2

Aviation Activity Forecasts

TABLE OF CONTENTS

AVIATION ACTIVITY FORECASTS

EXHIBITS

TABLES

2 AVIATION ACTIVITY FORECASTS

2.1 BACKGROUND

This chapter presents comprehensive forecasts of aviation activity (i.e., demand) at the San Francisco International Airport (SFO, or the Airport). The Airport Development Plan (ADP) forecasts were developed to provide Airport management with a customized, adaptive, and enduring framework to inform long-term facility planning. The forecasts estimate how air service at SFO could increase based on market trends, while growth potential is constrained by the airfield capacity of the existing runway system.

Future demand for annual enplaned passengers, air cargo tonnage, aircraft operations, and commercial passenger fleet mix were forecast. Because facility design is based on peak, not annual, activity, peak period month, day, and hour forecasts were developed to guide the planning process. The cargo, general aviation (GA), and air taxi aircraft operations forecasts were derived from industry and local and national trends.

The forecast was developed for four timeframes, or "demand levels": 2018, 2023, Base Constrained, and High Constrained. For purposes of the ADP, the forecast demand levels were identified as Near-Term (present through 2021) and Long-Term (beyond 2021, through the Base Constrained and High Constrained demand levels).

All aviation activity forecasts are subject to uncertainty. For example, it is not possible to predict exact aircraft replacements, as airline fleet mixes and load factors are subject to variability. Therefore, actual activity will vary from the forecast presented in this chapter. The forecast represents average growth rates over five or more years, so although the 2018 and 2023 demand levels are identified by a specific year, actual activity will fluctuate with macroeconomic and airline industry conditions. The ADP is designed to be flexible in case these demand levels occur sooner or later than forecast.

2.2 DEMAND FOR AIR TRAVEL

2.2.1 Unconstrained Demand

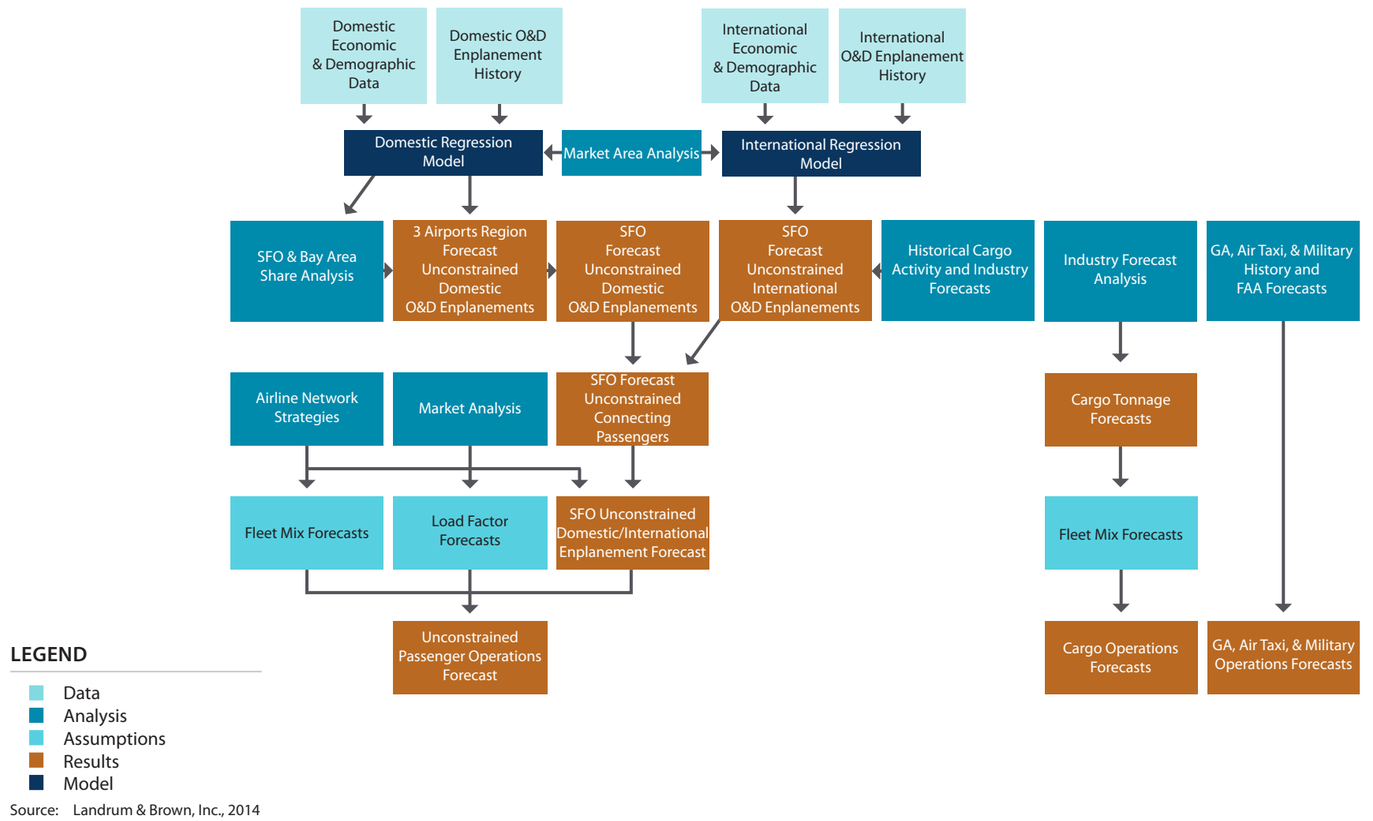
The passenger forecasts from 2013 through the 2023 demand level reflect growth unconstrained by capacity. These forecasts reflect the market-driven demand for air service and, as such, facility constraints or other outside limiting factors were not considered. In other words, for the purpose of forecasting future demand, it was assumed that adequate SFO facilities can be provided to accommodate demand through the 2023 demand level.

