AIRFIELD & TERMINAL MODERNIZATION PROJECT

LOS ANGELES INTERNATIONAL AIRPORT (LAX)

DRAFT ENVIRONMENTAL IMPACT REPORT (DRAFT EIR)

Appendix B

Activity Forecasts and Operational Analyses

[State Clearinghouse No. 2019049020]

City of Los Angeles
Los Angeles World Airports

LAWA
LOS ANGELES WORLD AIRPORTS

October 2020

Appendix B – Activity Forecasts and Operational Analyses

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Appendix B – Table of Contents

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Appendix B.1 Activity Forecasts Report

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

Western-Pacific Region
Airports Division
Los Angeles Airports District Office

777 S. Aviation Blvd, Suite 105
El Segundo, CA 90245

September 30, 2020

Transmitted Electronically via email

Ms. Evelyn Quintanilla
Chief of Airport Planning II
Environmental Planning
Los Angeles World Airports
P.O. Box 92216
Los Angeles, CA 90009-2216

Los Angeles International Airport (LAX)
Aviation Activity Forecast Approval

Dear Ms. Quintanilla,

The Federal Aviation Administration (FAA) has reviewed the aviation forecast for the Los Angeles International Airport, Airfield and Terminal Modernization Project (ATMP) dated August 21, 2020. The forecast is consistent with the FAA Terminal Area Forecast (TAF) and is approved for airport planning purposes only, specifically for preparation of the Environmental Assessment for the proposed ATMP.

In summary, aviation forecast results are considered consistent with the TAF if the results differ by less than 10 percent in the 5-year forecast period and 15 percent in the 10-year forecast period. The 5 year projected airport forecast for operations is 2.90 percent higher than the TAF and the 10-year airport forecast 1.5 percent lower.

It is important to note that the approval of this forecast does not guarantee future funding for capital improvements as future projects will need to be justified by current activity levels reached at the time the projects are proposed for implementation and will need to be further analyzed for Airport Improvement Program eligibility purposes.

If you have any questions about this forecast approval, please call me at 424-405-7271.

Sincerely,

JAIME DURAN

Digitally signed by JAIME DURAN
Date: 2020.09.30 16:22:15 -07'00'

Jaime Duran
Lead Airport Planner

LAWA
LOS ANGELES WORLD AIRPORTS

August 21, 2020

Transmitted Electronically via email

Ms. Holly Dixon
Federal Aviation Administration
Acting Los Angeles District Office Manager
Office of Airports-Western-Pacific Region
777 S. Aviation Boulevard,
El Segundo, CA 90245

Re: Request for Approval of Aviation Activity Forecasts for Los Angeles International Airport

Dear Ms. Dixon,

The Los Angeles World Airports (LAWA) hereby respectfully submits for FAA review and approval a report documenting the aviation activity forecasts prepared for the Los Angeles International Airport (LAX) Airfield and Terminal Modernization Project.

This Activity Forecast Report provides detailed background information which was used to develop an unconstrained activity forecast using an industry-standard regression analysis approach based on socioeconomic factors. This Report further documents the results of the development of a constrained demand scenario which reflects potential anticipated constraints at LAX over the forecast period. At the end of this Report, you will find a table comparing the results of the LAX Airfield and Terminal Modernization Project activity forecasts compared to the 2019 Terminal Area Forecast (in a format consistent with FAA guidance on review and approval of aviation forecasts) to facilitate your review.

Upon your review and approval, this Activity Forecast Report will be finalized and included in environmental review documentation being prepared for the LAX Airfield and Terminal Modernization Project.

Do not hesitate to contact me at equintanilla@lawa.org or via telephone at (424) 646-5188 if you have any questions or comments, or if we can help facilitate your review and approval process.

Best Regards,

Evelyn Quintanilla
Chief of Airport Planning II
Los Angeles World Airports

EQ:oc

cc: Samantha Bricker (LAWA)
Dave Kessler (FAA)
Jaime Duran (FAA)
Arlene Draper (FAA)
Kyler Erhard (FAA)

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AUGUST 2020 | DRAFT

Los Angeles International Airport

LAX Airfield and Terminal Modernization Project

Draft Activity Forecasts Report

Prepared for:

Los Angeles World Airports

Prepared by:

RICONDO

PREAMBLE

This Activity Forecasts Report was prepared to document the aviation activity forecasts developed for the purposes of the LAX Airfield and Terminal Modernization Project environmental analyses. These aviation activity forecasts represent long-term forecasts between fiscal years 2018 and 2045. As documented in this Report, the unconstrained activity forecasts, constrained demand scenario, and associated operational analyses were the result of a planning process that concluded in October 2019. Therefore, these forecasts were prepared prior to the COVID-19 global pandemic which emerged in early 2020.

As of the publication date of this Report, the severity and duration of the contraction in aviation activity resulting from the COVID-19 global pandemic are still unknown. Governments, airlines, and airports around the world are still in the process of identifying and implementing regulations and processes to reduce public health risks. Identification of a treatment for COVID-19 will support a more meaningful recovery beyond the modest recent increase in aviation activity that has occurred during the summer of 2020. A full recovery to pre-pandemic levels of aviation activity will likely require the development and widescale deployment of a vaccine to treat COVID-19. The timing of both of these medical events is unknown.

The Federal Aviation Administration (FAA) addressed these uncertainties in the 2020-2040 Aerospace Forecast report, published in March 2020, as follows:

> *The rapid spread of the novel coronavirus (COVID-19) that began in early 2020 now presents a new risk without clear historical precedent. Although the FAA forecast is a long-term trend forecast and does not focus on short-term perturbations, the great uncertainty surrounding the impact of the virus leaves open the possibility that it could affect values for 2020 and 2021. This uncertainty arises from not being able to assess the spread or intensity of the human consequences, whether within the U.S. or abroad, as well as the breadth and depth of possible economic fallout.*[1]

Over the long-term (such as the 2018-2045 forecast period analyzed in this Report), demand for air travel and airline activity are expected to grow consistent with the various parameters used to develop the forecasts (e.g., U.S. Gross Domestic Product (GDP), population, employment, and income). This is evidenced by the economic and aviation activity recovery recorded over the last decades after disruptive events, such as the terrorist attacks on September 11, 2001 and the 2008 U.S. recession. As per any long-term forecast, it is assumed that periods of declines would be followed by periods of rebound in air travel demand, following cycles in domestic and international economies. Thus, the long-term forecasts documented in this Report are still valid and relevant for the long-term planning purposes of the LAX Airfield and Terminal Modernization Project environmental analyses.

[1] U.S. Department of Transportation, Federal Aviation Administration, *FAA Aerospace Forecast - Fiscal Years 2020-2040,* March 2020, p. 64. Available: https://www.faa.gov/data_research/aviation/aerospace_forecasts/media/FY2020-40_FAA_Aerospace_Forecast.pdf.

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TABLE OF CONTENTS

LIST OF ATTACHMENTS

LIST OF TABLES

LIST OF EXHIBITS

1. INTRODUCTION

Aviation activity forecasts were developed for the purposes of the environmental documentation and associated analyses of the LAX Airfield and Terminal Modernization Project. This Activity Forecasts Report presents background and an historical overview of aviation activity at Los Angeles International Airport (LAX or the airport) in **Section 2** and summarizes forecasts of activity through the end of fiscal year (FY) 2045 (in **Sections 3** and **4**).[2] Annual activity forecasts were developed for passengers and the associated aircraft operations, which are referred to as scheduled passenger operations (including passenger air carrier and air taxi operations). Annual activity forecasts were also developed for unscheduled operations, which comprise all-cargo (i.e., cargo aircraft operated by cargo companies such as FedEx or UPS), other air taxi (i.e., other than passenger air taxi operations), general aviation (GA), and military aircraft operations.

The "unconstrained" forecasts presented in Section 3 were developed independently from any existing or future limitations (e.g., physical, operational or potential regulatory limitations at LAX. For planning purposes, it is anticipated that certain facilities at LAX may become constrained over an extended period of time (FY 2018 through FY 2045) as the forecasted number of operations and passengers increases. A "constrained demand" scenario was, therefore, developed to reflect a potential constrained future environment. The unconstrained analysis was used as a starting point, and then the forecast was adjusted to reflect constraints that may exist at LAX in the future. The constrained demand scenario forecast is documented in Section 4. It is important to note that the forecasts prepared for the LAX Airfield and Terminal Modernization Project are estimates of future activity at the airport. Actual activity may vary throughout the forecast period due to unforeseen circumstances.

2 The forecasts developed for the purposes of the LAX Airfield and Terminal Modernization Project extend to FY 2045 to coincide with the horizon year of the ongoing 2020-2045 Regional Transportation Plan/Sustainable Communities Strategy (RTP/SCS) prepared by the Southern California Association of Governments (SCAG), also known as the Connect SoCal Plan.

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2. BACKGROUND INFORMATION

The following sections present historical aviation activity and trends, as well as a discussion of factors affecting aviation demand. The aviation activity forecasts in this report are based on various socioeconomic factor assumptions for the airport's Air Trade Area (ATA). An ATA is the geographic region served by an airport that provides the underlying demand for aviation. For the purposes of these analyses, the Los Angeles ATA consists of Los Angeles County, in which the airport is located, and the surrounding counties of Orange, Riverside, San Bernardino, and Ventura.

2.1 HISTORICAL AVIATION ACTIVITY AND TRENDS

The review of historical aviation activity and trends was based on data for fiscal year 2017 (from July 2016 through June 2017), which represents the latest 12-month period of historical data available at the time the forecast analyses were initiated (i.e., October 2017). Therefore, the following discussion covers the historical period of Fiscal Year ("FY") 2007 through FY 2017. Sections 3 and 4 cover the forecast period of FY 2018 through FY 2045.

In FY 2017, the airport recorded 41,586,754 enplaned passengers (i.e., the number of passengers departing from LAX) and 708,235 operations (i.e., the total number of aircraft departures and arrivals), as shown in **Table 2-1**. Between FY 2007 and FY 2017, enplaned passengers grew at a compound annual growth rate (CAGR) of 3.0 percent, while aircraft operations grew at a 0.7 percent CAGR. Between FY 2009 and FY 2017, enplaned passengers grew at a faster 4.9 percent CAGR, while operations grew at a 2.9 percent CAGR. This higher CAGR for the period 2009 to 2017 is indicative of the fast-paced recovery recorded at LAX after the 2008-2009 economic recession.

TABLE 2-1 HISTORICAL ENPLANED PASSENGERS AND AIRCRAFT OPERATIONS AT LAX

	ENPLANED PASSENGERS		AIRCRAFT OPERATIONS	
FISCAL YEAR[1]	TOTAL	ANNUAL GROWTH	TOTAL	ANNUAL GROWTH
2007	30,803,470	-	663,509	-
2008	31,142,339	1.1%	679,781	2.5%
2009	28,329,019	-9.0%	561,989	-17.3%
2010	29,003,142	2.4%	562,383	0.1%
2011	30,280,571	4.4%	585,638	4.1%
2012	31,516,917	4.1%	610,585	4.3%
2013	32,524,178	3.2%	601,044	-1.6%
2014	34,332,525	5.6%	629,826	4.8%
2015	36,121,768	5.2%	642,228	2.0%
2016	38,952,367	7.8%	672,368	4.7%
2017	41,586,754	6.8%	708,235	5.3%
CAGR				
2007-2009	-4.1%		-8.0%	
2009-2017	4.9%		2.9%	
2007–2017	3.0%		0.7%	

NOTES:
CAGR: Compound Annual Growth Rate (a growth rate averaged over a period of time)
1 The fiscal year is July 1 through June 30.
SOURCES: City of Los Angeles, Los Angeles World Airports, *Traffic Comparison (TCOM) Monthly Reports*. Available: https://www.lawa.org/en/lawa-investor-relations/statistics-for-lax/volume-of-air-traffic (numbers of enplaned passengers and aircraft operations); Ricondo & Associates, Inc., October 2017 (annual growth percentages).

2.1.1 PASSENGER ACTIVITY

Table 2-2 presents LAX's share of total U.S. enplaned passengers, which has increased from 4.0 percent in FY 2008 and FY 2009 to 4.9 percent in FY 2017. Between FY 2007 and FY 2017, total U.S. enplaned passengers grew at a 1.1 percent CAGR, a lower rate than enplaned passenger growth at LAX over the same period which was 3.0 percent CAGR. Between FY 2009 and FY 2017, LAX enplaned passengers grew at a 4.9 percent CAGR, compared to 2.2 percent CAGR for the U.S. enplanements, which is indicative of the fast-paced recovery recorded at LAX after the 2008-2009 economic recession, and the ability of LAX to outpace U.S. growth in enplanements.

TABLE 2-2 HISTORICAL ENPLANED PASSENGER COMPARISON – LAX AND UNITED STATES

	LAX		UNITED STATES		
FISCAL YEAR[1]	ENPLANED PASSENGERS	ANNUAL GROWTH	ENPLANED PASSENGERS	ANNUAL GROWTH	LAX SHARE
2007	30,803,470	-	759,805,387	-	4.1%
2008	31,142,339	1.1%	773,529,080	1.8%	4.0%
2009	28,329,019	-9.0%	712,683,099	-7.9%	4.0%
2010	29,003,142	2.4%	711,490,830	-0.2%	4.1%
2011	30,280,571	4.4%	731,339,027	2.8%	4.1%
2012	31,516,917	4.1%	741,294,817	1.4%	4.3%
2013	32,524,178	3.2%	742,321,360	0.1%	4.4%
2014	34,332,525	5.6%	755,664,016	1.8%	4.5%
2015	36,121,768	5.2%	782,140,601	3.5%	4.6%
2016	38,952,367	7.8%	823,409,710	5.3%	4.7%
2017	41,586,754	6.8%	848,037,949	3.0%	4.9%
CAGR					
2007-2009	-4.1%		-3.2%		
2009-2017	4.9%		2.2%		
2007–2017	3.0%		1.1%		

NOTES:
CAGR: Compound Annual Growth Rate
1 The fiscal year is July 1 through June 30.
SOURCES: City of Los Angeles, Los Angeles World Airports, *Traffic Comparison (TCOM) Monthly Reports*. Available: https://www.lawa.org/en/lawa-investor-relations/statistics-for-lax/volume-of-air-traffic (numbers of LAX enplaned passengers); U.S. Department of Transportation, Bureau of Transportation Statistics, *Air Carrier Statistics Database T-100*, October 2017 (numbers of U.S. enplaned passengers); Ricondo & Associates, Inc., October 2017 (annual growth and LAX share percentages).

2.1.2 AIRCRAFT OPERATIONS ACTIVITY

Table 2-3 presents historical data on aircraft operations at LAX. As shown, passenger airline aircraft operations have averaged approximately 90 percent of total airport aircraft operations at LAX from FY 2007 to FY 2017. The share of passenger airline aircraft operations increased from 87.8 percent in FY 2007 to 91.5 percent in FY 2009 (high end). In FY 2017, the passenger airline aircraft operations share of total aircraft operations at LAX was 89.4 percent.

Over the historical period shown in Table 2-3 (FY 2007 to FY 2017), scheduled passenger airline operations increased at a 0.8 percent CAGR, in line with the growth in total aircraft operations at LAX (0.7 percent CAGR). After a decline between FY 2007 and FY 2009 as a result of the 2008-2009 economic recession, scheduled passenger airline operations recovered at a 2.6 percent CAGR between FY 2009 and FY 2017.

TABLE 2-3 HISTORICAL AIRCRAFT OPERATIONS AT LAX

FISCAL YEAR[1]	AIRCRAFT OPERATIONS SCHEDULED PASSENGER AIRLINE	AIRCRAFT OPERATIONS UNSCHEDULED	AIRCRAFT OPERATIONS TOTAL	SHARE SCHEDULED PASSENGER AIRLINE	SHARE UNSCHEDULED
2007	582,776	80,733	663,509	87.8%	12.2%
2008	600,338	79,443	679,781	88.3%	11.7%
2009	514,298	47,691	561,989	91.5%	8.5%
2010	511,344	51,039	562,383	90.9%	9.1%
2011	529,358	56,280	585,638	90.4%	9.6%
2012	553,944	56,641	610,585	90.7%	9.3%
2013	546,510	54,534	601,044	90.9%	9.1%
2014	572,492	57,334	629,826	90.9%	9.1%
2015	584,996	57,232	642,228	91.1%	8.9%
2016	598,392	73,976	672,368	89.0%	11.0%
2017	632,860	75,375	708,235	89.4%	10.6%
CAGR					
2007-2009	-6.1%	-23.1%	-8.0%		
2009-2017	2.6%	5.9%	2.9%		
2007–2017	0.8%	-0.7%	0.7%		
Average					
				90.1%	9.9%

NOTES:
CAGR – Compound Annual Growth Rate
1 The fiscal year is July 1 through June 30.
SOURCES: Innovata, October 2017 (number of scheduled-passenger airline operations); U.S. Department of Transportation, Federal Aviation Administration (FAA) *Air Traffic Activity Data System (ATADS)*, October 2017 (numbers of unscheduled and total aircraft operations). Available: https://aspm.faa.gov/opsnet/sys/Main.asp?force=atads; Ricondo & Associates, Inc., October 2017 (share. CAGR and average percentages).

Unscheduled aircraft operations comprise all-cargo, other air taxi, GA, and military operations. As shown in Table 2-3, from FY 2007 to FY 2017, unscheduled operations decreased from approximately 80,700 operations to approximately 75,400 operations, or a negative 0.7 percent CAGR. Over the same period, the share of unscheduled operations decreased from 12.2 percent to 10.6 percent. Between FY 2009 and FY 2017, recovery has been recorded, with unscheduled operations growing at a 5.9 percent CAGR, after a substantial decrease of 23.1 percent CAGR as a result of the 2008-2009 economic recession.

2.1.3 LOS ANGELES BASIN AIRPORTS

The Greater Los Angeles Basin (LA Basin) includes LAX and four other commercial airports with scheduled passenger airline service, referred to herein as the LA Basin airports. The four airports include: Hollywood Burbank – Bob Hope Airport (BUR), Long Beach Airport (LGB), Ontario International Airport (ONT), and John Wayne Airport in Santa Ana (SNA).

Onboard departing passenger totals, as recorded in U.S. Department of Transportation (DOT) T100 forms, are presented for the LA Basin airports in **Table 2-4**.[3] LAX's share of the LA Basin airports departing passengers

[3] The U.S. DOT reports "onboard" departing passenger data, as opposed to total enplaned (or departing) passenger data. Onboard departing passenger data is based on airline ticket purchase data reported to the U.S. DOT which does not include nonrevenue passenger data (including airline employees traveling for free, or at a fare or discount available only to employees, or authorized persons of air carriers or their agents) which is not collected by the U.S. DOT. Therefore, the onboard departing passenger counts documented above are lower than the enplaned passenger counts discussed throughout this report.

increased from 70.5 percent (FY 2007) to 78.5 percent (FY 2017); LAX outperformed all other LA Basin airports in terms of onboard departing passenger growth. From FY 2007 to FY 2017, total onboard departing passengers for the LA Basin airports increased from approximately 43.1 million to 52.5 million, or a 2.0 percent CAGR, a lower rate than LAX (3.1 percent CAGR) over the same period. As a group, BUR, LGB, ONT and SNA (see "Other Than LAX Total" column in Table 2-4) recorded a decline in their onboard departing passenger totals of 1.2 percent CAGR over the period of FY 2007 through 2017.

TABLE 2-4 HISTORICAL ONBOARD DEPARTING PASSENGERS – LOS ANGELES BASIN AIRPORTS

	ONBOARD DEPARTING PASSENGERS						
FISCAL YEAR[1]	LAX	BUR	LGB	ONT	SNA	OTHER THAN LAX TOTAL	GRAND TOTAL
2007	30,401,326	2,925,741	1,375,741	3,477,260	4,954,490	12,733,232	43,134,558
2008	30,741,224	2,953,816	1,386,496	3,516,271	4,779,429	12,636,012	43,377,236
2009	27,993,642	2,450,300	1,428,659	2,622,178	4,262,730	10,763,867	38,757,509
2010	28,959,066	2,315,666	1,391,411	2,433,965	4,391,821	10,532,863	39,491,929
2011	30,369,961	2,268,619	1,478,891	2,410,246	4,295,129	10,452,885	40,822,846
2012	31,823,220	2,204,763	1,589,163	2,253,772	4,322,084	10,369,782	42,193,002
2013	32,299,653	2,063,361	1,475,486	2,103,418	4,556,260	10,198,525	42,498,178
2014	34,073,129	1,949,065	1,394,370	2,010,873	4,587,607	9,941,915	44,015,044
2015	35,687,284	1,993,421	1,287,627	2,080,025	4,718,853	10,079,926	45,767,210
2016	38,467,098	2,048,303	1,240,029	2,126,903	5,235,811	10,651,046	49,118,144
2017	41,170,443	2,287,840	1,670,078	2,201,354	5,147,932	11,307,204	52,477,647
CAGR							
2007-2009	-4.0%	-8.5%	1.9%	-13.2%	-7.2%	-8.1%	-5.2%
2009-2017	4.9%	-0.9%	2.0%	-2.2%	2.4%	0.6%	3.9%
2007–2017	3.1%	-2.4%	2.0%	-4.5%	0.4%	-1.2%	2.0%
Share of Onboard Passengers							
2007	70.5%	6.8%	3.2%	8.1%	11.5%	29.50%	100.0%
2008	70.9%	6.8%	3.2%	8.1%	11.0%	29.10%	100.0%
2009	72.2%	6.3%	3.7%	6.8%	11.0%	27.80%	100.0%
2010	73.3%	5.9%	3.5%	6.2%	11.1%	26.70%	100.0%
2011	74.4%	5.6%	3.6%	5.9%	10.5%	25.60%	100.0%
2012	75.4%	5.2%	3.8%	5.3%	10.2%	24.60%	100.0%
2013	76.0%	4.9%	3.5%	4.9%	10.7%	24.00%	100.0%
2014	77.4%	4.4%	3.2%	4.6%	10.4%	22.60%	100.0%
2015	78.0%	4.4%	2.8%	4.5%	10.3%	22.00%	100.0%
2016	78.3%	4.2%	2.5%	4.3%	10.7%	21.70%	100.0%
2017	78.5%	4.4%	3.2%	4.2%	9.8%	21.50%	100.0%

NOTES: CAGR – Compound Annual Growth Rate; BUR – Hollywood Burbank – Bob Hope Airport; LAX – Los Angeles International Airport; LGB – Long Beach Airport; ONT – Ontario International Airport; SNA – John Wayne Airport

1 The fiscal year is July 1 through June 30.

SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, *Air Carrier Statistics Database T-100*, October 2017 (numbers of onboard passengers); Ricondo & Associates, Inc., October 2017 (compounded annual growth rates and share of onboard passengers' percentages).

