,084,000
Unmet Demand (2019 Updated Forecast)	*11,000*	*1,892,000*	*32,000*	*5,111,000*

The table below and the graph that follows compare the No Action and Proposed Action aircraft operations and passenger levels for 2027 and 2032. As discussed above, the comparison of these activity levels will be an important input into several different environmental impact categories.

Table 5: Proposed Action and No Action Aircraft Operations and Passengers

	2027		2032	
	Aircraft Operations	Total Passengers	Aircraft Operations	Total Passengers
No Action	499,000	58,077,000	506,000	60,718,000
Proposed Action	508,000	59,224,000	524,000	63,084,000
Difference Between Proposed Action and No Action	*9,000*	*1,146,000*	*18,000*	*2,366,000*


No Action vs Proposed Action Operations
600,000
550,000
500,000
450,000
400,000
350,000
300,000
250,000
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2019 Forecast (Unconstrained)
No Action
Proposed Action
Historical

U.S. Department
of Transportation
**Federal Aviation
Administration**

Northwest Mountain Region
Seattle Airports District Office
2200 S. 216th Street
Des Moines, WA 98198

January 10, 2020

Mr. Lance Lyttle
Managing Director, Aviation
Port of Seattle
17801 International Drive
Seattle, WA 98158

Re: Seattle-Tacoma International Airport (SEA) Aviation Activity Forecast Update Approval

Dear Mr. Lyttle:

The Federal Aviation Administration (FAA), Seattle Airports District Office has reviewed SEA's *Aviation Activity Forecast Update,* which includes a derivative *Constrained Growth Scenario*, submitted January 7, 2020. The FAA approves these forecasts for use in the environmental review of the Sustainable Airport Master Plan (SAMP) near-term projects. The FAA approval is based on the following:

1. The differences between the FAA Terminal Area Forecast (TAF) and SEA's forecast for passenger enplanements, commercial operations, and total operations are within the 10 percent and 15 percent allowance for the 5-year and 10-year planning horizons respectively.
2. The *Aviation Activity Forecast Update* estimates unconstrained future demand, while the *Constrained Growth Scenario* incorporates near-term limitations due to the number of existing gates and resulting ramp congestion.
3. The forecast is based on reasonable planning assumptions, current data, and appropriate forecasting methodologies.
4. The existing and future critical aircraft has not changed from the prior forecast approval.

The approval of the forecast does not automatically constitute a commitment on the part of the Unites States to participate in any development recommended in the master plan or shown on the Airport Layout Plan. All future development will need to be justified by current activity levels at the time of proposed implementation. Further, the approved forecasts may be subject to additional analysis, or the FAA may request a sensitivity analysis, if this data is to be used for Part 150 noise planning purposes.

If you have any questions about this approval, please call me at (206) 231-4135.

Sincerely,

Jennifer I. Kandel
Planner, FAA Seattle Airports District Office