The 2018 and 2023 forecasts were developed by applying regional and individual airport regression approaches. The following is a summary of the methodology used to forecast unconstrained demand (see **Exhibit 2.2-1**):

1. Historical and projected demographic and socioeconomic data were collected and analyzed (see Section 2.3). Historical traffic and yields[1] at SFO and the other two major Bay Area airports (Oakland International Airport [OAK] and Norman Y. Mineta San Jose International Airport [SJC]) were also analyzed.
2. Multilinear regression models were developed to quantify the relationship between origin and destination (O&D) passengers and statistically significant socioeconomic variables.
3. Regression models were developed to evaluate domestic O&D demand at SFO alone and at the three major Bay Area airports combined. International regression models were developed for SFO only because of the limited international traffic at OAK and SJC.
4. The results of the domestic Bay Area regression models were compared with the results of the individual airport models to determine the appropriate level of O&D activity for the planning horizon. The results of the international SFO models were compared with regional forecasts to determine the most appropriate methodology to forecast future international demand at SFO.
5. Historical domestic and international connecting passengers were analyzed to forecast numbers of connecting passengers at SFO. The sum of forecast O&D and connecting passengers equals the forecast total enplaned passengers.

1 Yield is the average fare paid per mile, per passenger.

Exhibit 2.2-1 | Unconstrained Demand Methodology



Source: Landrum & Brown, Inc., 2014

2.2.2 Constrained Demand

Beyond 2023, the forecast is constrained by the maximum runway capacity at SFO, as defined by the results of the ultimate runway capacity simulation analysis. Two demand levels were developed for the constrained forecast after 2023: Base Constrained and High Constrained. Refer to **Appendix B, Ultimate Airport Capacity and Delay Simulation Modeling Analysis**, for details on methodology used to determine the number of constrained daily operations.

An airfield/airspace simulation analysis was conducted to determine airside performance at various demand levels in order to quantify the maximum practical capacity of SFO's airfield. Maintaining airline schedule integrity is the primary operational goal of defining maximum practical airfield capacity. While delays are expected in peak periods during instrument flight rule (IFR) operating conditions, peak hour delays should dissipate in the following few hours to avoid excessive cancellations and missed connections. Activity levels that result in high delays cascading throughout the day during predominant operating conditions are not acceptable. Therefore, average daily delays, delays in each hour of the day, and the percentage of flights delayed were all considered in defining the maximum practical capacity of the SFO airfield. Based on the simulation modeling, the existing Airport runway system has a maximum practical capacity of approximately 1,425 daily operations.

Certain NextGen[2] procedures could allow for additional throughput with similar or lower aircraft delay levels. Wake Recat, a Federal Aviation Administration (FAA) program that reduces wake vortex protection separations required between certain arriving aircraft, is believed to provide an increase of approximately 20 daily operations. Implementation of the FAA Order JO 7110.308, *1.5-Nautical Mile Dependent Approaches to Parallel Runways Spaced Less than 2,500 Feet Apart*, procedure, permitting staggered arrivals to the two arrival runways at 1.5 nautical mile (nm) spacing in IFR conditions, could reduce overall delays and increase arrival capacity during morning IFR periods, allowing for an additional 30 operations in addition to the increase provided by Wake Recat. Assuming the effectiveness of these programs, the existing Airport runway system would have a maximum design day capacity of 1,475 daily operations.

The design day capacity of 1,475 daily operations established the Base Constrained demand level. The Base Constrained forecast estimates that daily passenger aircraft operations will not exceed 1,368 (1,120 domestic and 248 international). It was assumed that the remaining 107 operations will consist mainly of GA activity, with some all-cargo and military aircraft operations.