Post 2008-2009 economic recession, between FY 2009 and FY 2017, the number of onboard departing passengers at LAX recovered faster than any other airports in the LA Basin at a 4.9 percent CAGR, compared to a 0.6 percent CAGR for the other airports as a group (BUR, LGB, ONT and SNA).

2.2 FACTORS AFFECTING AVIATION DEMAND

This section discusses the qualitative factors that may influence future aviation activity at the airport. These factors were considered, either directly or indirectly, in developing the aviation activity forecasts for the airport.

2.2.1 ECONOMIC ACTIVITY

Historically, trends in airline travel demand have been correlated with trends in national and local economic activity and socioeconomic factors. As discussed in FAA guidance, and as further documented in **Section 3.2** below, developing airport planning forecasts should include socioeconomic data and variables such as population, income, and employment.[4] Historical trends have shown that demand for air travel is strong during times of economic growth, allowing people to travel for business and providing disposable income to support leisure travel.

2.2.2 GEOPOLITICAL CONSIDERATIONS

Since September 11, 2001, the recurrence of domestic or global terrorist incidents remains an ongoing risk to aviation demand. Tighter security measures have restored the public's confidence in the integrity of U.S. and world aviation security systems. However, a terrorist incident aimed at aviation could have an immediate and significant effect on the demand for aviation services. In addition, political and economic events may also influence air travel demand throughout the world. Examples of these worldwide events may be the establishment or relaxation of travel restrictions to certain countries, the opening of new international routes or the award of new airport slots; or any global health-related events affecting the ability of people to travel to or from the United States (such as governmental restrictions implemented to contain epidemic or pandemic diseases). However, it was assumed that it is unlikely these geopolitical considerations will impede LAX's future growth over the long-term period through FY 2045. See the preamble to this Report for a discussion of the COVID-19 global pandemic that emerged in early 2020.

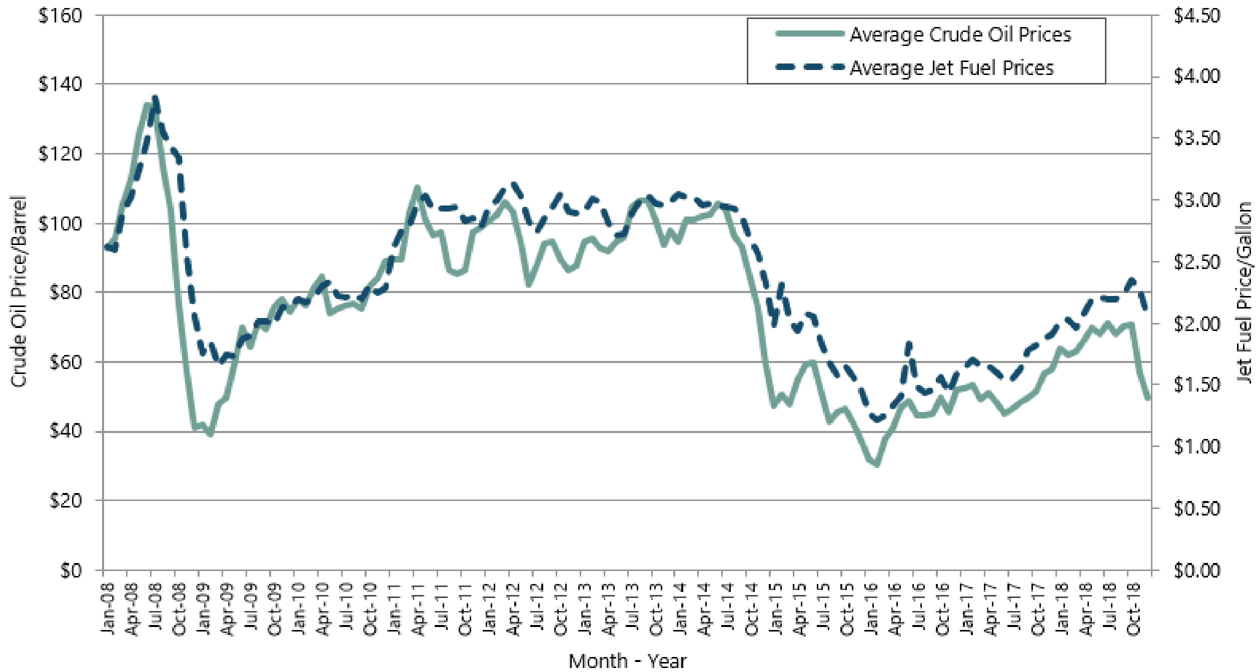
2.2.3 COST OF AVIATION FUEL

Historically, in conjunction with labor costs, fuel has been the highest or second highest operating expense for the airline industry. In the first quarter of 2018, fuel was the second largest operating expense for the airline industry after labor, representing 18.0 percent of total operating expenses.[5] **Exhibit 2-1** shows the historical quarterly average prices of jet fuel and crude oil between January 2008 and December 2018. Since 2008, the average monthly price of jet fuel fluctuated between a high of $3.84 per gallon in July 2008 to a low of $1.21 in February 2016 in airline operating costs. Airlines are expected to continue monitoring fuel prices, resorting to fuel hedging (which allows airlines to lock the price of future fuel purchases), managing available seat capacity, ordering fuel-efficient aircraft, and keeping load factors relatively high to offset any rising fuel costs over the planning horizon. As such, it was assumed that it is unlikely these variations in fuel prices will significantly impede LAX's future growth through FY 2045.

4 U.S. Department of Transportation, Federal Aviation Administration, *Forecasting Aviation Activity by Airport*, April 2001, p. 10. Available: https://www.faa.gov/airports/planning_capacity/.

5 Airlines for America, *A4A Passenger Airline Cost Index (PACI)*, 2016.

EXHIBIT 2-1 2008-2018 HISTORICAL QUARTERLY COST OF AVIATION FUEL



SOURCE: Ricondo & Associates, Inc., July 2020, based on database information from the U.S. Bureau of Transportation Statistics, *Airline Fuel Costs*. Available: http://www.transtats.bts.gov/fuel.asp; and U.S. Energy Information Administration, *Petroleum & Other Liquids*. Available: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=rwtc&f=m.

2.3 LOS ANGELES BASIN AIRPORTS

As noted in Section 2.1.3, LAX and four other commercial service airports provide scheduled passenger airline service in the LA Basin. The following provides an overview of the operating environment and known operational limitations at the four commercial service airports other than LAX that were considered in developing the forecasts.

BUR—BUR's runway lengths and limited terminal facilities (14 gates) restrict the airport's ability to handle aircraft larger than Airplane Design Group (ADG) III (e.g., Airbus A321, Boeing 737). In addition, a voluntary nighttime curfew is imposed on aircraft operations between 10:00 p.m. and 6:59 a.m. Other noise abatement-related rules may limit the ability of older noisier aircraft to operate at BUR.

LGB—A noise ordinance is enforced at LGB that restricts the number of operations based on noise levels (e.g., 25 commuter and 41 air carrier departures per day based on current noise levels). Passenger airline operations may increase as airlines operate quieter aircraft and if terminal capacity becomes available. At the time the forecast analyses were initiated in late 2017/early 2018, LGB's terminal provided 11 gates, and noise ordinances required all airline operations to be scheduled between 7:00 a.m. and 10:00 p.m. The absence of a Federal Inspection Services (FIS) facility at LGB also constitutes a limiting factor because arriving passengers from international destinations are not able to be processed and cleared by U.S. Customs and Border Protection personnel at LGB.

ONT—ONT does not have any significant facility or operational limitations similar to BUR, LGB, and SNA. Runway length and the ability to expand beyond the existing 26 gates allows ONT the opportunity to provide more air service (e.g., additional flights, destinations of greater distance).

SNA—SNA's runway length and limited terminal facilities restrict the operational environment. Per an existing settlement agreement, there is a limit on the number of passengers that can be accommodated at SNA (12.5 Million Annual Passengers [MAP] through 2030, subject to conditions).

Despite the operating environment and known operational limitations discussed above, BUR, LGB, ONT, and SNA will continue to play a critical role in supporting the LA Basin's passenger demand.

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3. UNCONSTRAINED ACTIVITY FORECASTS

The following sections discuss the development of unconstrained activity forecasts based on the background information presented in Section 2. **Section 3.1** includes a discussion of assumptions regarding LAX's role in the region to support the overall unconstrained activity forecast analyses. Scheduled passenger airline activity and unscheduled operations activity were forecasted separately, as documented in **Sections 3.2** and **3.3**, respectively. A series of tables are included in the following sections to provide historical data on which the forecast data was based.

3.1 ASSUMPTIONS REGARDING LAX'S ROLE IN THE REGION

Considering the other LA Basin airports' operating environment and operational limitations discussed above, it is assumed that LAX will continue to accommodate the largest share of passengers and operations in the region through FY 2045, for the reasons summarized below:

- Airlines: All LAX major airlines and alliance partners are anticipated to continue operating at LAX, providing passengers access to many domestic and international destinations on either nonstop or connecting flights.[6]
  - Dominant domestic network airlines: the four major domestic airlines operating at LAX today (American Airlines, Delta Air Lines, United Airlines, and Southwest Airlines), which represented approximately 68 percent of all commercial-passenger operations at LAX in FY 2018, have recently made large investments in planning and modernizing their facilities at LAX.
  - International airlines: LAX has FIS facilities of greater passenger-processing capacity compared to other LA Basin airports. With access to many FIS facilities, international airlines will continue operating at LAX, either as an Origin and Destination (O&D) or connecting beyond LAX through alliance and joint venture partners. Many international airlines will also continue to rely on LAX to accommodate freight operations (using either all-cargo aircraft or passenger airline aircraft).
- Operational limitations: unlike many of the other LA Basin airports, LAX does not have any aircraft landing or takeoff curfew or noise policies[7] that would restrict the number of flights operating at LAX.
- Airport facilities: ongoing and planned modernization projects are focused on improving airport facilities at LAX, including airfield taxiways, parking, terminal and processor facilities, including LAX Airfield and Terminal Modernization Project improvements, as well as landside access operations. These improvements would support existing airlines' ability to continue to operate at LAX and meet their passengers' expectations.

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[6] Future airline decisions to start new service or stop existing service at LAX are challenging to predict and are part of uncertainties reflected in the forecasting process.

[7] LAWA has negotiated a series of preferred operating procedures for LAX that are designed to ease noise impacts over certain areas and during noise-sensitive hours. These procedures are generally followed; however, the FAA may instruct pilots to deviate from these noise-abatement-preferred procedures and programs if weather conditions are hazardous or to address other safety considerations (the FAA has the final determination of where aircraft fly). LAWA's preferred noise-reducing operating procedures for LAX are further discussed at https://www.lawa.org/en/lawa-environment/noise-management/lawa-noise-management-lax/efforts-to-reduce-or-limit-aircraft-noise-at-lax.

3.2 UNCONSTRAINED SCHEDULED PASSENGER ACTIVITY FORECASTS

Forecasts of passenger airline activity (i.e., enplaned passengers, passenger aircraft operations, and passenger airline fleet mix)[8] were developed considering multiple historical and forecast factors, including trends in passenger numbers at LAX and throughout the industry, as well as historical trends and projections of local and national socioeconomic drivers of demand. This section provides an overview of the methodologies used to forecast aviation activity at LAX to support Airfield and Terminal Modernization Project analyses, and this section also presents the results of the unconstrained forecasts.

3.2.1 ASSUMPTIONS AND METHODOLOGY

The forecasts of enplaned passengers, aircraft operations, and aircraft fleet mix were based on several underlying assumptions:

- LAX will remain an important part of the major airlines' (i.e., American Airlines, Delta Air Lines, United Airlines, and Southwest Airlines) and their alliance partners' route networks and operations, as discussed in Section 3.1.
- BUR, LGB, ONT, and SNA will continue to play a critical role in supporting the LA Basin's passenger demand base.
- For these analyses, and similar to the FAA nationwide forecast, it was assumed that during the forecast period, no terrorist incidents would have significant, negative, and prolonged effects on aviation activity at the airport or nationwide through FY 2045, evidenced by the fast-paced recovery recorded at LAX after the September 11, 2001 terrorist attack events.
- Economic, global health, and geopolitical disturbances (e.g., periods of growth or recession) will likely occur during the forecast period, causing year-to-year variations in aviation demand; however, long-term economic growth through FY 2045 is assumed. See the preamble to this Report for a discussion of the COVID-19 global pandemic that emerged in early 2020.
- No major "acts of God" (e.g., earthquakes, tsunamis) that would negatively affect the local, national, or international air travel demand are assumed to occur during the forecast period.

Many of the factors influencing aviation activity cannot be quantified, and any forecast is subject to uncertainties. As a result, the forecast process should not be viewed as precise. Actual activity at the airport may differ from the forecasts presented herein, because events and circumstances do not occur as assumed, and these differences may be material. Therefore, over the long-term forecast period through 2045, deviations in activity levels from the results presented herein are expected. This is acknowledged by the FAA which allows a certain percentage of variance between the results of the airport sponsor's forecast and the FAA's Terminal Area Forecasts (TAF).[9]

Published airline schedules for the forecast baseline year of FY 2018 were analyzed, and information such as load factors (the percentage of seats occupied by passengers on a flight) and completion rates (i.e., the percentage of flights that actually operated compared to the published schedules) was compiled through analysis of actual

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8 Aircraft fleet mix is a list of aircraft types that aircraft operators currently operate or have ordered.

9 The Terminal Area Forecast (TAF) is the official FAA forecast of aviation activity for U.S. airports. The forecasts are prepared by the FAA to meet the budget and planning needs of the FAA. Airport sponsor forecasts (such as the LAX Airfield and Terminal Modernization Project activity forecasts) are considered consistent with the TAF if the results differ by less than 10 percent in the 5-year forecast period, and 15 percent in the 10-year forecast period. See U.S. Department of Transportation, Federal Aviation Administration, *Review and Approval of Aviation Forecasts*, June 2008, p.1. Available: https://www.faa.gov/airports/planning_capacity/media/approval_local_forecasts_2008.pdf.

performance data tracked by Los Angeles World Airports (LAWA), as well as through analysis of U.S. DOT enplaned passenger and O&D data.

The long-term growth forecast of enplaned passengers developed for the airport through FY 2045 is supported by the projections of local and nationwide economic activity. It is assumed that the economic bases of the LA Basin and the nation are diversified, stable, and capable of generating long-term increases in demand for air transportation for the LA Basin airports and, specifically, at LAX within the planning horizon.

The development of the scheduled passenger operations activity forecasts began with an assessment of enplaned passenger forecast numbers, which were then converted to total passenger numbers. Based on the passenger forecast numbers, assumptions were applied to derive forecasts of total operations required to accommodate the forecast passenger demand.

3.2.2 UNCONSTRAINED PASSENGER ACTIVITY LEVELS FORECASTS

Enplaned passengers comprise O&D and connecting passengers, which are defined as follows:

- O&D Passengers:
  - Domestic O&D passengers use LAX as an origin or destination point for journeys within the United States.
  - International O&D passengers use LAX as an origin or destination point for journeys to or from points outside the United States. This category also includes passengers whose ultimate origin or destination is an international point, but whose trip includes a domestic flight segment to another U.S. airport that serves as the international gateway (e.g., a passenger flying from an LA Basin airport to Frankfurt Airport, Germany, via O'Hare International Airport).
- Connecting Passengers:
  - Domestic connecting passengers use LAX as a transfer point for journeys between two other airports within the United States.
  - International connecting passengers use LAX as a transfer point for journeys between two other airports, at least one of which is an international point. This category includes international-to-international journeys. This category also includes passengers who depart from LAX on a domestic flight after arriving at the airport on an international flight.

Future O&D passenger activity at the airport was modeled using a socioeconomic regression analysis. Socioeconomic regression analysis is used to identify historical predictive relationships between a dependent variable (e.g., O&D passenger numbers) and one or more independent variables (e.g., socioeconomic factors, such as population, employment, and per capita personal income). These relationships, expressed as regression models, can be employed to forecast future growth in aviation activity using forecasts of the independent variables.[10] A standard measure of how well each independent variable explains passenger demand is the regression model's

[10] As discussed in guidance published by the FAA, "[w]hile there are several acceptable techniques and procedures for forecasting aviation activity at a specific airport, most forecasts utilize basic techniques such as regression or share analysis." Source: U.S. Department of Transportation, Federal Aviation Administration, *Forecasting Aviation Activity by Airport*, April 2001, p. 11. Available: https://www.faa.gov/airports/planning_capacity/. Accordingly, a socioeconomic regression analysis was selected as the most appropriate method for an airport such as LAX. Note that the activity forecasts also analyzed aviation activity market shares (the second method cited above). In addition, the use of socioeconomic regression models ensures consistency with previous LAX analyses, as well as analyses conducted by SCAG in forecasting aviation activity in the Los Angeles region.

coefficient of determination, or R-squared. A result of 100 percent is the maximum value possible for a coefficient of determination, and it represents a perfect fit among the variables analyzed. For the purposes of this analysis, relationships with an R-squared value of 75 percent or better were considered to represent a predictive relationship.

Socioeconomic regression analyses were conducted separately for domestic and international O&D passengers. As presented in **Table 3-1**, historical and projected socioeconomic data were sourced from Woods & Poole Economics, Inc., for the Los Angeles – Long Beach Combined Statistical Area (CSA) which includes the counties of Los Angeles, Ventura, Orange, San Bernardino, and Riverside, and for the U.S. Gross Domestic Product (GDP).

The regression analyses were averaged to create a baseline O&D passenger activity forecast for the LA Basin.[11] Aggregate passenger growth was apportioned to LA Basin airports, considering historical shares and expected share trends, as shown in **Table 3-2**.

Table 3-3 shows the unconstrained forecasts of enplaned passengers for LAX categorized between O&D and connecting passengers. As a result of the apportionment of O&D passengers to LAX presented in Table 3-2, O&D passengers are forecast to grow at a CAGR of 2.4 percent, from 33,058,000 in FY 2018 to 62,266,000 in FY 2045. Domestic and international connecting passenger volumes were also forecast to follow the historical 15-year trends (assuming that domestic connecting passenger volumes are projected to decrease while international connecting passenger volumes are projected to increase). As a result, connecting enplaned passengers are forecast to grow at a CAGR of 1.6 percent, from 10,008,000 in FY 2018 to 15,512,000 in FY 2045 as shown in Table 3-3. As a result, total enplaned passengers are forecast to grow at a CAGR of 2.2 percent, from 43,066,000 in FY 2018 to 77,778,000 in FY 2045.

Table 3-4 presents unconstrained forecasts of enplaned passengers for LAX categorized between domestic and international enplaned passengers. As shown, international enplaned passengers are forecast to represent a larger share of enplaned passengers in FY 2045 than in FY 2017 (34.6 percent in FY 2045 compared to 29.1 percent in FY 2017).

For the purposes of the LAX Airfield and Terminal Modernization Project analyses, the unconstrained forecast domestic and international enplanement numbers presented in Table 3-4 were converted to unconstrained forecast total passenger numbers by multiplying enplanement numbers by two, and rounded to the nearest 1,000 passengers for estimation purposes.[12] **Table 3-5** presents the unconstrained forecast total annual passengers between FY 2018 and FY 2045.

[11] The regression analyses yielded a range of annual domestic O&D growth rates between 1.8 and 2.0 percent for the LA Basin airports and between 1.8 and 2.9 percent for LAX for the period 2017 through 2045. The range of annual international O&D growth rates yielded 1.8 and 2.9 percent for the LA Basin airports and 1.8 and 2.8 percent for LAX over the same period. Based on a range of O&D passenger forecast results, the total O&D CAGR for LAX is projected to be 2.5 percent for the period 2017 through 2045.

[12] For planning purposes, it is an industry standard practice that enplanements represent approximately 50 percent of all passengers. Therefore, multiplying the number of enplanements by two is an appropriate means to estimate the number of total passengers. This standard practice is confirmed by a review of LAWA's records for 2017 during which enplanements represented 50.2 percent of all passengers. Source: City of Los Angeles, Los Angeles World Airports, *Traffic Comparison (TCOM) Monthly Report for CY 2017*. Available: https://www.lawa.org/en/lawa-investor-relations/statistics-for-lax/volume-of-air-traffic.

TABLE 3-1 INDEPENDENT HISTORICAL AND PROJECTED SOCIOECONOMIC VARIABLES

CALENDAR YEAR[1]	LOS ANGELES – LONG BEACH COMBINED STATISTICAL AREA (CSA)							
	POPULATION	EMPLOYMENT	EARNINGS (MILLIONS)	TOTAL PERSONAL INCOME (MILLIONS)	NET EARNING (MILLIONS)	PER CAPITA PERSONAL INCOME	GROSS REGIONAL PRODUCT (MILLIONS)	U.S. GROSS DOMESTIC PRODUCT (MILLIONS)
Historical								
2007	17,499,359	9,993,103	$562,289.10	$747,135.99	$506,074.86	$42,695.00	$922,872.84	$14,820,650.45
2008	17,612,540	9,835,827	$543,636.02	$738,793.63	$487,843.31	$41,947.00	$901,714.76	$14,617,094.89
2009	17,750,392	9,429,095	$518,696.60	$712,721.97	$465,210.50	$40,152.00	$863,246.96	$14,320,115.01
2010	17,913,101	9,316,143	$524,788.10	$726,551.25	$471,884.03	$40,560.00	$871,815.68	$14,618,132.27
2011	18,085,449	9,518,071	$539,291.80	$754,934.35	$490,896.41	$41,743.00	$880,607.91	$14,792,271.66
2012	18,242,277	9,857,644	$557,573.35	$787,707.94	$508,640.43	$43,180.00	$902,096.50	$15,115,991.20
2013	18,393,734	10,165,452	$556,830.98	$775,261.89	$500,656.47	$42,148.00	$916,419.14	$15,415,697.65
2014	18,539,231	10,478,058	$573,645.19	$806,768.76	$515,474.13	$43,517.00	$946,514.87	$15,829,180.02
2015	18,679,763	10,764,043	$605,948.63	$851,683.97	$545,087.79	$45,594.00	$1,001,401.54	$16,501,907.79
2016	18,856,911	10,930,327	$622,127.74	$874,702.66	$559,508.33	$46,386.00	$1,028,940.89	$16,923,957.85
2017	19,049,503	11,099,062	$636,233.82	$896,204.43	$572,185.18	$47,046.00	$1,052,866.28	$17,298,637.51
Projected[2]								
2018	19,243,862	11,268,586	$650,485.80	$918,211.59	$585,067.48	$47,715.00	$1,077,043.59	$17,673,837.10
2023	20,241,206	12,143,126	$725,120.60	$1,036,872.17	$653,859.73	$51,226.00	$1,203,633.48	$19,622,540.11
2028	21,268,133	13,040,766	$804,803.06	$1,163,233.39	$728,420.91	$54,694.00	$1,338,699.82	$21,688,340.14
2033	22,285,919	13,915,354	$887,771.96	$1,286,378.02	$806,026.90	$57,722.00	$1,479,189.34	$23,846,445.40
2038	23,245,224	14,750,275	$973,258.46	$1,409,357.01	$886,995.29	$60,630.00	$1,623,654.80	$26,096,052.55
2043	24,156,953	15,559,182	$1,061,947.90	$1,530,230.38	$970,671.93	$63,345.00	$1,773,045.03	$28,467,869.93
2045	24,512,091	15,877,272	$1,098,508.21	$1,581,938.35	$1,005,586.28	$64,537.00	$1,834,448.02	$29,457,796.36
CAGR								
2007–2017	0.9%	1.1%	1.2%	1.8%	1.2%	1.0%	1.3%	1.6%
2018–2045	0.9%	1.3%	2.0%	2.0%	2.0%	1.1%	2.0%	1.9%

NOTES:

All dollar values shown are 2009 dollars.

CAGR: Compound Annual Growth Rate

1 Woods & Poole data is reported by calendar year.

2 Projected data provided for every five years between 2018 and 2045.

SOURCE: Ricondo & Associates, Inc., October 2017, based on Woods & Poole Economics Regional Projections and Database.

TABLE 3-2 HISTORICAL AND FORECAST SHARE OF ORIGIN AND DESTINATION DEMAND

FISCAL YEAR[1]	LAX			OTHER LA BASIN AIRPORTS[2]		
	DOMESTIC	INTERNATIONAL	TOTAL	DOMESTIC	INTERNATIONAL	TOTAL
Historical						
2007	57%	97%	66%	43%	3%	34%
2008	57%	97%	66%	43%	3%	34%
2009	59%	98%	68%	41%	2%	32%
2010	60%	98%	69%	40%	2%	31%
2011	61%	97%	70%	39%	3%	30%
2012	62%	97%	71%	38%	3%	29%
2013	64%	96%	72%	36%	4%	28%
2014	65%	96%	73%	35%	4%	27%
2015	66%	97%	74%	34%	3%	26%
2016	67%	96%	75%	33%	4%	25%
2017	68%	96%	75%	32%	4%	25%
Forecast[3]						
2018	68%	96%	75%	32%	4%	25%
2023	70%	96%	77%	30%	4%	23%
2028	72%	95%	78%	28%	5%	22%
2033	73%	95%	79%	27%	5%	21%
2038	74%	95%	80%	26%	5%	20%
2043	74%	95%	80%	26%	5%	20%
2045	74%	94%	80%	26%	6%	20%

NOTES:
1 The fiscal year is July 1 through June 30.
2 Other LA Basin airports include: Hollywood Burbank – Bob Hope Airport; Long Beach Airport; Ontario International Airport; and John Wayne Airport.
3 Forecast data is provided for every five years between FY 2018 and FY 2045.
SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, *Airline Origin and Destination Survey (DB1B) Database*, October 2017 (numbers of O&D passengers); Ricondo & Associates, Inc., October 2017 (percentage calculations for historical and forecast data).

TABLE 3-3 HISTORICAL AND UNCONSTRAINED FORECAST ORIGIN AND DESTINATION AND CONNECTING ENPLANED PASSENGERS FOR LAX

FISCAL YEAR[1]	O&D	CONNECTING	TOTAL	SHARE	
				O&D	CONNECTING
Historical					
2007	24,217,330	6,586,140	30,803,470	78.6%	21.4%
2008	24,185,242	6,957,097	31,142,339	77.7%	22.3%
2009	21,726,658	6,602,361	28,329,019	76.7%	23.3%
2010	22,133,762	6,869,380	29,003,142	76.3%	23.7%
2011	22,822,124	7,458,447	30,280,571	75.4%	24.6%
2012	23,898,039	7,618,878	31,516,917	75.8%	24.2%
2013	24,601,999	7,922,179	32,524,178	75.6%	24.4%
2014	25,993,337	8,339,188	34,332,525	75.7%	24.3%
2015	27,483,277	8,638,491	36,121,768	76.1%	23.9%
2016	30,170,048	8,782,319	38,952,367	77.5%	22.5%
2017	32,091,465	9,495,289	41,586,754	77.2%	22.8%
Unconstrained Forecast[2]					
2018	33,058,000	10,008,000	43,066,000	76.8%	23.2%
2023	38,138,000	10,728,000	48,866,000	78.0%	22.0%
2028	43,498,000	11,893,000	55,391,000	78.5%	21.5%
2033	48,906,000	13,017,000	61,923,000	79.0%	21.0%
2038	54,389,000	14,087,000	68,476,000	79.4%	20.6%
2043	59,958,000	15,106,000	75,064,000	79.9%	20.1%
2045	62,266,000	15,512,000	77,778,000	80.1%	19.9%
CAGR					
2007–2017	2.9%	3.7%	3.0%		
2018–2045	2.4%	1.6%	2.2%		

NOTES:
O&D: Origin and Destination
CAGR: Compound Annual Growth Rate
1 The fiscal year is July 1 through June 30.
2 Forecast data is provided for every five years between FY 2018 and FY 2045.
SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, *Airline Origin and Destination Survey (DB1B) Database*, October 2017 (numbers of O&D passengers); U.S. Department of Transportation, Bureau of Transportation Statistics, *Air Carrier Statistics Database T-100*, October 2017 (numbers of connecting passengers); Ricondo & Associates, Inc., October 2017 (share percentages, forecast data and compounded annual growth rate percentages).

TABLE 3-4 HISTORICAL AND UNCONSTRAINED FORECAST DOMESTIC AND INTERNATIONAL ENPLANED PASSENGERS FOR LAX

FISCAL YEAR[1]	DOMESTIC	INTERNATIONAL	TOTAL	SHARE	
				DOMESTIC	INTERNATIONAL
Historical					
2007	22,374,333	8,429,137	30,803,470	72.6%	27.4%
2008	22,427,379	8,714,960	31,142,339	72.0%	28.0%
2009	20,662,591	7,666,428	28,329,019	72.9%	27.1%
2010	21,127,610	7,875,532	29,003,142	72.8%	27.2%
2011	22,151,724	8,128,847	30,280,571	73.2%	26.8%
2012	23,019,627	8,497,290	31,516,917	73.0%	27.0%
2013	23,855,876	8,668,302	32,524,178	73.3%	26.7%
2014	25,016,409	9,316,116	34,332,525	72.9%	27.1%
2015	26,237,839	9,883,929	36,121,768	72.6%	27.4%
2016	28,076,459	10,875,908	38,952,367	72.1%	27.9%
2017	29,500,843	12,085,911	41,586,754	70.9%	29.1%
Unconstrained Forecast[2]					
2018	30,145,000	12,921,000	43,066,000	70.0%	30.0%
2023	33,790,000	15,076,000	48,866,000	69.1%	30.9%
2028	37,832,000	17,559,000	55,391,000	68.3%	31.7%
2033	41,767,000	20,156,000	61,923,000	67.4%	32.6%
2038	45,606,000	22,870,000	68,476,000	66.6%	33.4%
2043	49,357,000	25,707,000	75,064,000	65.8%	34.2%
2045	50,877,000	26,901,000	77,778,000	65.4%	34.6%
CAGR					
2007–2017	2.8%	3.7%	3.0%		
2018–2045	2.0%	2.8%	2.2%		

NOTES:
CAGR – Compound Annual Growth Rate
1 The fiscal year is July 1 through June 30.
2 Forecast data is provided for every five years between FY 2018 and FY 2045.
SOURCES: City of Los Angeles, Los Angeles World Airports, *Traffic Comparison (TCOM) Monthly Reports*. Available: https://www.lawa.org/en/lawa-investor-relations/statistics-for-lax/volume-of-air-traffic (historical numbers of domestic, international and total passengers); Ricondo & Associates, Inc., January 2018 (forecast numbers of domestic, international and total enplaned passengers, and share and compounded annual growth rate percentages).

TABLE 3-5 UNCONSTRAINED FORECAST TOTAL ANNUAL PASSENGERS – FISCAL YEARS 2018-2045

FISCAL YEAR[1]	DOMESTIC	INTERNATIONAL	TOTAL	MILLION ANNUAL PASSENGERS (MAP)
2018	60,290,000	25,842,000	86,132,000	86.1
2019	61,682,000	26,654,000	88,336,000	88.3
2020	63,108,000	27,488,000	90,596,000	90.6
2021	64,566,000	28,350,000	92,916,000	92.9
2022	66,056,000	29,238,000	95,294,000	95.3
2023	67,580,000	30,152,000	97,732,000	97.7
2024	69,164,000	31,104,000	100,268,000	100.3
2025	70,794,000	32,092,000	102,886,000	102.9
2026	72,424,000	33,090,000	105,514,000	105.5
2027	74,046,000	34,098,000	108,144,000	108.1
2028	75,664,000	35,118,000	110,782,000	110.8
2029	77,268,000	36,146,000	113,414,000	113.4
2030	78,864,000	37,182,000	116,046,000	116.0
2031	80,430,000	38,216,000	118,646,000	118.6
2032	81,988,000	39,258,000	121,246,000	121.2
2033	83,534,000	40,312,000	123,846,000	123.8
2034	85,078,000	41,374,000	126,452,000	126.5
2035	86,632,000	42,454,000	129,086,000	129.1
2036	88,178,000	43,546,000	131,724,000	131.7
2037	89,702,000	44,640,000	134,342,000	134.3
2038	91,212,000	45,740,000	136,952,000	137.0
2039	92,720,000	46,850,000	139,570,000	139.6
2040	94,226,000	47,976,000	142,202,000	142.2
2041	95,716,000	49,104,000	144,820,000	144.8
2042	97,212,000	50,252,000	147,464,000	147.5
2043	98,714,000	51,414,000	150,128,000	150.1
2044	100,224,000	52,596,000	152,820,000	152.8
2045	101,754,000	53,802,000	155,556,000	155.6
CAGR				
2018–2045	2.0%	2.8%	2.2%	2.2%

NOTES:
CAGR – Compound Annual Growth Rate
1 The fiscal year is July 1 through June 30.
SOURCE: Ricondo & Associates, Inc., January 2018 (based on results of forecast analyses).

3.2.3 UNCONSTRAINED PASSENGER OPERATIONS FORECASTS

Forecasting the number of scheduled passenger airline operations consists of estimating how many aircraft would be required to transport the total forecast passengers discussed in the previous section, based on assumed aircraft load factors and the average aircraft seat capacity.

The aircraft operations forecast for passenger airlines considered publicly available future aircraft orders, known aircraft retirement schedules, and anticipated plans to upgauge fleets (i.e., increase the size of aircraft) of existing aircraft based on the size and types of routes flown to and from the airport. Specific assumptions used in the development of the passenger airline fleet mix include:

- Airlines operating 50-seat regional jets at LAX will increasingly upgauge to larger regional jets and smaller ADG III aircraft, consistent with the industrywide trend of retiring small regional jets.
- Use of high-density seating configurations in Airbus A320 and A321 aircraft will increase as domestic (both legacy and low-cost carriers) and foreign carriers increase their presence at the airport.
- The proportion of Boeing 787 and Airbus A350 aircraft of the airport fleet mix will increase as older ADG IV aircraft, such as the Boeing 757 and Boeing 767, are retired from medium- and long-haul routes.
- Major domestic airlines will continue to upgauge aircraft as passenger demand increases. For example:
  - American Airlines will increase the seat density of its Boeing 737 and MAX 8 aircraft fleet from 150 or 160 seats to a standard 172 seats across the fleet. Similarly, seating on its Airbus A321 aircraft will be increased from 181 or 187 seats to 190 seats.
  - Delta Air Lines' Airbus A321neos (the airline's largest order by aircraft type) are planned to have a seat capacity of 197 seats.
  - Southwest Airlines' Boeing 737-800 aircraft with 175 seats represented approximately 30 percent of Southwest's fleet in 2017. If all current orders are completed as scheduled, the Boeing 737-800 with 175 seats will represent approximately 50 percent of the airline's fleet, upgrading its aircraft fleet with newer aircraft and replacing older and smaller Boeing 737-700 aircraft with 143 seats.
  - United Airlines' new narrowbody aircraft orders consist primarily of Boeing 737 aircraft, with average seat capacity ranging from 179 to 200 seats.

Passenger growth in the long term is forecast to be accommodated by a combination of higher load factors and average seats per departure, as well as an increase in aircraft operations. **Table 3-6** presents historical and unconstrained forecast enplaned passengers, along with associated departing seats, average load factors, and total operations, to calculate average aircraft seat capacity per departure.[13]

TABLE 3-6 (1 OF 2) HISTORICAL AND UNCONSTRAINED FORECAST TOTAL SCHEDULED PASSENGER AIRLINE OPERATIONS AND SUPPORTING DATA

FISCAL YEAR[1]	ENPLANED PASSENGERS[2]	DEPARTING SEATS[3]	LOAD FACTOR[4]	OPERATIONS[5]	AVERAGE SEATS PER DEPARTURE[6]
Historical					
2007	30,803,470	39,383,552	78.2%	582,776	135.2
2008	31,142,339	39,936,734	78.0%	600,338	133.0
2009	28,329,019	36,026,345	78.6%	514,298	140.1
2010	29,003,142	36,141,151	80.2%	511,344	141.4
2011	30,280,571	37,253,732	81.3%	529,358	140.8
2012	31,516,917	38,530,772	81.8%	553,944	139.1
2013	32,524,178	38,871,752	83.7%	546,510	142.3
2014	34,332,525	41,063,515	83.6%	572,492	143.5
2015	36,121,768	43,190,185	83.6%	584,996	147.7
2016	38,952,367	46,640,805	83.5%	598,392	155.9
2017	41,586,754	49,493,457	84.0%	632,860	156.4

13 As discussed in footnote 12, this analysis is based on enplaned passengers and associated information on departing seats and departing load factors, until the end of the process at which point numbers will be multiplied by two to convert to total numbers of passengers or operations.

TABLE 3-6 (2 OF 2) HISTORICAL AND UNCONSTRAINED FORECAST TOTAL SCHEDULED PASSENGER AIRLINE OPERATIONS AND SUPPORTING DATA

FISCAL YEAR[1]	ENPLANED PASSENGERS[2]	DEPARTING SEATS[3]	LOAD FACTOR[4]	OPERATIONS[5]	AVERAGE SEATS PER DEPARTURE[6]
Unconstrained Forecast[7]					
2018	43,066,000	51,046,751	84.4%	643,089	158.8
2023	48,866,000	56,879,681	85.9%	676,711	168.1
2028	55,391,000	63,383,412	87.4%	719,859	176.1
2033	61,923,000	70,675,195	87.6%	768,124	184.0
2038	68,476,000	77,704,237	88.1%	812,161	191.4
2043	75,064,000	84,788,963	88.5%	852,610	198.9
2045	77,778,000	87,719,985	88.7%	868,643	202.0
CAGR[8]					
2007–2017	3.0%			0.8%	1.5%
2012-2017	5.7%			2.7%	2.4%
2018–2045	2.2%			1.1%	0.9%

NOTES:
CAGR – Compound Annual Growth Rate
1 The fiscal year is July 1 through June 30.
2 Source of historical data: Los Angeles World Airports, *Traffic Comparison (TCOM) Monthly Reports*. Available: https://www.lawa.org/en/lawa-investor-relations/statistics-for-lax/volume-of-air-traffic.
3 Source of historical data: Innovata, October 2017.
4 Source of historical data: U.S. Department of Transportation, Bureau of Transportation Statistics, *Air Carrier Statistics Database T-100*, October 2017.
5 Source of historical data: Los Angeles World Airports, *Traffic Comparison (TCOM) Monthly Reports*. Available: https://www.lawa.org/en/lawa-investor-relations/statistics-for-lax/volume-of-air-traffic.
6 Source: Ricondo & Associates, Inc., January 2018 (calculated average number of seats per operation using total operations divided by two).
7 Forecast data is provided for every five years between FY 2018 and FY 2045. Source of forecast data: Ricondo & Associates, Inc., January 2018 (based on results of LAX forecast analyses).
8 Source: Ricondo & Associates, Inc., January 2018 (compounded annual growth rate percentages).
SOURCES: As noted in footnotes 2 through 8.

3.3 UNCONSTRAINED UNSCHEDULED OPERATIONS ACTIVITY FORECASTS

As shown in Table 2-3 in Section 2.1.2, passenger airline aircraft operations have averaged approximately 90 percent of total airport aircraft operations from FY 2007 to FY 2017, while the remaining 10 percent accounted for unscheduled operations. For planning purposes, the forecast assumed that unscheduled operations activity will continue to account for 10 percent of all operations at LAX through FY 2045. **Table 3-7** presents historical and unconstrained forecast unscheduled operations through FY 2045.

3.4 UNCONSTRAINED ACTIVITY FORECAST RESULTS

The forecasts presented below were developed independently from any existing or future constraints (e.g., operational or regulatory constraints) at LAX and are, therefore, considered unconstrained. Refer to Section 4 below for a discussion of a constrained demand scenario.

Table 3-8 presents the unconstrained activity forecast total annual passengers (presented in terms of MAP) and operations (rounded to the nearest 1,000 operations for estimation purposes) between FY 2018 and FY 2045, based on the forecast results presented in the above sections. Passenger activity levels are forecasted to grow at a 2.2 percent CAGR through FY 2045, while total aircraft operations are forecasted to grow at a 1.1 percent CAGR through FY 2045.

TABLE 3-7 HISTORICAL AND UNCONSTRAINED FORECAST TOTAL UNSCHEDULED OPERATIONS

	AIRCRAFT OPERATIONS		SHARE
FISCAL YEAR[1]	UNSCHEDULED[2]	TOTAL[3]	UNSCHEDULED[4]
Historical			
2007	80,733	663,509	12.2%
2008	79,443	679,781	11.7%
2009	47,691	561,989	8.5%
2010	51,039	562,383	9.1%
2011	56,280	585,638	9.6%
2012	56,641	610,585	9.3%
2013	54,534	601,044	9.1%
2014	57,334	629,826	9.1%
2015	57,232	642,228	8.9%
2016	73,976	672,368	11.0%
2017	75,375	708,235	10.6%
Unconstrained Forecast[5]			
2018	71,454	714,543	10.0%
2023	75,190	751,901	10.0%
2028	79,984	799,843	10.0%
2033	85,347	853,471	10.0%
2038	90,240	902,401	10.0%
2043	94,735	947,345	10.0%
2045	96,516	965,159	10.0%
CAGR[6]			
2007-2017	-0.7%	0.7%	
2012-2017	5.9%	3.0%	
2018-2045	1.1%	1.1%	

NOTES:
CAGR – Compounded Annual Growth Rate
1 The fiscal year is July 1 through June 30
2 Source of historical data: Los Angeles World Airports, *Traffic Comparison (TCOM) Monthly Reports*. Available: https://www.lawa.org/en/lawa-investor-relations/statistics-for-lax/volume-of-air-traffic.
3 Source of historical data: Los Angeles World Airports, Traffic Comparison (TCOM) Monthly Reports. Available: https://www.lawa.org/en/lawa-investor-relations/statistics-for-lax/volume-of-air-traffic.
4 Source: Ricondo & Associates, Inc., January 2018 (calculated percentages of total operations).
5 Forecast data is provided for every five years between FY 2018 and FY 2045.
6 Source: Ricondo & Associates, Inc., January 2018 (compounded annual growth rate percentages).
SOURCES: As noted in footnotes 2 through 5.

TABLE 3-8 UNCONSTRAINED ACTIVITY FORECAST TOTAL ANNUAL PASSENGERS AND OPERATIONS – FISCAL YEARS 2018-2045

FISCAL YEAR[1]	MILLION ANNUAL PASSENGERS	ANNUAL OPERATIONS
2018	86.1	715,000
2019	88.3	722,000
2020	90.6	729,000
2021	92.9	736,000
2022	95.3	744,000
2023	97.7	752,000
2024	100.3	760,000
2025	102.9	769,000
2026	105.5	778,000
2027	108.1	789,000
2028	110.8	800,000
2029	113.4	811,000
2030	116.0	822,000
2031	118.6	833,000
2032	121.2	843,000
2033	123.8	853,000
2034	126.5	864,000
2035	129.1	874,000
2036	131.7	883,000
2037	134.3	893,000
2038	137.0	902,000
2039	139.6	912,000
2040	142.2	921,000
2041	144.8	930,000
2042	147.5	939,000
2043	150.1	947,000
2044	152.8	956,000
2045	155.6	965,000
CAGR		
2018–2045	2.2%	1.1%

NOTES:
CAGR: Compound Annual Growth Rate
1 The fiscal year is July 1 through June 30.
SOURCE: Ricondo & Associates, Inc., January 2018 (based on results of forecast analyses).

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4. CONSTRAINED DEMAND SCENARIO

4.1 APPROACH

The aviation activity forecast documented in Section 3 provides estimates of future activity at LAX through FY 2045 based on a review of historical data and trends, and the results of a regression analysis based on socioeconomic factors. These results represent "unconstrained" activity forecast results because no constraints were applied that would limit the ability of LAX to accommodate the projected demand for air travel to and from the LA Basin. In other words, the unconstrained analysis assumes that LAX could accommodate projected growth in demand that may exist between now and FY 2045, as discussed in Section 3.

In the real world, this assumption may be unrealistic. Airports, including LAX, generally have facility or operational constraints that limit the extent to which they can accommodate unlimited market demand. The "constrained demand" scenario is designed to reflect this eventuality. The unconstrained analysis is used as a starting point, and then the constrained forecast is developed to reflect constraints that may exist at an airport at a particular point in time.

As discussed in FAA Advisory Circular 150/5060-5, each airport is comprised of various airport functional components such as runways, taxiways, and gates.[14] For analytical purposes, LAX's functional components can be grouped into three categories: airfield (including runways and taxiways); terminal (including terminal facilities and gates); and landside (including roadways and terminal roadway curbs). The intent of developing a constrained demand scenario was to assess if any of the three categories of functional components would limit LAX's ability to accommodate the unconstrained forecast activity levels discussed in Section 3.

Based on their expert and institutional knowledge of LAX's airside, facilities, and operations, LAWA's consultant team recommended the development and testing of design day flight schedules to identify potential constraints, based on which, results would be annualized and compared to the annual unconstrained forecast results presented in Section 3. In addition, the LAWA consultant team analyzed the airfield component as a starting point for the technical analyses, as discussed in **Section 4.2** because the airfield component is the vital component which accommodates aircraft landings and takeoffs. The terminal and landside components are subsequently discussed in **Section 4.3**.

4.2 AIRFIELD COMPONENT

The following sections present the technical analyses conducted to estimate potential constraints associated with airfield operations at LAX.

4.2.1 DEFINITION OF AIRFIELD PRACTICAL CAPACITY

As discussed in the U.S. Congress Office of Technology Assessment report on airport system development, there are two commonly used definitions of airfield capacity. The first definition is the throughput capacity definition. FAA Advisory Circular 150/5060-5 defines capacity as "throughput capacity" which is "a measure of the maximum

[14] U.S. Department of Transportation, Federal Aviation Administration, *Advisory Circular 150/5060-5, Airport Capacity and Delay*, September 1983, Section 1-2, page 1-1. Available: https://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.current/documentNumber/150_5060-5.

number of aircraft operations which can be accommodated on the airport or airport component in an hour."[15] The second definition is the practical capacity definition which incorporates the concept of aircraft delay into the definition of throughput capacity.[16] Accordingly, practical capacity is "the number of operations (takeoffs and landings) that can be accommodated with no more than a given amount of delay, usually expressed in terms of maximum acceptable average delay."[17]

The following definitions further help to define the concept of practical capacity used for planning purposes in the LAX Airfield and Terminal Modernization Project technical analyses. Each definition builds upon the previous definition to eventually define the concept of practical capacity of the airfield component.

Delay: as defined in FAA Advisory Circular 150/5060-5, aircraft delay is "the difference between constrained and unconstrained operating time."[18] For the purposes of the LAX Airfield and Terminal Modernization Project technical analyses, delay refers to the difference between the actual time it takes an aircraft to conduct an arrival or departure and the time it would take to conduct the same operation with no interference from other aircraft or vehicles on the airfield.

Average annual delay: as discussed in FAA Advisory Circular 150/5060-5, "calculations of hourly capacity are needed to determine average delay. Since airport and airport component hourly capacities vary throughout the day due to variations in runway use, aircraft mix, [air traffic control] ATC rules, etc., a number of calculations may be needed."[19] For the purposes of the LAX Airfield and Terminal Modernization Project technical analyses, and to capture average conditions throughout the year, the technical analyses focused on average annual delays.

Acceptable delay: per the Office of Technology Assessment, "practical capacity is value judgment-a consensus among airport users and operators—about how much delay they can tolerate."[20] Per FAA guidance, average delay per operation of 10 minutes or more may be considered severe. Beyond 20 minutes of average delay, growth in operations would be impeded and airlines would make schedule adjustments.[21] Based on discussions with FAA and

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[15] U.S. Department of Transportation, Federal Aviation Administration, *Advisory Circular 150/5060-5, Airport Capacity and Delay*, September 1983, Section 1-2, page 2. Available: https://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.current/documentNumber/150_5060-5.

[16] Throughput capacity is a measure of the maximum number of aircraft operations which can be accommodated on the airport or airport component in an hour. U.S. Department of Transportation, Federal Aviation Administration, *Advisory Circular 150/5060-5, Airport Capacity and Delay*, September 1983, Section 1-2, page 2. Available: https://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.current/documentNumber/150_5060-5.

[17] U.S. Congress, Office of Technology Assessment (OTA-STI-231), *Airport System Development*, August 1984, Chapter 3, page 46. Available: https://www.princeton.edu/~ota/disk3/1984/8403/8403.PDF.

[18] U.S. Department of Transportation, Federal Aviation Administration, *Advisory Circular 150/5060-5, Airport Capacity and Delay*, September 1983, Section 1-3, page 2. Available: https://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.current/documentNumber/150_5060-5.

[19] U.S. Department of Transportation, Federal Aviation Administration, *Advisory Circular 150/5060-5, Airport Capacity and Delay*, September 1983, Section 1-3, page 2. Available: https://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.current/documentNumber/150_5060-5.

[20] U.S. Congress, Office of Technology Assessment (OTA-STI-231), *Airport System Development*, August 1984, Chapter 3, page 46. Available: https://www.princeton.edu/~ota/disk3/1984/8403/8403.PDF.

[21] U.S. Department of Transportation, Federal Aviation Administration, *FAA Airport Benefit-Cost Analysis Guidance*, December 1999, Section 10.4, page 39. Available: https://www.faa.gov/airports/aip/bc_analysis/.

simulation analyses of the LAX airfield, LAWA selected 15 minutes of annual average delay per aircraft operation as an indicator beyond which airfield delay may be increasingly unacceptable to airport management and operators.

All weather delay: Airfield operating configurations are defined to represent the runways that are used for arrivals and departures under a variety of operating conditions and Air Traffic Control (ATC) procedures. Wind speed and wind direction dictate the direction in which the runways are utilized for arrivals and departures (i.e., east flow or west flow). Ceiling height and visibility determine the ATC procedures that are in effect, which include visual flight rules (VFR), marginal visual flight rules (MVFR), and instrument flight rules (IFR). Airport operations are generally more efficient under VFR, with operations being less efficient under MVFR and IFR, as visibility decreases or cloud cover increases and increased separation is required between aircraft to maintain safe operations.[22] For the purposes of the LAX Airfield and Terminal Modernization Project technical analyses, simulation results were averaged among all conditions (VFR, MFVR, and IFR) to represent average annual all weather delays.

Practical capacity: Based on the above definitions, practical capacity of the airfield was defined for planning purposes in the LAX Airfield and Terminal Modernization Project technical analyses as the annualized number of aircraft operations that can be accommodated by the airfield resulting in 15 minutes of annualized average all-weather delay.

It is important to note that 15 minutes of average delay is not considered a fixed limit or ceiling. Instead, it is meant to reflect an indicator of average delay conditions consistent with current guidance provided by the FAA as discussed above (i.e., within a range between 10 and 20 minutes of delay). It is challenging to estimate with precise certainty how much delay LAX aircraft operators would tolerate and, as a result, how airlines would adjust to increased congestion and delays. In addition, what is considered acceptable level of delay may change over time, depending on the airport operators or the airport's operational conditions. Therefore, these analyses reflect industry standard approaches to defining airfield practical capacity and the LAWA consultant team's understanding of airline operations and business practices.

4.2.2 ACTIVITY LEVELS ASSOCIATED WITH ESTIMATED AIRFIELD PRACTICAL CAPACITY

As defined above, the intent was to estimate the annualized number of aircraft operations at an assumed level of 15 minutes of annualized average all-weather delay (i.e., the estimated airfield practical capacity). This annualized number of aircraft operations would represent the level of activity beyond which delays are considered increasingly unacceptable and airlines would be expected to make changes in their schedules and operations. Under this scenario, demand for air travel would be considered constrained by airfield limitations, because such delays are expected to impede operations and trigger airlines to make schedule adjustments (including changes in fleet mix and reductions operations), as discussed above. See **Section 4.4** for a detailed discussion on the anticipated changes and constrained demand scenario characteristics.

As discussed in FAA Advisory Circular 150/5070-6B, computer simulation modeling may be necessary to support the analysis of airfield capacity, specifically for complex airports such as LAX which operate around the clock.[23]

[22] VFR: ceiling and visibility allow for visual approaches, at least 5,000 feet ceiling and 3 miles visibility; MVFR: ceiling and visibility below visual approach minima but better than Instrument conditions; IFR: ceiling and visibility below 600 feet ceiling or 2 miles visibility.

[23] U.S. Department of Transportation, Federal Aviation Administration, *Advisory Circular 150/5070-6B, Change 2 to Airport Master Plans*, January 2015, Section 805, page 51. Available: https://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.current/documentNumber/150_5070-6.

Accordingly, and as recommended in FAA Advisory Circular 150/5060-5,[24] the LAWA consultant team used the FAA's approved simulation model SIMMOD. SIMMOD is a fast-time simulation model used to analyze airspace and airfield operations. The FAA originally developed the model and released it to the public in 1989. Since its release, the model has been further developed by both private and government entities, and it has been used to support numerous airport planning and environmental analyses.

Estimating the activity levels associated with 15 minutes of annualized average all-weather delays was conducted through an iterative process, which included the development of design day flight schedules and the analysis of SIMMOD simulation delay results.

As discussed in the U.S. Congress Office of Technology Assessment report, as demand approaches the limit of throughput capacity, delays increase sharply.[25] Accordingly, the relationship between the increase in the number of operations and the sharp increase in average delay levels is defined as exponential in mathematical terms.[26] For planning purposes, an exponential delay curve was used to estimate activity levels associated with the estimated airfield practical capacity.

Three activity levels are required to define an exponential delay curve. The first two activity levels corresponded to flight schedules developed for the purposes of the LAX Airfield and Terminal Modernization Project environmental analyses: a FY 2018 design day flight schedule (with 2,013 daily operations) representative of approximately 715,000 annual aircraft operations; and a FY 2028 design day flight schedule (with 2,253 daily operations) representative of approximately 800,000 annual aircraft operations. A third design day flight schedule was selected to be FY 2035 (with 2,461 daily operations) representative of approximately 874,000 annual aircraft operations.

Exhibit 4-1 depicts the estimated airfield delay curves developed based on SIMMOD simulation results. Each dot represents simulated annualized average all-weather delay results for each tested level of activity for FY 2018, 2028 and 2035. The estimated delay curve was then computed to illustrate the exponential relationship between the number of aircraft operations and the resulting annualized average delays. Accordingly, annualized average all-weather delays would reach 15 minutes at approximately 833,000 annual aircraft operations (as extrapolated).

The estimated airfield practical capacity was, therefore, assumed to be approximately 833,000 annual aircraft operations at 15 minutes of annualized average all-weather delay. Based on the results of the forecasts presented in Table 3-8 in Section 3.4. 833,000 annual aircraft operations would be reached around FY 2031.

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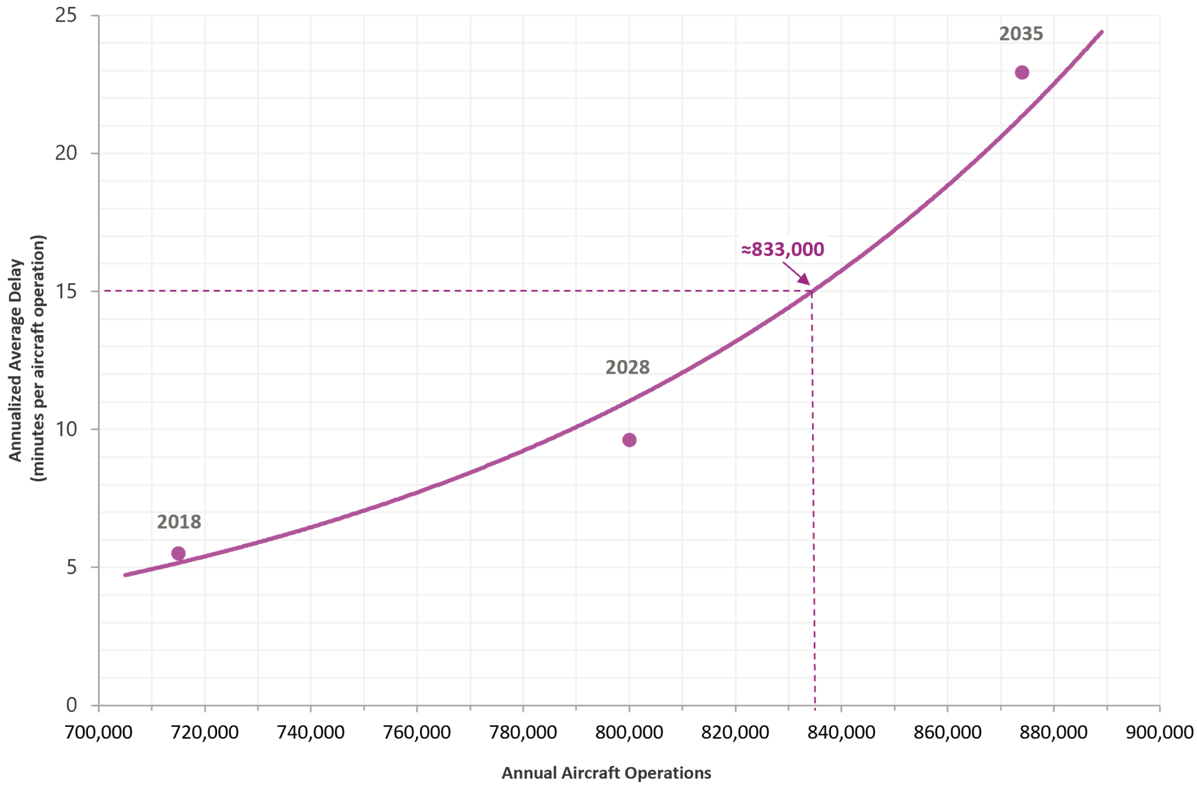
[24] U.S. Department of Transportation, Federal Aviation Administration, Advisory Circular 150/5060-5, *Airport Capacity and Delay*, September 1983, Section 5-2, page 91. Available: https://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.current/documentNumber/150_5060-5.

[25] U.S. Congress, Office of Technology Assessment (OTA-STI-231), *Airport System Development*, August 1984, Chapter 3, page 46. Available: https://www.princeton.edu/~ota/disk3/1984/8403/8403.PDF.

[26] Exponential growth refers to a sharp increase in one variable (in this case, average airfield delay) as a result of an increase in another variable (in this case, the number of aircraft operations).

EXHIBIT 4-1 ESTIMATED AIRFIELD DELAY CURVE



SOURCE: Ricondo & Associates, Inc., July 2018, based on results of airfield SIMMOD simulation analyses.

Similar to the discussion above regarding the 15-minute indicator, it is important to note that an activity level of 833,000 annual aircraft operations is not considered a fixed, rigid limit on the number of flights that LAX can accommodate. Rather, it is an estimate of the number of flights at which aircraft delay would reach 15 minutes of annualized average all-weather delay. Many factors contribute to aircraft delays, such as air traffic control procedures, weather conditions, and aircraft fleet mix, to name a few. Accordingly, aircraft delay levels may occur at an activity level below or above 833,000 annual aircraft operations. LAX would continue to accommodate aircraft operations beyond 833,000 annual operations, but at increasingly higher congestion and levels of delay commensurate with a higher number of aircraft operations, as depicted in Exhibit 4-1. Similarly, depending upon how demand at LAX varies over the next decade, 833,000 annual aircraft operations may be reached before or after FY 2031. Accordingly, the associated year (in this instance, FY 2031) is not as critical as the level of activity at which LAX would reach 15 minutes of annualized average all-weather delay. As discussed in Section 2.2 and the preamble to this Report, many factors and events may affect timing of LAX reaching 833,000 annual aircraft operations.

4.3 TERMINAL AND LANDSIDE COMPONENTS

As discussed in Section 4.1, the intent of developing a constrained demand scenario was to assess if any of the three airport components (airfield, terminal, and landside) would limit LAX's ability to accommodate the unconstrained forecast activity levels. In light of the results of the analysis of the airfield component presented in Section 4.2, the next step is to determine if the terminal or landside components would limit LAX's ability to accommodate the unconstrained forecast activity levels before the airfield component would.

Terminal Component

Several terminal facilities at LAX have been in the process of being modernized to ensure the ability of aging terminal facilities and passenger processors to accommodate demand for air travel.[27] These projects include the Midfield Satellite Concourse, the LAX Terminals 2 and 3 Modernization Project, and LAX Terminal 1.5 Project. Therefore, existing and planned terminal facilities would provide adequate processing facilities for all existing and planned passenger gates in FY 2028 and FY 2033. This is evidenced by the fact that flight schedules developed to support airfield simulation efforts for FY 2028 and FY 2033 were successfully gated, and that existing and planned passenger gates at LAX can accommodate the FY 2028 and FY 2033 projected aircraft fleet mixes.

Landside Component

As shown in Table 2-1, passenger activity levels at LAX grew at a 4.9 percent CAGR between FY 2009 and FY 2017 suggesting no direct correlation between historical passenger activity levels and the existing congested conditions of the LAX Central Terminal Area (CTA) and surrounding roadways. Therefore, airport roadway congestion has not presented an obstacle to passenger growth. Although congested traffic conditions in the CTA at LAX may cause passengers to alter their behavior and arrive at the Airport earlier to account for traffic delays, the decision to choose to fly to, from, or through LAX is driven by many other factors such as air service availability, price, itineraries, flight schedules, airport convenience, airline quality, airport quality, and loyalty programs.[28] Similarly, airlines do not consider CTA or nearby surface traffic congestion as a factor in their business decisions regarding scheduling flights at LAX. Rather airlines consider a complex mix of network-wide aircraft inventory and yield management to support their scheduling decisions.[29] Airlines have continued to schedule more seats to respond to passenger demand over the period of FY 2009 and FY 2018, despite surface congestion, and there is no indication that they will change this pattern. Ongoing and planned improvements to landside facilities and operations at LAX, including the LAX Landside Access Modernization Program, aim to alleviate congestion inside the LAX CTA over the forecast period. For these reasons, the landside component is expected to be able to accommodate passengers in FY 2028 and FY 2033.

Accordingly, the airfield component would be the first of the three airport system components to constrain the ability of LAX to accommodate the forecasted unconstrained demand presented in Section 3. As discussed in Section 4.2, airfield limitations would result in an anticipated slowdown in aircraft operation growth by FY 2033 as a result of activity levels reaching the estimated airfield practical capacity and airlines making changes in aircraft operations (e.g., larger aircraft with higher seat counts and higher passenger load factors). The anticipated slowdown in aircraft operations is the basis for the development of a constrained demand scenario, documented in the following sections.

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[27] For more details, see: https://www.lawa.org/lawa-our-lax/environmental-documents.

[28] Transportation Research Board of the National Academies, Airport Cooperative Research Program, *ACRP Report 98, Understanding Airline and Passenger Choice in Multi-Airport Regions*, 2013, p. 13, Available: http://www.trb.org/Publications/Blurbs/170194.aspx.

[29] Transportation Research Board of the National Academies, Airport Cooperative Research Program, *ACRP Report 98, Understanding Airline and Passenger Choice in Multi-Airport Regions*, 2013, p. 5, Available: http://www.trb.org/Publications/Blurbs/170194.aspx.

4.4 CONSTRAINED DEMAND SCENARIO CHARACTERISTICS

4.4.1 ANTICIPATED OPERATIONAL CHANGES

Formulating a constrained demand scenario entails assessing potential changes in operations as a result of LAX experiencing delays approaching 15 minutes of annualized average all-weather delay. As LAWA continues to maintain and provide modernized facilities at LAX, changes in operations in a constrained environment could result from actions taken by the FAA or the airlines and other aircraft operators, as further discussed below.

The FAA categorizes airports based on levels (Levels 1-3) indicating their degree of congestion.[30] LAX continues to be designated as a Level 2 airport by the FAA because existing delays can be managed with some guidance on the number and timing of flights through schedule facilitation.[31] This is typically the case during periods of construction at airports that are frequently busy and operating at levels where reductions in capacity associated with construction would increase levels of congestion and delay. It is uncertain how long LAX will remain a designated Level 2 airport, or if the FAA would consider additional demand management controls to limit the number of aircraft operations as aircraft delays continue to increase.

In FY 2018, LAX accommodated approximately 65 commercial passenger airlines, 30 cargo carriers, and a number of unscheduled business and leisure aircraft operators. Commercial passenger airlines are inherently more sensitive to delays than cargo and unscheduled operators because delays have direct impacts on passenger satisfaction, network connections, and operating costs. FAA guidance states that airlines would react to increased congestion and delay prior to reaching 20 minutes of delay, and would begin to use larger aircraft, adjust schedules, and cancel or consolidate flights during peak delay periods.[32] In addition, any changes implemented by the aircraft operators (mainly commercial passenger airlines and cargo operators) must be in the context of the overall operators' networks, not just based on LAX operations. Adjustments to flight schedules is a complex task which involves considering various objectives to optimize flight schedules, considering revenues (including decisions on times, frequencies, competition), constraints (aircraft size, maintenance, flight crews), reliability (flexibility, spare aircraft, reserve crews), and efficiency (aircraft size, gate utilization, flight crews, and maintenance).[33] Similar changes would also apply to cargo operators; and to a certain extent to unscheduled operators, specifically corporate operators, as opposed to general aviation operators.

Absent any outside regulatory actions (such as the establishment of additional demand management controls by the FAA), the extent to which the commercial passenger airlines and other aircraft operators would proactively adjust their schedules and operations remains challenging to predict, especially at an airport such as LAX with many different aircraft operators and different business models and operating requirements. The primary anticipated

[30] Level 1 airports have sufficient capacity to meet demand. Level 2 airports may have some periods when demand approaches one or more capacity limits, but a voluntary schedule-facilitation process prevents systemic delays. Level 3 airports are under slot control and require advance approval to operate during slot controlled hours. Source: U.S. Department of Transportation, Federal Aviation Administration, Slot Definition. Available: https://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/systemops/perf_analysis/slot_administration/slot_definition/, accessed March 8, 2020.

[31] U.S. Department of Transportation, Federal Aviation Administration, Slot Administration Level 2 Airports. Available: https://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/systemops/perf_analysis/slot_administration/slot_administration_schedule_facilitation/level-2-airports/, accessed March 8, 2020.

[32] U.S. Department of Transportation, Federal Aviation Administration, *FAA Airport Benefit-Cost Analysis Guidance*, December 1999, Section 10.4, page 39. Available: https://www.faa.gov/airports/aip/bc_analysis/.

[33] Cook, Gerald N. and Billig, Bruce G., *Airline Operations and Management*, 2017, p. 135.

changes under a constrained demand scenario would be up-gauging to larger aircraft (to increase both seat counts and cargo payloads), letting load factors increase (both passenger load factors and payload factors), and revising flight schedules (including consolidations, cancellations, and air service decisions on which airports to serve from LAX).

4.4.2 TIMING

The section above described the changes anticipated to be implemented as a result of increased congestion and annualized average delays approaching 15 minutes. The next step was to estimate when LAX aircraft operators would start to implement these changes.

The following assumptions were made for the purposes of the LAX Airfield and Terminal Modernization Project technical analyses:

- Commercial passenger airlines: a typical airline's planning process at a specific airport in its network takes place between one and three years prior to flight (e.g., making decisions related to pricing policies, code sharing agreements, alliance participation, and predicting competitors' behavior). Potential changes in destinations and routes are considered between 12 and 18 months in advance. Flight schedule changes would be considered between a few months and more than a year prior to flight.[34] Accordingly, for the purposes of the LAX Airfield and Terminal Modernization Project technical analyses, it was assumed that airlines would start adjusting schedules and operations between 18 months and 24 months before continued unconstrained growth would cause increasingly unacceptable conditions and delays approaching 15 minutes. This assumption assumes a voluntary and proactive approach by the airlines as part of their business planning process. It can be reasonably assumed that airlines would anticipate the impacts of increasing airfield delays on passenger level of service and satisfaction, as well as their ability to arrive and depart from gates per the scheduled times by proactively looking ahead at their future schedules.
- Cargo operators: although cargo operators do not operate on strict published schedules the same way commercial-passenger airlines do and tend to operate during off-peak hours of the day, an increase in airfield delays may affect loading and unloading of cargo times, and eventually on-time parcel deliveries. For the purposes of the LAX Airfield and Terminal Modernization Project technical analyses, it was assumed that cargo operators would react to increased congestion and delays within the same period of time assumed for the commercial passenger airlines, and most likely closer to flight time. It can be reasonably assumed that cargo operators would anticipate the impacts of increasing airfield delays on their operations by proactively looking ahead at their typical hours of operations and make any adjustments as necessary.
- Unscheduled operators: corporate business and general aviation operators operate at unpredictable times throughout the year. Unscheduled operators do not operate on strict schedules and can elect to fly to different airports in the region. As a result, no advanced adjustments in operations was assumed for the purposes of the LAX Airfield and Terminal Modernization Project technical analyses.

Therefore, it was estimated that airport operators would begin to anticipate potential effects of increasing airfield delays on their operations (and make necessary adjustments)around FY 2029, two years ahead of FY 2031 when LAX is forecasted to reach 833,000 annual aircraft operations at approximately 15 minutes of annualized average all-weather delay.

[34] Cook, Gerald N. and Billig, Bruce G., *Airline Operations and Management*, 2017, p. 133.

4.4.3 CONSTRAINED GROWTH IN AIRCRAFT OPERATIONS

As discussed above, it is estimated that aircraft operators would start reacting to increased congestion and delays by adjusting fleets, flight schedules, and load factors when approaching approximately 833,000 and 15 minutes of annualized average all-weather delay (i.e., the assumed airfield practical capacity) resulting in a slowdown in growth in aircraft operations.

As noted in Sections 4.2.1 and 4.2.2, 833,000 annual aircraft operations and 15 minutes of average delay are not limits beyond which growth would stop. Growth in aircraft operations will continue to occur but at a slower rate, in a constrained environment characterized by increasing airfield congestion and delays. Formulating a constrained demand scenario entails estimating such a constrained growth rate reflecting the anticipated slowdown in activity levels through FY 2045. In other words, the intent is to estimate the number of annual aircraft operations in FY 2045 which would reflect the anticipated slowdown in aircraft operations in a constrained environment starting around FY 2029.

As noted above, the average delay per aircraft increases exponentially as demand approaches throughput capacity. Each additional aircraft operation above the throughput capacity of the airfield component creates delays that can persist in the system for long periods of time.[35] The SIMMOD results demonstrated that an additional 60 daily aircraft operations (or approximately 20,000 annual aircraft operations) would result in increasingly longer delays beyond the 15-minute indicator.

Using the estimated airfield delay curve in Exhibit 4-1, an additional 20,000 operations or 853,000 annual aircraft operations would result in approximately 18 minutes of annualized average all-weather delay, which is approximately midpoint between 15 and 20 minutes of annualized average all-weather delay.[36] The approach to estimating 853,000 annual aircraft operations in FY 2045 is consistent with the results of the SIMMOD estimated airfield delay curve (see Section 4.2.2), as well as FAA guidance discussed in Section 4.2.1 which suggests that airfield average delays between 10 and 20 minutes would be severe and would impede growth in aircraft operations.

The process of adjusting fleets and flight schedules is expected to be gradual over time. As a result, anticipated growth in aircraft operations would continue to increase at a reduced rate of growth under the constrained demand scenario through FY 2045. Changes to aircraft types and schedules at LAX results in operational effects throughout the airline networks, not just at LAX. In addition, as discussed above, airline fleet and schedule planning typical occurs between 12 and 18 months in advance. Therefore, these anticipated gradual adjustments are reflected in a reduced rate of growth through FY 2045 at approximately 0.7 percent CAGR (i.e., the growth rate between 715,000 annual aircraft operations in FY 2018 and 853,000 annual aircraft operations in FY 2045) under a constrained demand scenario. This compares to an unconstrained growth in aircraft operations at a 1.1 percent CAGR between FY 2018 and FY 2045, as discussed in Section 3.4.

[35] U.S. Congress, Office of Technology Assessment (OTA-STI-231), *Airport System Development*, August 1984, Chapter 3, page 46. Available: https://www.princeton.edu/~ota/disk3/1984/8403/8403.PDF.

[36] The contribution to overall airfield delays of these additional 20,000 annual aircraft operations (between 833,000 and 853,000 annual aircraft operations) would be partially dependent on the specific characteristics of these additional operations (e.g., aircraft type, origin or destination, etc.) and what time of day they would occur (i.e., during peak or during non-peak periods).

4.4.4 CONSTRAINED GROWTH IN PASSENGER ACTIVITY LEVELS

As discussed in Section 4.4.1, it is anticipated that commercial passenger airlines would modify their flight schedules to respond to increased congestion and delays by implementing any combination of the following actions: upgauging to larger aircraft; allowing load factors to increase; and revising flight schedules (including consolidations, cancellations, and air service decisions on which airports to serve from LAX). It would be speculative to attempt to predict which sets of actions each of the 65+ commercial passenger airlines would implement over time. Therefore, the estimated reduced rate in passenger activity level growth was determined based on assumptions for LAX as a whole as described below.

A constrained demand scenario would result in approximately 853,000 annual aircraft operations by FY 2045. As documented in Section 2.1.1, commercial passenger operations were assumed to represent approximately 90 percent of the overall operations at LAX, which would equate to approximately 767,700 annual commercial passenger aircraft operations. It was also assumed that commercial passenger airlines would allow load factors to increase up to approximately 90 percent, while continuing to operate a predominantly narrowbody fleet at LAX (as documented in Table 3-6 by the LAX average number of seats per departure representative of ADG III aircraft) allowing them to service and load and unload passengers within more expeditious timeframes than widebody aircraft. An airport average of approximately 190 seats per aircraft (representative of a large ADG III aircraft) was assumed.[37] As a result, a constrained demand scenario with approximately 853,000 annual aircraft total operations would result in approximately 127.9 MAP by FY 2045, which represents a 1.5 percent CAGR in passenger activity levels. This compares to an unconstrained growth in passengers at a 2.2 percent CAGR between FY 2018 and FY 2045, as discussed in Section 3.4.

4.5 CONSTRAINED DEMAND SCENARIO FORECAST RESULTS

Table 4-1 presents the forecast total annual passengers and operations (rounded to the nearest 1,000 operations for estimation purposes) between FY 2018 and FY 2045 under the constrained demand scenario documented in the above sections. A measured decrease in growth rate was assumed to begin approximately two years ahead of activity levels reaching 833,000 annual aircraft operations around FY 2029. Beyond that point, aircraft operations and passenger activity levels are assumed to grow at a slower pace through FY 2045.

As shown in Table 4-1, under the constrained demand scenario forecast, passenger activity levels are forecasted to grow at a 1.5 percent CAGR through FY 2045, while total aircraft operations are forecasted to grow at a 0.7 percent CAGR through FY 2045 (compared to 2.2 percent and 1.1 percent under the unconstrained activity forecast, respectively).

Exhibit 4-2 below provides line graphs comparing the results of the unconstrained activity forecast (documented in Section 3) and the constrained demand scenario forecast for passenger activity levels and aircraft operations. As this exhibit shows, passenger activity levels would continue to grow from year to year, but the rate of growth would be lower due to the anticipated airfield-related constraints described above.

To support the FAA's review and approval process, please see the **Attachment** to this Report for a comparison of these LAX activity forecasts and the FAA's TAF.

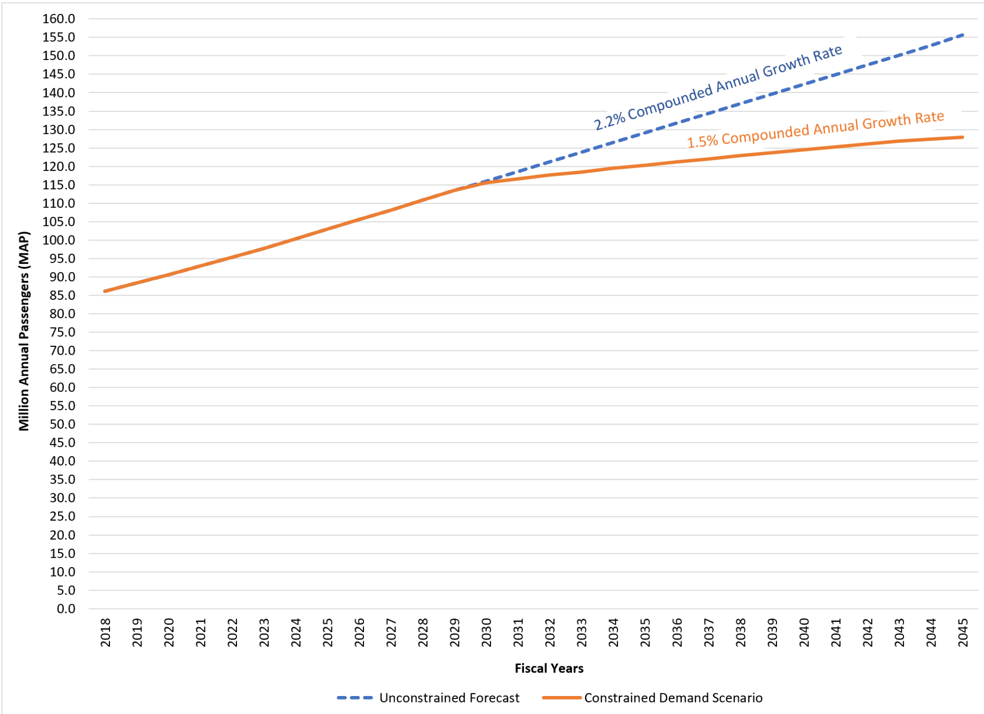
[37] This is an airport average number of seats per aircraft. Airlines operating at LAX will continue to operate widebody aircraft (ADG V and VI) with higher seat counts on long-distance flights.

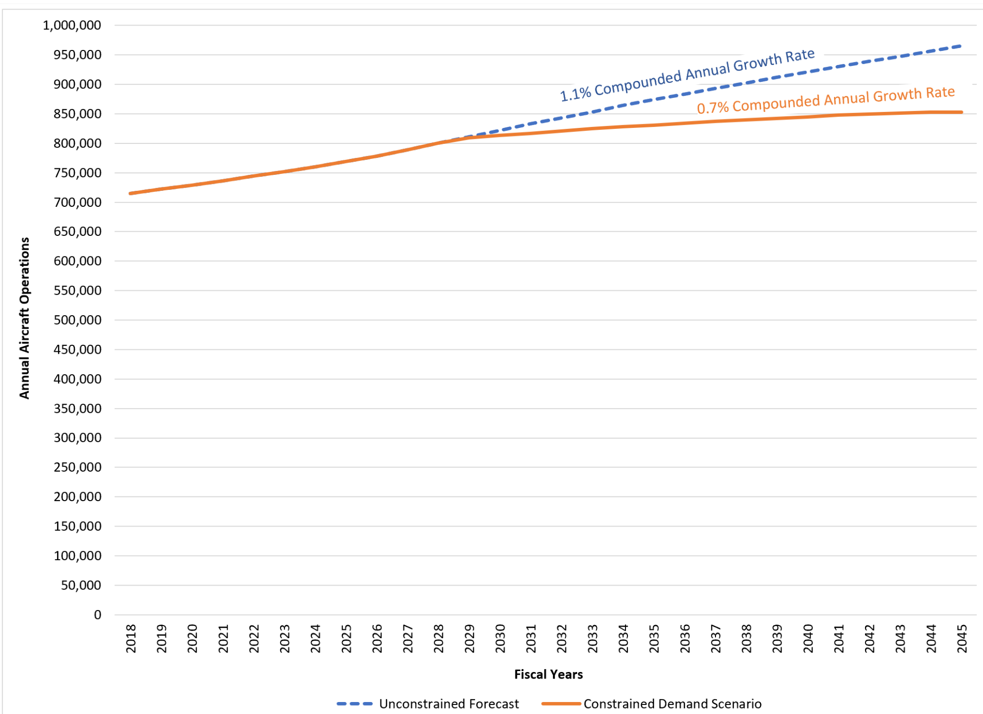
TABLE 4-1 CONSTRAINED DEMAND SCENARIO FORECAST TOTAL ANNUAL PASSENGERS AND OPERATIONS – FISCAL YEARS 2018-2045

FISCAL YEAR[1]	MILLION ANNUAL PASSENGERS	ANNUAL OPERATIONS
2018	86.1	715,000
2019	88.3	722,000
2020	90.6	729,000
2021	92.9	736,000
2022	95.3	744,000
2023	97.7	752,000
2024	100.3	760,000
2025	102.9	769,000
2026	105.5	778,000
2027	108.1	789,000
2028	110.8	800,000
2029	113.4	809,000
2030	115.6	813,000
2031	116.6	817,000
2032	117.6	821,000
2033	118.5	824,500
2034	119.5	828,000
2035	120.3	831,000
2036	121.2	834,000
2037	122	837,000
2038	122.9	840,000
2039	123.7	842,500
2040	124.5	845,000
2041	125.3	847,500
2042	126.1	849,500
2043	126.8	851,500
2044	127.4	852,500
2045	127.9	853,000
CAGR		
2018–2045	1.5%	0.7%

NOTES:
CAGR – Compound Annual Growth Rate
1 The fiscal year is July 1 through June 30.
SOURCE: Ricondo & Associates, Inc., May 2019 (based on results of forecast analyses).

EXHIBIT 4-2 COMPARISON OF UNCONSTRAINED AND CONSTRAINED DEMAND SCENARIO FORECASTED PASSENGERS AND OPERATIONS ACTIVITY LEVELS





SOURCE: Ricondo & Associates, Inc., May 2019 (based on results of forecast analyses).

ATTACHMENT

LAX Airfield and Terminal Modernization Project Forecasts Comparison with 2019 FAA Terminal Area Forecast Results

ATTACHMENT: LAX AIRFIELD AND TERMINAL MODERNIZATION PROJECT FORECASTS COMPARISON WITH 2019 FAA TERMINAL AREA FORECAST RESULTS

For Federal Aviation Administration (FAA) review purposes, **Table 1** provides a comparison of the forecast results prepared for the LAX Airfield and Terminal Modernization Project and the most recent FAA Terminal Area Forecast (TAF) results. The forecasting efforts and the constrained demand scenario was completed in May 2019. However, since then, the FAA has published the 2019 TAF results in January 2020, which were used in this table.

TABLE 1 FORECAST COMPARISONS WITH 2019 FAA TERMINAL AREA FORECAST RESULTS

YEARS[1]		AIRPORT FORECASTS		2019 FAA TERMINAL AREA FORECAST	AIRPORT FORECAST/TAF (% DIFFERENCE)	
		UNCONSTRAINED FORECAST	CONSTRAINED DEMAND SCENARIO		UNCONSTRAINED FORECAST	CONSTRAINED DEMAND SCENARIO
Passenger Enplanements						
Base Year	2018	43,066,000	43,066,000	42,381,489	1.60%	1.60%
Base Year + 5 Years	2023	48,866,000	48,866,000	45,922,110	6.40%	6.40%
Base Year + 10 Years	2028	55,391,000	55,391,000	51,680,294	7.20%	7.20%
Base Year + 15 Years	2033	61,923,000	59,250,000	58,005,183	6.80%	2.10%
Commercial Operations						
Base Year	2018	700,252	700,252	688,079	1.80%	1.80%
Base Year + 5 Years	2023	736,960	736,960	711,958	3.50%	3.50%
Base Year + 10 Years	2028	784,000	784,000	792,962	-1.10%	-1.10%
Base Year + 15 Years	2033	835,940	808,010	884,558	-5.50%	-8.70%
Total Operations						
Base Year	2018	714,543	714,543	706,513	1.10%	1.10%
Base Year + 5 Years	2023	752,000	752,000	730,722	2.90%	2.90%
Base Year + 10 Years	2028	800,000	800,000	812,240	-1.50%	-1.50%
Base Year + 15 Years	2033	853,000	824,500	904,365	-5.70%	-8.80%

NOTES:
TAF: Terminal Area Forecast
1 The LAX forecasts were prepared based on City of Los Angeles fiscal year (July 1 through June 30); whereas the FAA Terminal Area Forecasts are prepared based on the Federal Government fiscal year (October 1 through September 30).
SOURCES: U.S. Department of Transportation, Federal Aviation Administration, 2019 Terminal Area Forecast results, January 2020; Ricondo & Associates, Inc., March 2020 (based on forecast results and calculations of variance percentages with the 2019 FAA Terminal Area Forecast results).

Based on FAA variance guidance, forecast results are considered consistent with the TAF if the results differ by less than 10 percent in the 5-year forecast period, and 15 percent in the 10-year forecast period.[38] As documented in Table 1, all variance percentages are below 10 percent.

The constrained demand scenario forecast results represent the recommended forecasts to be used for the purposes of the LAX Airfield and Terminal Modernization Project analyses and would be deemed consistent with the most recent TAF based on the FAA variance guidelines.

[38] U.S. Department of Transportation, Federal Aviation Administration, *Review and Approval of Aviation Forecasts*, June 2008, p.1. Available: https://www.faa.gov/airports/planning_capacity/media/approval_local_forecasts_2008.pdf.

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Appendix B.2 Operational Analyses Report

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October 2020 | DRAFT

Los Angeles International Airport

LAX Airfield and Terminal Modernization Project

Operational Analyses Report

Prepared for:

Los Angeles World Airports

Prepared by:

RICONDO

TABLE OF CONTENTS

LIST OF TABLES

LIST OF EXHIBITS

This Operational Analyses Report documents technical analyses conducted to support the preparation of LAX Airfield and Terminal Modernization Project environmental documents. These technical analyses were conducted to evaluate potential air quality and noise operational impacts associated with the proposed project compared to no project conditions. This entailed converting the annual activity forecast results (documented in the LAX Airfield and Terminal Modernization Project Activity Forecasts Report) [1] into flight schedules representative of anticipated future aircraft operations and passenger activity levels at LAX (including anticipated aircraft types, destinations and flight schedule characteristics). **Section 1** documents the development of Design Day Flight Schedules (DDFSs) prepared based on results of the forecast analyses. **Section 2** presents the results of the gating process during which flights included in DDFSs are assigned to terminals and passenger gates. **Section 3** documents the airfield simulation analyses of the DDFSs.

Technical analyses documented in this report were initiated in early 2018, in the middle of Fiscal Year (FY) 2018. Therefore, the sections below discuss data for activity in Calendar Years (CY) 2017 and 2018 used to estimate data for the entirety of FY 2018.

1. DESIGN DAY FLIGHT SCHEDULES

1.1 INTRODUCTION

This section presents the assumptions, methodology, and analyses used to develop the DDFSs. The DDFSs represent a reasonable depiction of anticipated aircraft operations and passenger activity levels expected to be representative of operations on a peak month average day (PMAD) at LAX.[2] DDFSs are modeled representations of potential arriving and departing passenger and aircraft activity at LAX on a future PMAD; they are intended to provide an indication of potential future individual aircraft operator activity and service patterns, and are used as input files into technical analyses related to the LAX Airfield and Terminal Modernization Project. The DDFSs were developed based on results of the forecast analyses, presented in the LAX Airfield and Terminal Modernization Project Activity Forecasts Report and, therefore, include similar uncertainties associated with predicting operational and scheduling characteristics, of future aircraft fleets.

The DDFSs include aircraft operations and passenger activity projected at LAX during a PMAD for baseline year FY 2018 and future years FY 2028, which is consistent with the long-term forecast presented in the LAX Airfield and Terminal Modernization Project Activity Forecasts Report.[3]

1.2 FY 2018 DESIGN DAY FLIGHT SCHEDULE DEVELOPMENT

Historically, the months of July and August are the busiest months at LAX, often representing similar percentages of annual operations. Based on the FAA's Air Traffic Activity Data System database, the months of July and August

1 Ricondo & Associates, Inc., *LAX Airfield and Terminal Modernization Project Activity Forecasts Report*, August 2020.

2 Flight schedules are prepared to be representative of anticipated future aircraft and passenger activity levels at LAX. Following industry standards for airport planning, and as discussed in the Transportation Research Board (TRB) Airport Cooperative Research Program (ACRP) Synthesis 2, *Airport Aviation Activity Forecasting* (p. 9), projected activity levels are intended to represent activity during a busy (or "peak") month at an airport, while capturing average conditions (as opposed to a day with the highest number of operations and passengers which may not happen often). Accordingly, flight schedules representative of activity on an average day in the peak month were prepared for these analyses, as documented in this report.

3 Ricondo & Associates, Inc., *LAX Airfield and Terminal Modernization Project Activity Forecasts Report*, August 2020.

were the busiest months in CY 2017 at LAX, with 62,402 and 62,068 monthly operations, respectively. Each month represented 8.9 percent of the CY 2017 total operations.[4] Using the peak month of July 2017 operations, the PMAD number of operations was calculated to be 2,013 daily operations (62,402 divided by 31 days), of which 1,852 operations are scheduled passenger airline operations, with the remaining 161 operations being unscheduled operations.

Scheduled Passenger Airline Operations

Published airline schedules provide information on each scheduled passenger airline operation, including types of aircraft, numbers of seats, market served, and flight times by airline. A published airline schedule including 1,852 scheduled passenger airline operations was selected as the basis for the FY 2018 DDFS.[5] Passenger totals on each flight were calculated by applying load factors (defined as the percentage of seats occupied by passengers on a flight) to the number of seats on the flight per the published airline schedules. Origin and Destination (O&D) and connecting passenger percentages were applied to estimate the O&D and connecting passenger numbers for each flight.[6]

Unscheduled Operations

To develop the unscheduled activity portion of the FY 2018 DDFS (i.e., all-cargo, air taxi, general aviation [GA], and military operations), a radar flight dataset was captured from LAWA's Airport Noise and Operations Management System. A day with approximately 161 unscheduled operations was selected as representative of PMAD conditions at LAX, and it served as the FY 2018 baseline schedule for unscheduled operations. This radar flight dataset provided data on carrier, aircraft type, tail number, origin/destination, flight number, and time of arrival/departure.

1.3 FUTURE YEARS DESIGN DAY FLIGHT SCHEDULE DEVELOPMENT

The future year FY 2028 DDFS was developed to represent the PMAD activity associated with the results of the long-term constrained demand scenario forecasts presented in the LAX Airfield and Terminal Modernization Project Activity Forecasts Report.[7]

The ratios of base year PMAD activity to annual activity of passengers (0.31 percent) and operations (0.28 percent) were assumed to remain consistent over the planning horizon, and were applied to the results of the annual forecasts. The resulting aircraft operations and passenger activity assumptions for FY 2018 and 2028are summarized in **Tables 1-1** and **1-2**.

[4] U.S. Department of Transportation, Federal Aviation Administration, *Air Traffic Activity System (ATADS) Report*, January 2018. Available: https://aspm.faa.gov/opsnet/sys/Airport.asp.

[5] Source: Ricondo & Associates, Inc., January 2018, based on published scheduled data downloaded from Diio, Inc.

[6] Origin & Destination (O&D) passengers are passengers who begin or end their trip at LAX, as opposed to connecting passengers who only travel via LAX on their way to their final destination. Source: Ricondo & Associates, Inc., January 2018, based on United States Department of Transportation T-100 and Origin and Destination (O&D) databases (accessed through Diio, Inc.).

[7] Ricondo & Associates, Inc., *Activity Forecasts Report*, May 2020.

TABLE 1-1 PEAK MONTH AVERAGE DAY TO ANNUAL RATIOS – PASSENGERS

	PASSENGERS		
FISCAL YEAR[1]	ANNUAL	PMAD	RATIO: PMAD TO ANNUAL
2018	86,132,000	267,602	0.31%
2028	110,782,000	344,185	0.31%

NOTES:
PMAD – Peak Month Average Day
1 The fiscal year is July 1 through June 30.
SOURCE: Ricondo & Associates, Inc., January 2018 (based on results of forecast analyses).

TABLE 1-2 PEAK MONTH AVERAGE DAY TO ANNUAL RATIOS – AIRCRAFT OPERATIONS

	SCHEDULED PASSENGER AIRLINE OPERATIONS			OTHER (UNSCHEDULED) AIRCRAFT OPERATIONS[1]			TOTAL AIRCRAFT OPERATIONS		
FISCAL YEAR[2]	ANNUAL	PMAD	RATIO: PMAD TO ANNUAL	ANNUAL	PMAD	RATIO: PMAD TO ANNUAL	ANNUAL	PMAD	RATIO: PMAD TO ANNUAL
2018	643,089	1,852	0.29%	71,454	161	0.23%	714,543	2,013	0.28%
2028	720,000	2,073	0.29%	80,000	180	0.23%	800,000	2,253	0.28%

NOTES:
PMAD – Peak Month Average Day
1 Other (unscheduled) aircraft operations include all-cargo, other air taxi, general aviation, and military aircraft operations.
2 The fiscal year is July 1 through June 30.
SOURCE: Ricondo & Associates, Inc., October 2019 (based on results of forecast analyses).

The following paragraphs summarize the approach used to develop the FY 2028 DDFS.

Scheduled Passenger Airline Operations

The development of scheduled passenger airline operations in the future DDFS was based on a process by which new flights were incrementally added until targeted daily activity levels (i.e., number of daily operations and passengers documented in Tables 1-1 and 1-2) were reached. The assumptions used to develop the FY 2028 DDFS are summarized as follows:

- Aircraft fleet mix: on an airline and market basis, each aircraft in the DDFS was reviewed in order to decide whether to add a frequency or to increase the size of the aircraft, while considering the availability and reasonableness of a larger aircraft being scheduled to a particular market, based upon the known aircraft fleets of each scheduled passenger airline operating at LAX.
- Airline market shares for each scheduled passenger airline were assumed to remain relatively constant through FY 2028.
- Schedule peaking characteristics: the FY 2028 DDFS maintained the schedule peaking characteristics of the FY 2018 baseline DDFS. Each new flight added in the FY 2028 DDFS was reviewed to determine if it would be scheduled during peak or off-peak periods.
- Approximately 170 destinations were served by commercial passenger airlines operating at LAX in the FY 2018 DDFS. Due to uncertainties as to which new destinations would be offered out of LAX within the planning horizon, new flights added in the FY 2028 DDFS were assigned to existing destinations as representative destinations. It is possible that new destinations may be offered, and existing destinations may be eliminated.

Because there is no way to predict how this variable will play out, however, it was determined that the best approach would be to use existing destinations.

- Passenger load factors: it was assumed that load factors in schedules representative of PMAD conditions would be higher than annual averages, reflecting the busy conditions of summer activity at LAX. A load factor percentage in the low 90s was targeted to develop the FY 2028 DDFS. It was also assumed that commercial passenger airlines would continue to rely on higher load factors, as discussed in the LAX Airfield and Terminal Modernization Project Activity Forecasts Report.

Accordingly, the FY 2028 DDFS was developed considering each of the assumptions listed above until a total of 2,073 scheduled passenger airline operations was reached in FY 2028. These numbers are derived from Table 1-2.

Unscheduled Operations

<u>All-cargo activity</u>

For the purposes of estimating future all-cargo activity for the FY 2028 DDFS (which does not include belly cargo transported by commercial passenger airlines), information on anticipated growth in airfreight and airmail tonnage was obtained from the 2016–2017 Boeing World Air Cargo Forecast.[8] On average, a 4.2 percent annual growth rate in worldwide tonnage is estimated between 2015 and 2035. The Boeing report documents the annual growth factors through 2035 for each world region. These baseline annual growth factors (as opposed to the low- or high-growth scenario growth factors) were used in this analysis (specifically, United States, 2.0 percent; South America, 4.3 percent; Asia, 4.7 percent; and Europe, 2.5 percent) to provide conservative growth estimates for LAX.

The majority of the all-cargo operator fleet in the FY 2018 baseline schedule is expected to be in operation through FY 2028. This analysis of the all-cargo operator fleet considered the ongoing replacement of older FedEx McDonnell Douglas MD-10 and MD-11 aircraft with Boeing 767F and 777F aircraft. It was also assumed that older B747F will continue to serve international destinations over the planning horizon.

The annual growth factors were then applied to the all-cargo tonnage in the baseline schedule to estimate future all-cargo tonnage for 2028. Similar to the development process for scheduled passenger airline flights, a process was employed to develop the all-cargo operations DDFS by deciding to maintain the flight as is, add a new flight, or increase the size of the aircraft. For example, a FedEx flight arriving from Indianapolis International Airport was estimated to operate at a payload factor of approximately 55 percent in 2018. After applying the growth factor for markets in the United States, the estimated payload factor would be approximately 69 percent in FY 2028, which was assumed to be acceptable, and no change to the aircraft size was applied. Should the resulting payload factor in 2028 be above 100 percent, the decision to either add a flight or convert the aircraft to a larger aircraft (that would reduce the payload factor to an acceptable level) would have been made.

<u>Air Taxi and General Aviation Activity</u>

Unscheduled air taxi and GA operations represent a small percentage (i.e., 3 percent) of total operations at LAX; they are, by definition, less predictable than scheduled operations. It was, therefore, assumed that unscheduled air taxi and GA operations would grow at the same rate as all LAX operations over the planning horizon. The air taxi and GA fleet operating at LAX consists of a wide variety of older and newer model aircraft types. A review of the existing fleet was conducted to identify aircraft that are still in production compared to aircraft that are expected to

8 The Boeing Company, *2016-2017 World Air Cargo Forecast*, 2016, p. 2.

be retired by FY 2028. The latter types were converted to newer similar aircraft. New flights were created to reach the forecast numbers of unscheduled operations.

Military Activity

In the FY 2018 baseline schedule, only one military operation was recorded. Therefore, for the purposes of this analysis, no growth was assumed in military operations through FY 2028.

Table 1-3 provides summary information on the FY 2018 and 2028 DDFSs.

A summary of the DDFS results follows:

- Total PMAD passengers are forecast to increase from 267,602 in FY 2018 to 344,185in FY 2028, representing a 2.5 percent Compound Annual Growth Rate (CAGR).
- Total PMAD scheduled passenger airline operations are forecast to increase from 1,852 in FY 2018 to 2,073 in FY 2028 (i.e., a 1.1 percent CAGR).
- PMAD load factors are forecast to increase from 90.3 percent in FY 2018 to 92.4 percent in FY 2028.
- Consistent with the previous discussion on increases in aircraft size and seat counts to accommodate higher passenger demand, average seats per operation are forecast to increase from 160 seats in FY 2018 to 180 seats in FY 2028, evidence of the fact that the vast majority of operations at LAX are performed by Airplane Design Group (ADG) III aircraft. In FY 2028 DDFS, approximately 77 percent of scheduled passenger airline operations are forecast to be ADG III operations, which is similar to the percentage in the FY 2018 PMAD.

TABLE 1-3 SUMMARY INFORMATION ON FY 2018 AND 2028 DESIGN DAY FLIGHT SCHEDULES

PEAK MONTH AVERAGE DAY (PMAD) DATA	FY 2018	FY 2028	FY 2018-2028 CAGR
Operations:			
Scheduled Passenger Airline	1,852	2,073	1.1%
Air Carrier	95	106	1.1%
Air Taxi	34	38	1.1%
General Aviation	31	35	1.2%
Military	1	1	0.0%
Total:	2,013	2,253	1.1%
Scheduled Passenger Airline Operations Data:			
Passengers	267,602	344,185	2.5%
Seats	296,361	372,492	2.3%
Load Factor	90.3%	92.4%	
Average Seats	160	180	

SOURCE: Ricondo & Associates, Inc., October 2019 (based on results of forecast analyses and design day flight schedule development).
NOTES:
CAGR – Compound Annual Growth Rate; FY – Fiscal Year: July 1 through June 30.

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2. GATING ANALYSIS

Using a proprietary gating model discussed further below, each of the scheduled passenger airline flights in the DDFSs was assigned a gate at a terminal or a remote gate facility at LAX. The process of assigning flights to gates is herein referred to as "gating." The FY 2018 DDFS was gated using existing aircraft gate conditions, and the FY 2028 DDFS was gated for future conditions. The gating analysis was conducted for two future condition scenarios. The No Project scenario assumes changes in terminal facilities or passenger gates that would occur whether or not the LAX Airfield and Terminal Modernization Project is implemented. The With Project scenario assumes improvements associated with the LAX Airfield and Terminal Modernization Project which includes airfield, terminal (including the construction of Concourse 0 and Terminal 9) and landside roadway improvements.

Gating analyses are conducted for the following purposes:

- To verify the assumed gate layouts provide an adequate number of gates to accommodate anticipated future demand.
- To provide flight schedules to be used as input files for the airfield simulation modeling efforts.

All-cargo, air taxi (other than scheduled passenger airline operations operated by air taxi operators), GA, and military operations are not included in the gating model. Instead, these operations were assigned to specific locations on the airfield to support the airfield simulation modeling effort. Therefore, this section focuses on gating scheduled passenger airline operations.

The gating model used in this analysis is a proprietary model developed by aviation experts Ricondo & Associates, Inc. It is based on algorithms, logic statements, and an iterative process that assigns flights to gates until all aircraft are gated. Each gate is coded for an airline and a nominal gate size (i.e., the largest aircraft type that can be accommodated at the gate). At LAX, there are instances in which the aircraft size that can be accommodated at some gates is dependent on aircraft occupancy at an adjacent gate. Gate dependencies can exist, for example, when a large aircraft is parked at a gate that requires an adjacent gate to either be closed or a smaller aircraft be designated as the nominal gate size. The gating model maximizes the use of each gate by matching commercial passenger airlines and aircraft types to available gates. The model replicates common airline practices, such as applying a minimum gate rest time between two flights (typically a minimum of 15 minutes) to provide time for aircraft tug operations or to simulate aircraft temporarily towed off a gate to accommodate another aircraft before being brought back to the gate at a later time. Efficiencies, such as ensuring a large aircraft takes precedence over smaller aircraft to maximize the use of the gate, are also programmed in the model to replicate real-life practices.

The two DDFSs for 2018 and 2028 were gated assuming the following passenger gate layouts:

- 2018 Passenger Gate Layout: Provides a total of 146 passenger gates at the Central Terminal Area (CTA) terminals (Terminals 1 through 8), the Tom Bradley International Terminal (TBIT), the West Remote Gates, and the American Eagle commuter facility (see **Exhibit 2-1**).

- 2028 No Project Passenger Gate Layout: Provides a total of 166 passenger gates at the CTA terminals (Terminals 1 through 8), TBIT, the North Midfield Satellite Concourse (MSC), the South MSC, and the West Remote Gates (see **Exhibit 2-2**). [9]
- 2028 With Project Passenger Gate Layout: Provides a total of 178 passenger gates at Concourse 0, the CTA terminals (Terminals 1 through 8), Terminal 9, TBIT, North MSC, South MSC, and the West Remote Gates (see **Exhibit 2-3**).[10]

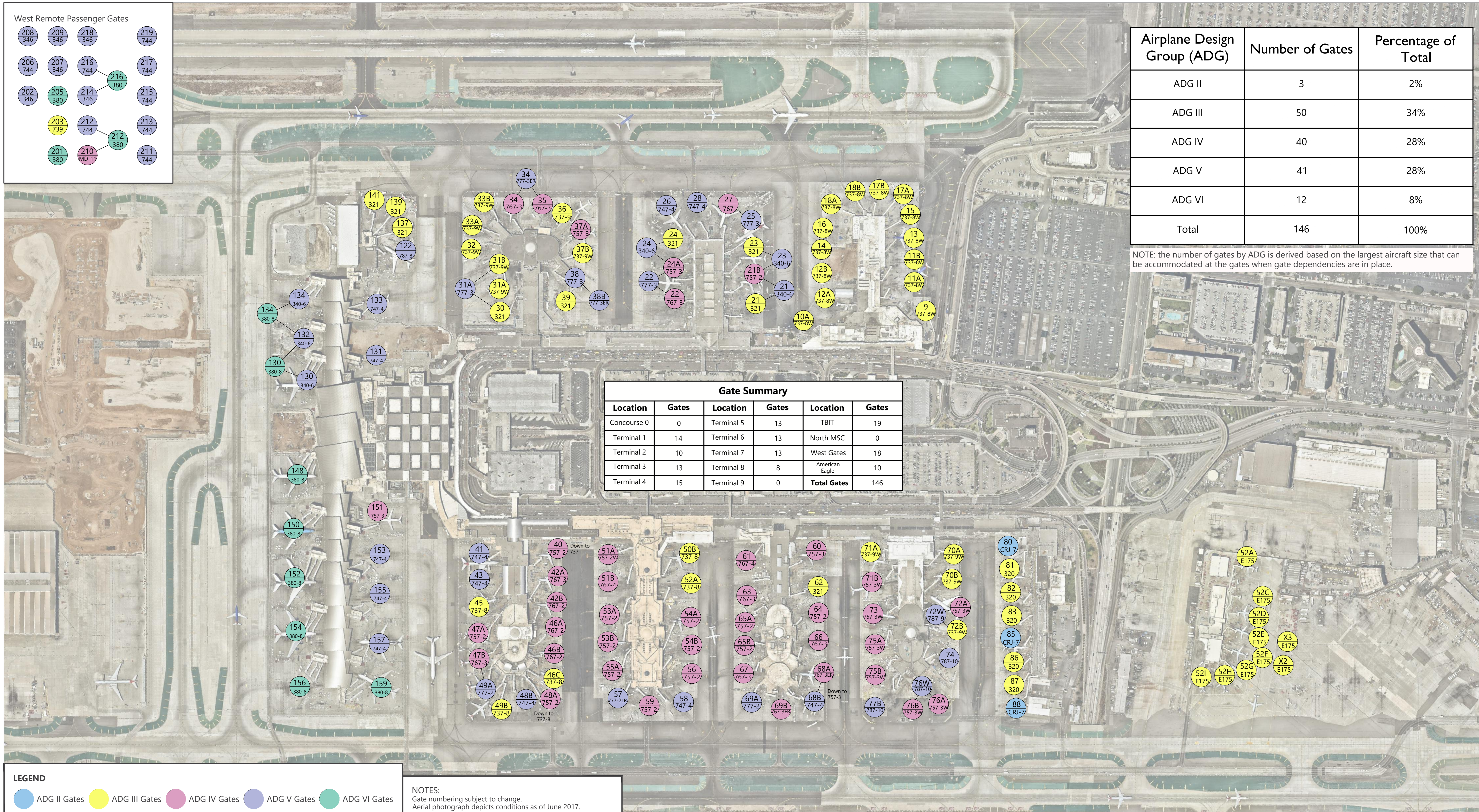
As discussed above, it is anticipated that a vast majority of operations at LAX would be operated with narrowbody, ADG III aircraft. Accordingly, as documented on Exhibits 2-1 through 2-3, the percentage of ADG III gates at LAX is expected to increase from approximately 34 percent in FY 2018, to 54 percent under the 2028 No Project conditions, and to 56 percent under the 2028 With Project conditions.

Table 2-1 below summarizes information regarding the passenger gates by facility assumed to be available under each scenario. Note that these assumptions were based on approved or planned projects and information available at the time these analyses were conducted in 2018 and early 2019, and do not reflect subsequent terminal or passenger gate plans or improvements. It should also be noted that LAWA has operational control over certain gates and, as a result, is able to activate or deactivate gates in operation.

Table 2-2 presents airline-terminal assignments assumed in the gating analysis. Note that these assumptions were based on information available at the time these analyses were conducted in 2018 and early 2019. These airline-terminal assignments were assumed for planning purposes and meant to be representative of anticipated airline locations in the future, understanding that commercial passenger airlines may start or cease service at LAX, or relocate to different terminals before FY 2028. Due to gate constraints, commercial passenger airlines may have been gated at terminals other than those listed in the table (e.g., at adjacent terminals). Gates at the North MSC and the West Remote Gates were assumed to be available to any commercial passenger airlines for which gates were not available at their originally assigned terminals.

[9] American Eagle commuter operations are planned to be relocated to a new MSC South facility as a separate project.

[10] American Eagle commuter operations are planned to be relocated to a new MSC South facility as a separate project.



Airplane Design Group (ADG)	Number of Gates	Percentage of Total
ADG II	3	2%
ADG III	50	34%
ADG IV	40	28%
ADG V	41	28%
ADG VI	12	8%
Total	146	100%

NOTE: the number of gates by ADG is derived based on the largest aircraft size that can be accommodated at the gates when gate dependencies are in place.

Gate Summary

Location	Gates	Location	Gates	Location	Gates
Concourse 0	0	Terminal 5	13	TBIT	19
Terminal 1	14	Terminal 6	13	North MSC	0
Terminal 2	10	Terminal 7	13	West Gates	18
Terminal 3	13	Terminal 8	8	American Eagle	10
Terminal 4	15	Terminal 9	0	**Total Gates**	146

NOTES:
Gate numbering subject to change.
Aerial photograph depicts conditions as of June 2017.

SOURCES: Los Angeles World Airports, June 2017 (aerial image); Ricondo & Associates, Inc., October 2020 (assumed passenger gate layouts and counts).

NORTH 0 550 ft.

EXHIBIT 2-1

2018 Passenger Gate Layout

Drawing: P:\Project-Carlsbad\LAX\NASIP\08_Forecast-Schedule Documentation\01_Gate Layouts\LAX NASIP_Basemap 2028_07312018 - Standard\LAX NASIP_Gating_2020-10-03_Existing.dwgLayout: 2018 Plotted: Oct 5, 2020, 12:24PM

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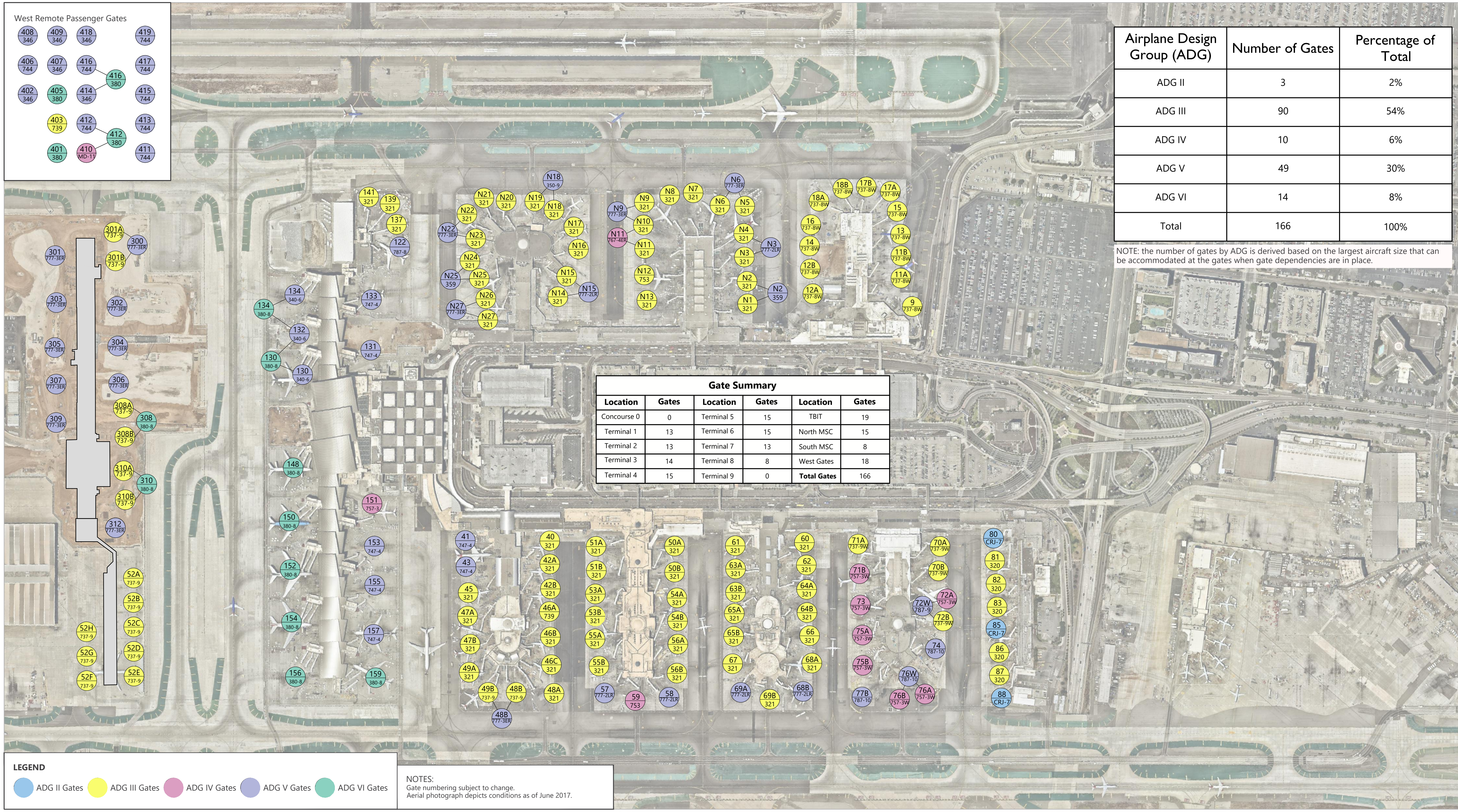

Airplane Design Group (ADG)	Number of Gates	Percentage of Total
ADG II	3	2%
ADG III	90	54%
ADG IV	10	6%
ADG V	49	30%
ADG VI	14	8%
Total	166	100%

NOTE: the number of gates by ADG is derived based on the largest aircraft size that can be accommodated at the gates when gate dependencies are in place.

Gate Summary

Location	Gates	Location	Gates	Location	Gates
Concourse 0	0	Terminal 5	15	TBIT	19
Terminal 1	13	Terminal 6	15	North MSC	15
Terminal 2	13	Terminal 7	13	South MSC	8
Terminal 3	14	Terminal 8	8	West Gates	18
Terminal 4	15	Terminal 9	0	**Total Gates**	166

SOURCES: Los Angeles World Airports, June 2017 (aerial image); Ricondo & Associates, Inc., October 2020 (assumed passenger gate layouts and counts).

EXHIBIT 2-2

2028 Passenger Gate Layout
No Project

Drawing: P:\Project-Carlsbad\LAX\NASIP\08_Forecast-Schedule Documentation\01_Gate Layouts\LAX NASIP_Basemap 2028_07312018 - Standard\LAX NASIP_Gating_2020-10-03_No Project.dwgLayout: 2028 No Project Plotted: Oct 5, 2020, 12:24PM

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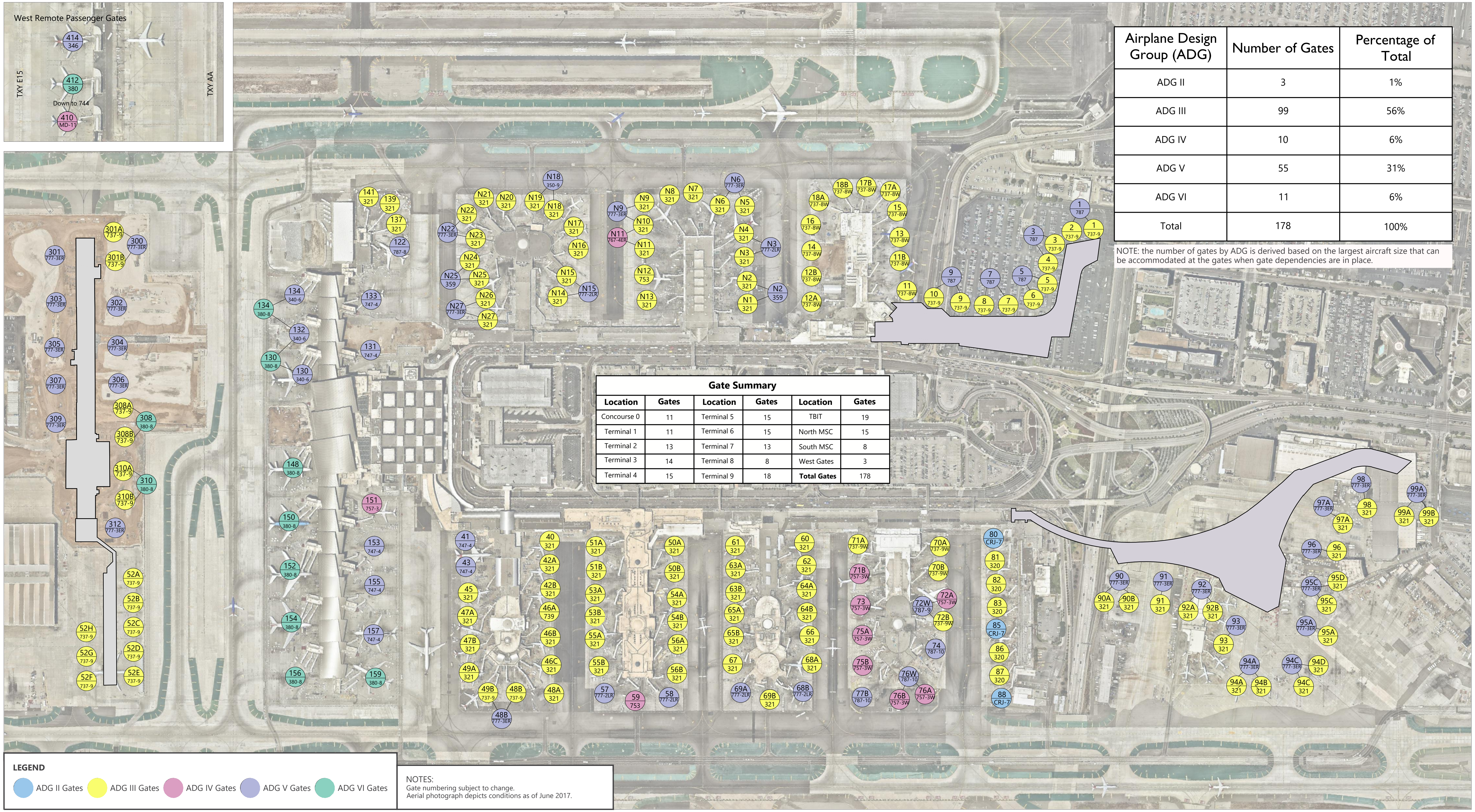

Airplane Design Group (ADG)	Number of Gates	Percentage of Total
ADG II	3	1%
ADG III	99	56%
ADG IV	10	6%
ADG V	55	31%
ADG VI	11	6%
Total	178	100%

NOTE: the number of gates by ADG is derived based on the largest aircraft size that can be accommodated at the gates when gate dependencies are in place.

Gate Summary

Location	Gates	Location	Gates	Location	Gates
Concourse 0	11	Terminal 5	15	TBIT	19
Terminal 1	11	Terminal 6	15	North MSC	15
Terminal 2	13	Terminal 7	13	South MSC	8
Terminal 3	14	Terminal 8	8	West Gates	3
Terminal 4	15	Terminal 9	18	**Total Gates**	178

NOTES:
Gate numbering subject to change.
Aerial photograph depicts conditions as of June 2017.

SOURCES: Los Angeles World Airports, June 2017 (aerial image); Ricondo & Associates, Inc., October 2020 (assumed passenger gate layouts and counts).

EXHIBIT 2-3

2028 Passenger Gate Layout
With Project

Drawing: P:\Project-Carlsbad\LAX\NASIP\08_Forecast-Schedule Documentation\01_Gate Layouts\LAX NASIP_Basemap 2028_07312018 - Standard\LAX NASIP_Gating_2020-10-03_With Project.dwgLayout: 2028 With Project Plotted: Oct 5, 2020, 12:25PM

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TABLE 2-1 SUMMARY OF PASSENGER GATES BY FACILITY BY SCENARIO

FACILITY	2018	2028 NO PROJECT	2028 WITH PROJECT	SUMMARY OF CHANGES IN THE TERMINAL PASSENGER GATE LAYOUT[1]
Concourse 0	0	0	11	A new 11-passenger gate Concourse 0 would be operational by 2028 under the With Project scenarios.
Terminal 1	14	13	11	Under the No Project conditions, one passenger gate on the west side of Terminal 1 will be removed with the completion of Terminal 1.5 (anticipated to be completed in 2020). Under the With Project conditions, one passenger gate on the west side of Terminal 1 will be removed with the completion of Terminal 1.5 (anticipated to be completed in 2020); and two gates on the east side of Terminal 1 will become part of Concourse 0.
Terminal 2	10	13	13	The LAX Terminals 2 and 3 Modernization Project will provide a total of 27 passenger gates at Terminals 2 and 3; will be operational by 2028 under the No Project and With Project scenarios.
Terminal 3	13	14	14	
Terminal 4	15	15	15	No change
Terminal 5	13	15	15	Planned gate resizing will provide two additional passenger gates at Terminal 5; and will be operational by 2028 under the No Project and With Project scenarios.
Terminal 6	13	15	15	Planned gate resizing will provide 2 additional passenger gates at Terminal 6; and will be operational by 2028 under the No Project and With Project scenarios.
Terminal 7	13	13	13	No change
Terminal 8	8	8	8	No change
Terminal 9	0	0	18	A new Terminal 9 would provide 12 widebody gates or up to 18 narrowbody gates and would be operational by 2028 under the With Project scenario.
TBIT	19	19	19	No change
North MSC	0	15	15	The new North MSC facility (anticipated to be completed in 2020) will provide up to 15 passenger gates.
South MSC	0	8	8	A new South MSC facility will provide up to 8 passenger gates, and will be operational by 2028 under the No Project and With Project scenarios.
West Remote Gates	18	18	3	Under the With Project conditions, three passenger gates at the West Remote Gates will remain available for passenger loading and unloading activities.
American Eagle Commuter Facility	10	0	0	It is anticipated that the American Eagle commuter operations would be relocated to the new MSC South facility as a separate project by 2028 under the No Project and With Project scenarios.
Total Airport[2]	**146**	**166**	**178**	

NOTES: 1 Based on approved projects and information available at the time these analyses were conducted in 2018 and early 2019; these assumptions do not reflect subsequent terminal or passenger gate improvements.
2 LAWA has operational control over certain gates and, as a result, is able to activate or deactivate gates in operation.
ADG – Airplane Design Group
MSC – Midfield Satellite Concourse
TBIT – Tom Bradley International Terminal
SOURCE: Ricondo & Associates, Inc., July 2018 (based on results of gating analysis).

TABLE 2-2 ASSUMED COMMERCIAL PASSENGER AIRLINE ASSIGNMENTS TO TERMINALS

TERMINAL	COMMERCIAL PASSENGER AIRLINES[1]
Concourse 0 [2]	Southwest Airlines (WN) and Miscellaneous Airlines
Terminal 1	Southwest Airlines (WN)
Terminal 2	Aer Lingus (EI), Aeromexico (AM), Delta Air Lines (DL), Virgin Atlantic Airways (VS), WestJet (WS)
Terminal 3	Delta Air Lines (DL)
Terminal 4	American Airlines (AA)
Terminal 5	Allegiant Air (G4), American Airlines (AA), Frontier Airlines (F9), Hawaiian Airlines (HA), JetBlue Airways (B6), Spirit Airlines (NK), Sun Country (SY)
Terminal 6	Air Canada (AC), Alaska Airlines (AS), Boutique Air (4B), Great Lakes (ZK), Mokulele Airlines (MW), Virgin America (VX)
Terminal 7	United Airlines (UA)
Terminal 8	United Airlines (UA)
Terminal 9 [3]	United Airlines (UA) and STAR Alliance Partners
Tom Bradley International Terminal (TBIT)	Aeroflot (SU), Air Berlin (AB), Air China (CA), Air France (AF), Air New Zealand (NZ), Air Tahiti Nui (TN), Alitalia (AZ), All Nippon Airways (NH), Asiana Airlines (OZ), Austrian Airlines (OS), Avianca (AV), British Airways (BA), Cathay Pacific Airways (CX), China Airlines (CI), China Eastern Airlines (MU), China Southern Airlines (CZ), Copa Airlines (CM), El Al Israel (LY), Emirates (EK), Ethiopian Airlines (ET), Etihad Airlines (EY), Eva Air (BR), Fiji Airways (FJ), Hainan Airlines (HU), Iberia (IB), InterJet (4O), Japan Airlines (JL), KLM Royal Dutch Airlines (KL), Korean Air Lines (KE), LATAM (LA), Lufthansa (LH), Norwegian Air (DY), Philippine Airlines (PR), Qantas Airways (QF), Qatar Airways (QR), Saudi Arabian Airlines (SV), Scandinavian Airline System (SK), Sichuan Airlines (3U), Singapore Airlines (SQ), Swiss International Air Lines (LX), Thomas Cook Airlines (MT), Turkish Airways (TK), Virgin Australia (VA), Volaris (Y4), Wow Air (WW), Xiamen Air (MF)
North MSC	Various Airlines
South MSC	American Eagle (AA)
West Remote Gates	Various Airlines
American Eagle Commuter Facility	American Eagle (AA) [4]

NOTES:
1 Based on approved information available at the time these analyses were conducted in 2018 and early 2019
2 "With Project" scenarios only
3 "No Project" scenarios only
4 In Fiscal Year 2018 only
MSC – Midfield Satellite Concourse
SOURCE: Ricondo & Associates, Inc., January 2018 (based on 2017 conditions).

An adequate number of gates, and associated existing and planned passenger processing facilities, were available to accommodate all scheduled passenger flights included in the FY 2018 and 2028 DDFSs.

3. AIRFIELD SIMULATION ANALYSIS

Airfield and airspace simulation models developed for previous LAX analyses were updated and recalibrated to represent existing (CY 2017) conditions. The updated, recalibrated models served as the basis for evaluating two scenarios associated with the LAX Airfield and Terminal Modernization Project:

- No Project—representing future-year conditions without LAX Airfield and Terminal Modernization Project improvements
- With Project—representing future-year conditions with LAX Airfield and Terminal Modernization Project improvements

The effects of the LAX Airfield and Terminal Modernization Project proposed improvements on aircraft operational efficiency were quantified by comparing several performance metrics (e.g., runway throughput, travel time, and delay) that were calculated using simulation model outputs for the With Project and No Project scenarios.

3.1 SIMULATION MODELING SOFTWARE

The analysis was conducted using the FAA's approved simulation model SIMMOD. SIMMOD is a fast-time simulation model used to analyze en-route, terminal area, and airfield operations. The FAA originally developed the model and released it to the public in 1989. Since its release, the model has been further developed by both private and government entities, and it has been used to support numerous airport planning and environmental analyses.

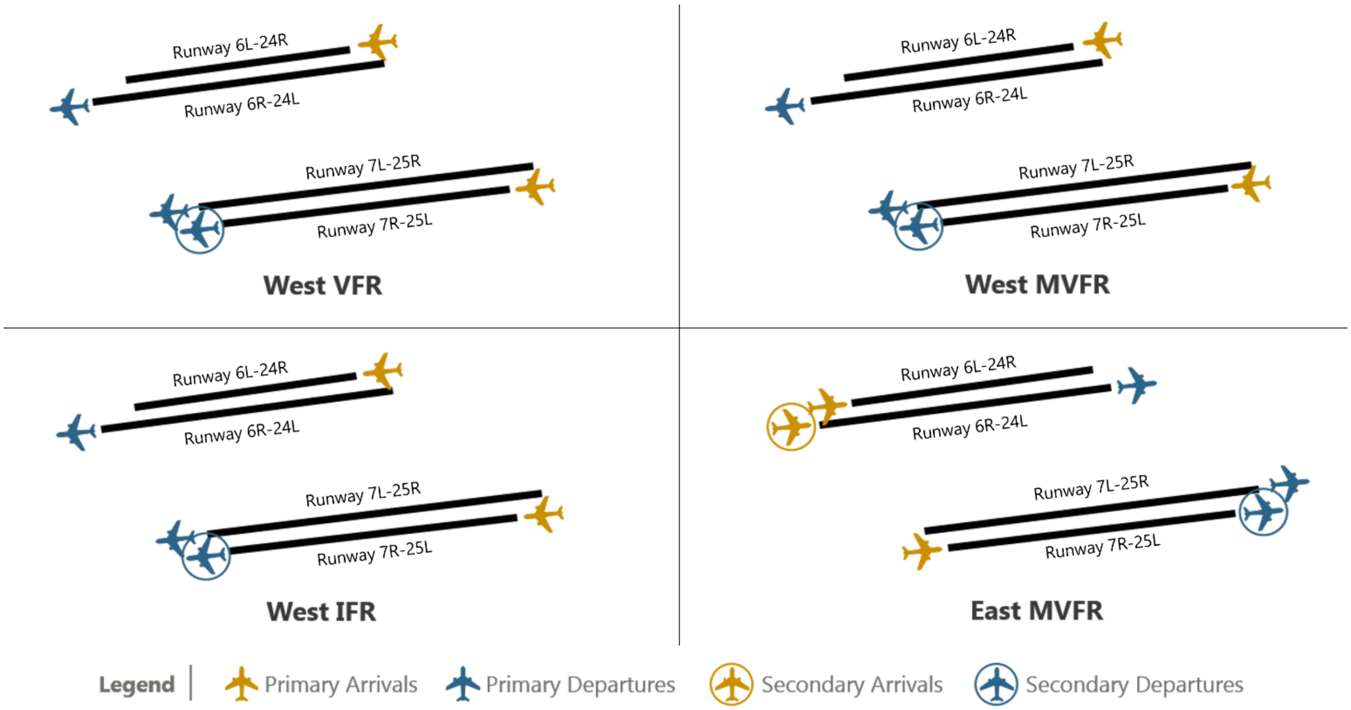
Analyses in SIMMOD are based on a network of defined links and nodes that represent aircraft operations along and between airspace routes, runways, taxiways, and other airport facilities. Operating procedures in the air and on the airfield specific to an airport are defined in the model to reflect conditions specific to that airport. Aircraft operations are defined in a DDFS, which serves as the basis for the level of aircraft activity and the types of aircraft modeled in SIMMOD. Utilizing the defined operational parameters and aircraft activity, users model a representative day(s) and analyze travel time, including delay, which is tabulated in model outputs as aircraft move through the simulation and interact with other aircraft. Users statistically vary model settings based on expertise and gathered assumptions to mimic real-world conditions and operational variability. Eleven iterations of each SIMMOD model are run, with each having a unique set of randomized variables. SIMMOD provides visual animations of aircraft movements that users and stakeholders can watch to visually validate models. Additionally, tabular model outputs can be used to calculate various performance metrics (e.g., throughput, travel time, and delay), which can be used to numerically validate models.

3.2 AIRFIELD OPERATING CONFIGURATIONS

Airfield operating configurations are defined to represent the runways that are used for arrivals and departures under a variety of operating conditions and air traffic control (ATC) procedures. Wind speed and wind direction dictate the direction in which the runways are utilized for arrivals and departures (i.e., east flow or west flow). Ceiling height and visibility determine the ATC procedures that are in effect, which include visual flight rules (VFR), marginal visual flight rules (MVFR), and instrument flight rules (IFR). Airport operations are generally more efficient under VFR, with operations being less efficient under MVFR and IFR, as visibility decreases or cloud cover increases and increased separation is required between aircraft to maintain safe operations.

Previous LAX analyses defined four airfield operating configurations to be representative of overall operating conditions at LAX. **Exhibit 3-1** depicts these assumed airfield operating configurations.

EXHIBIT 3-1 MODELED AIRFIELD OPERATING CONFIGURATIONS



NOTES:
VFR – visual flight rules
MVFR – marginal visual flight rules
IFR – instrument flight rules
SOURCE: Ricondo & Associates, Inc., February 2018.

Weighting factors were developed for each airfield operating configuration to represent the proportion of time each configuration is typically in use based on historical data. These weighting factors were applied to simulation results to calculate annualized average performance metrics. FAA Aviation System Performance Metrics (ASPM) Hourly Airport Efficiency data for January 1, 2008 through December 31, 2017 were analyzed to identify the weighting factors. ASPM provides hourly data indicating the arrival and departure runways in use, as well as meteorological conditions, including ceiling height and visibility. Hourly observations of nonmodeled operating configurations were allocated to the most similar modeled airfield operating configuration. **Table 3-1** shows the operating direction, meteorological conditions, and normalized occurrence of the modeled airfield operating configurations. West VFR and West MVFR are the predominant configurations, representing 94.1 percent of occurrences. These two configurations are dominant due to the relatively infrequent occurrence of poor weather conditions and the prevailing westerly winds coming off the Pacific Ocean just west of LAX.

TABLE 3-1 MODELED AIRFIELD OPERATING CONFIGURATIONS

CONFIGURATION	APPROACH TYPE	VISIBILITY (STATUTE MILES)	CEILING HEIGHT (FEET AGL)	NORMALIZED OCCURRENCE
West VFR	Visual Approaches	Visibility ≥ 3	Ceiling Height ≥ 5,000	68.4%
West MVFR	ILS Approaches	3 > Visibility ≥ 2	5,000 > Ceiling Height ≥ 600	25.7%
West IFR	ILS Approaches	2 > Visibility	600 > Ceiling Height	4.0%
East MVFR	ILS Approaches	3 > Visibility ≥ 2	5,000 > Ceiling Height ≥ 600	1.9%
			Total	**100.0%**

NOTES:
AGL – above ground level
IFR – instrument flight rules
ILS – instrument landing system
MVFR – marginal visual flight rules
VFR – visual flight rules
SOURCES: U.S. Department of Transportation, Federal Aviation Administration, Aviation System Performance Metrics, February 2018 (data for January 1, 2008 through December 31, 2017); Ricondo & Associates, Inc., February 2018 (analysis).

3.3 SIMMOD MODEL CALIBRATION

Airfield and airspace simulation models developed for previous analyses were updated to reflect current airfield and operational conditions. Efforts were made to recalibrate the models to typical busy days in August 2017, as this period represented a period when construction affecting airfield efficiency was minimal and all runways were operational. Operational data from other months in 2017 were used to calibrate models representing conditions that did not occur in August, as poor weather conditions typically occur in the winter or spring. Infrastructure modifications included the Runways 6R-24L and 7L-25R runway safety area (RSA) improvements, completed in 2016 and 2017, respectively. Airspace modifications included new arrival and departure procedures established as part of the Southern California Metroplex Project[11] and the implementation of Wake Turbulence Recategorization Phase II.[12]

Operating assumptions and model inputs were coordinated with and verified by LAX ATC representatives and LAWA Airport Operations personnel. Model outputs, including key performance metrics and model animations, were compared against actual airfield performance metrics. The models were then refined until model performance adequately approximated observed 2017 conditions. LAX ATC and LAWA Airport Operations representatives validated the calibrated model outputs.

[11] U.S. Department of Transportation, Federal Aviation Administration, *Final Environmental Assessment for the Southern California Metroplex Project*, August 2016.

[12] U.S. Department of Transportation, Federal Aviation Administration, *Order JO 7110.123, Wake Turbulence Recategorization Phase II*, August 3, 2016.

3.4 MODELED AIRFIELD SCENARIOS

Two future scenarios were modeled:

- No Project—representing future-year conditions without LAX Airfield and Terminal Modernization Project improvements
- With Project—representing future-year conditions with LAX Airfield and Terminal Modernization Project improvements to include a west extension of Taxiway D, the reconfiguration of Runway 6L-24R exit taxiways, Concourse 0 and Terminal 9, and associated taxiway/taxilane improvements

In addition to proposed airfield and terminal modifications, restrictions defined in modifications of standards (MOS) were assumed to be implemented under the future scenarios. The MOS would restrict certain aircraft types from holding between the north airfield runways and between the south airfield runways.[13] Noise-abatement procedures to reduce noise impacts on neighboring communities are in effect at LAX. When possible, Over-Ocean Operations procedures, where aircraft arrive from the west and depart to the west, are used between 12:00 a.m. and 6:30 a.m. This analysis focused on peak periods of demand, which do not occur between 12:00 a.m. and 6:30 a.m.; therefore, Over-Ocean Operations were not modeled in this analysis. Operating assumptions for the calibrated 2017 condition models were reviewed and adjustments were made as appropriate to reflect each of the various LAX Airfield and Terminal Modernization Project scenarios.

3.5 MODELED ACTIVITY LEVELS

Two DDFSs representative of PMAD conditions for fiscal years 2018 (2,013 daily operations) and 2028 (2,253 daily operations) were used to model activity levels using SIMMOD. See Section 1 and Table 1-2 above for further details regarding the DDFSs.

3.6 RESULTS

Simulation model outputs were processed and compiled to produce peak runway throughput, average travel time, and average delay performance metrics, which were used to evaluate and compare the performance of the two modeled scenarios. All models were run for 11 randomized iterations to replicate real-world variation in operations. Average travel times and delays per aircraft operation for each modeled airfield operating configuration and activity level were weighted based on the percentage use of each configuration. The weighted average metrics for each activity level were then summed to calculate annualized average metrics. Performance metrics for all models were tabulated and annualized delay metrics were used to define delay curves and to compare scenarios.

The performance metrics presented in this section are averages of all 11 randomized iterations. **Tables 3-2** and **3-3** summarize the key travel time and delay performance metrics as calculated from model outputs.

[13] City of Los Angeles, Los Angeles World Airports, *North and South Airfield Holding Position Analysis*, April 2016.

TABLE 3-2 MODELED PERFORMANCE METRICS FOR NO PROJECT SCENARIO

ACTIVITY LEVEL	CONFIGURATION	AVERAGE DELAY (MIN/OP)									AVERAGE UNIMPEDED TIME (MIN/OP)						AVERAGE OPERATIONAL TIME (MIN/OP)					
		ARRIVALS				DEPARTURES					ARRIVALS			DEPARTURES			ARRIVALS			DEPARTURES		
		AIR	RWY XING	TAXI IN	GATE	GATE	TAXI OUT	RWY XING	AIR	TOT	AIR	GND	TOT	AIR	GND	TOT	AIR	GND	TOT	AIR	GND	TOT
2,013 Operations (2018)	West VFR	2.2	1.0	1.9	0.0	0.5	3.9	0.2	0.0	4.9	18.3	12.7	31.0	11.1	16.4	27.5	20.5	15.6	36.1	11.1	21.0	32.1
	West MVFR	3.1	1.1	1.9	0.0	0.5	4.2	0.2	0.0	5.5	18.3	12.7	31.0	11.1	16.4	27.5	21.4	15.7	37.1	11.1	21.2	32.4
	West IFR	3.8	0.8	2.9	0.0	0.5	13.8	0.3	0.0	11.1	18.3	12.8	31.1	11.1	17.2	28.3	22.1	16.5	38.6	11.1	31.8	42.9
	East MVFR	24.8	1.1	1.9	0.0	0.4	4.1	0.1	0.0	16.2	20.3	13.9	34.3	8.4	17.4	25.8	45.1	16.9	62.1	8.5	22.0	30.5
	Annualized	2.9	1.0	1.9	0.0	0.5	4.4	0.2	0.0	**5.5**	18.4	12.7	31.1	11.1	16.4	27.5	21.3	15.7	37.0	11.1	21.5	32.6
2,253 Operations (2028)	West VFR	3.5	1.3	2.6	0.0	0.4	6.2	0.2	0.0	7.1	18.3	12.9	31.2	11.2	17.3	28.5	21.8	16.8	38.5	11.2	24.2	35.4
	West MVFR	6.5	1.3	2.8	0.0	0.4	6.9	0.2	0.0	9.1	18.3	13.0	31.2	11.2	17.3	28.5	24.8	17.1	41.9	11.2	24.9	36.1
	West IFR	14.3	0.8	4.3	0.0	0.4	65.8	0.3	0.0	42.9	18.3	13.0	31.3	11.2	17.6	28.8	32.6	18.1	50.8	11.2	84.1	95.3
	East MVFR	64.2	1.2	1.9	0.0	0.4	7.1	0.2	0.0	37.6	20.3	13.2	33.5	8.4	18.3	26.7	84.5	16.3	100.8	8.5	25.9	34.4
	Annualized	5.9	1.3	2.7	0.0	0.4	8.8	0.2	0.0	**9.6**	18.3	12.9	31.3	11.1	17.3	28.5	24.2	16.9	41.1	11.1	26.8	37.9

NOTES:
X.X – Annualized total average delay results are highlighted using bold font.
GND – Ground
IFR – Instrument Flight Rules
MIN/OP – Minutes per Aircraft Operation
MVFR – Marginal Visual Flight Rules
RWY XING – Runway Crossing
TOT – Total
VFR – Visual Flight Rules
SOURCE: Ricondo & Associates, Inc., July 2018 (processed SIMMOD output).

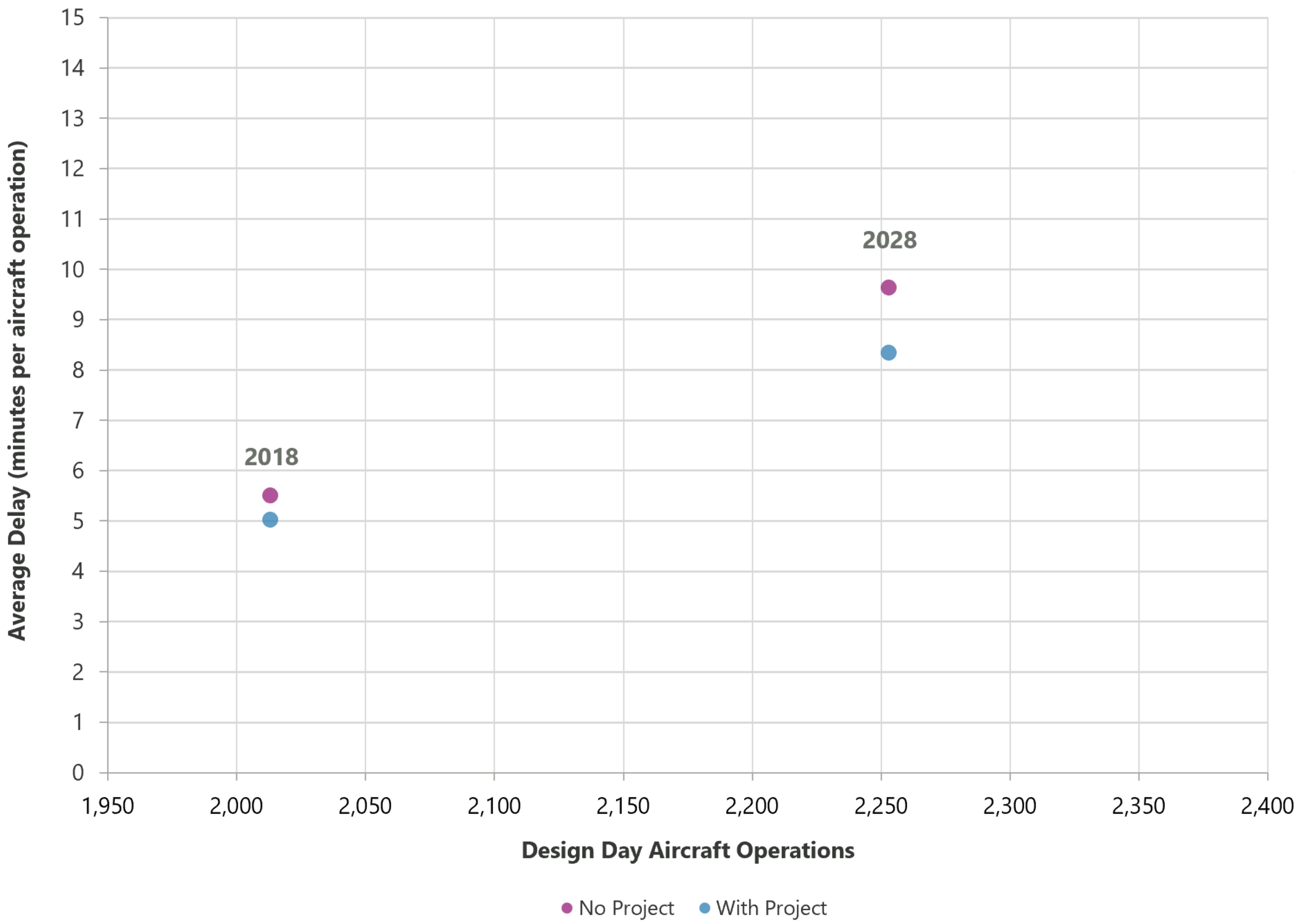
TABLE 3-3 MODELED PERFORMANCE METRICS FOR WITH PROJECT SCENARIO

ACTIVITY LEVEL	CONFIGURATION	AVERAGE DELAY (MIN/OP)									AVERAGE UNIMPEDED TIME (MIN/OP)						AVERAGE OPERATIONAL TIME (MIN/OP)					
		ARRIVALS				DEPARTURES					ARRIVALS			DEPARTURES			ARRIVALS			DEPARTURES		
		AIR	RWY XING	TAXI IN	GATE	GATE	TAXI OUT	RWY XING	AIR	TOT	AIR	GND	TOT	AIR	GND	TOT	AIR	GND	TOT	AIR	GND	TOT
2,013 Operations (2018)	West VFR	2.3	1.0	1.6	0.0	0.4	3.8	0.2	0.0	4.6	18.3	12.7	31.0	11.1	16.6	27.7	20.6	15.3	35.9	11.1	20.9	32.0
	West MVFR	3.1	1.1	1.7	0.0	0.4	4.3	0.2	0.0	5.4	18.3	12.6	31.0	11.1	15.7	26.8	21.4	15.4	36.8	11.1	20.6	31.7
	West IFR	3.8	0.7	1.9	0.0	0.4	10.0	0.3	0.0	8.5	18.3	12.6	31.0	11.1	17.3	28.4	22.1	15.3	37.4	11.1	27.9	39.0
	East MVFR	5.2	1.1	1.5	0.0	0.4	4.0	0.1	0.1	6.2	20.3	12.1	32.5	8.4	18.9	27.4	25.5	14.8	40.3	8.5	23.5	32.0
	Annualized	2.6	1.0	1.7	0.0	0.4	4.2	0.2	0.0	**5.0**	18.4	12.7	31.0	11.0	16.4	27.5	21.0	15.3	36.3	11.1	21.2	32.2
2,253 Operations (2028)	West VFR	3.5	1.3	2.3	0.0	0.4	5.5	0.2	0.0	6.6	18.3	12.5	30.8	11.2	16.9	28.1	21.8	16.0	37.9	11.2	23.0	34.2
	West MVFR	6.3	1.3	2.3	0.0	0.4	5.8	0.3	0.0	8.2	18.3	12.6	30.9	11.2	16.9	28.1	24.6	16.3	40.9	11.2	23.3	34.5
	West IFR	14.5	0.8	5.1	0.0	0.4	49.4	0.4	0.0	35.2	18.3	12.5	30.8	11.2	17.1	28.3	32.8	18.4	51.2	11.2	67.2	78.4
	East MVFR	19.5	1.4	1.6	0.0	0.3	8.8	0.2	0.0	15.9	20.3	11.5	31.8	8.4	19.0	27.4	39.8	14.5	54.3	8.5	28.3	36.7
	Annualized	5.0	1.3	2.4	0.0	0.4	7.4	0.2	0.0	**8.3**	18.3	12.5	30.8	11.1	16.9	28.1	23.3	16.2	39.5	11.1	25.0	36.1

NOTES:
X.X – Annualized total average delay results are highlighted using bold font.
GND – Ground
IFR – Instrument Flight Rules
MIN/OP – Minutes per Aircraft Operation
MVFR – Marginal Visual Flight Rules
RWY XING – Runway Crossing
TOT – Total
VFR – Visual Flight Rules
SOURCE: Ricondo & Associates, Inc., July 2018 (processed SIMMOD output).

The annualized average delays for each scenario were plotted relative to the number of daily aircraft operations in each DDFS, as depicted on **Exhibit 3-2**. The numbers of daily aircraft operations depicted on Exhibit 3-2 are based on the results of the DDFS analyses summarized in Table 1-2. These numbers of daily aircraft operations were derived from the constrained demand scenario annual forecast results presented in the LAX Airfield and Terminal Modernization Project Activity Forecasts Report, as documented in Section 1.3.

EXHIBIT 3-2 ANNUALIZED AVERAGE DELAY VS. DAILY AIRCRAFT OPERATIONS



SOURCE: Ricondo & Associates, Inc., March 2020.

Differences in operational conditions are expected under the With Project scenario compared with the No Project scenario as a result of airfield modifications and improvements, and associated operational changes:

- The Taxiway D extension provides operational flexibility to allow ATC to avoid routing aircraft on taxiways that restrict Runway 6R-24L departures.
- The additional Runway 6L exit taxiways eliminate the need for increased arrival spacing during east flow operating conditions (which currently occurs under existing conditions).

- Operations would be consolidated at Concourse 0 and Terminal 9, reducing aircraft towing operations and associated taxiway congestion. However, this would be offset by additional congestion occurring in the vicinity of Concourse 0 and Terminal 9.

These differences in operational conditions resulting from the With Project improvements translate into reductions in annualized average delay in FY 2028 as shown on Exhibit 3-2. It is important to note that the simulated reductions in delay were primarily driven by operational improvements during east flow operating conditions (dictated by changes in wind conditions) which occur less than two percent of the time at LAX, as documented in Table 3-1. The FAA manages the flow of aircraft and decides when wind conditions require the use of east flow. The remaining 98 percent of the time, LAX operates in west flow under which the With Project taxiway improvements would not provide arrival operational benefits as substantial as those measured in east flow. In addition, commercial passenger airlines schedule flights based on the typical operating conditions of the airport (e.g., passenger gate availability, network connectivity, and local weather conditions). Commercial passenger airlines prepare flight schedules to meet passenger demand and would, therefore, not change their scheduling practices based on an airfield operating condition which occurs less than two percent of the time.

Therefore, even though the With Project improvements provide an incremental benefit in east flow (in the form of reduced airfield delays), the forecasted aircraft operations and passenger demand (and airline scheduling practices to meet such demand) would not change as a result of the With Project improvements.