2 NextGen is an umbrella term for the ongoing, wide-ranging modernization of the United States national airspace system (NAS). NextGen represents an evolution from a ground-based system of air traffic control to a satellite-based system of air traffic management. The program intends to enhance NAS safety and efficiency that will benefit NAS capacity.

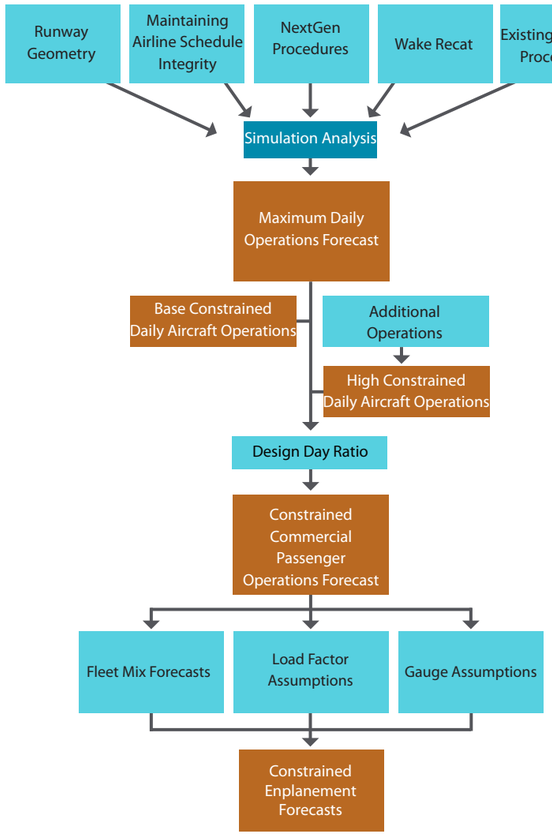
Under constrained conditions, airlines will increase the average size and capacity ("gauge") of their aircraft on routes where load factors are high and substitute aircraft are available. In the Base Constrained forecast demand, it is estimated that the average aircraft gauge would increase and load factors would reach an average of 88 percent. Aircraft operating in peak hours would achieve 95–100 percent load factors.

The High Constrained demand level adds 25 additional daily flights during off-peak periods, resulting in 1,500 daily aircraft operations. At this demand level, small increases in the number of operations would result in high hourly delays in visual flight rules (VFR) conditions, cascading for multiple hours. It was assumed that the average gauge of aircraft operating at SFO would continue to increase and that the load factors for domestic and international flights would reach an annual average of 95 percent. This high average load factor is unlikely, as it would cause many flights to operate at 100 percent capacity and it would take several days to accommodate passengers from a single canceled flight.

The number of daily operations in the Base Constrained and High Constrained forecasts were multiplied by a factor, referred to as the design day ratio, to determine the Base Constrained and High Constrained annual operations forecasts (see Section 2.10). The design day ratio is based on the analysis conducted for the Unconstrained Forecast.

The Base Constrained and High Constrained forecast demand levels for enplaned passengers were derived by increasing load factor and gauge assumptions. **Exhibit 2.2-2** presents the methodology for developing the constrained demand forecasts.

Exhibit 2.2-2 | Constrained Demand Methodology



Source: Landrum & Brown, Inc., 2014

2.3 ECONOMIC BASIS FOR AIR TRAVEL

The intrinsic links between aviation activity and economic activity are well documented. Growth in population, employment, personal income, and tourism typically leads to increased demand for air travel for both business and leisure purposes.

Aviation activity at SFO depends on a combination of trends in the airline industry, national and international economic conditions, and the socioeconomic conditions in the Bay Area. As the Bay Area is an influential global business location, as well as a vacation destination, changes in the broader U.S. and world economies affect the demand for air travel to SFO. An overview of the world, national, and local economic factors that generate underlying demand for air travel is provided in this section.

Because aviation competes with other modes of transportation in some markets, this "underlying demand" cannot be realized without the presence of airline service at a price that results in the decision to fly rather than use other modes of transportation or not traveling.

2.3.1 World Economy

Since the 2007–2009 global economic recession, the world economy has grown at a historically slow rate. Economic forecasts published in the *FAA Aerospace Forecast Fiscal Years 2013-2033* show world GDP growing 3.3 percent annually over the forecast period (see **Exhibit 2.3-1**). The Asia/Pacific and Latin America regions are forecast to experience the highest growth rates (4.7 percent and 4.1 percent average annual growth, respectively), while the more mature economies of Canada and Europe are forecast to experience slower average annual growth rates of 2.5 percent and 2.4 percent, respectively. These forecast growth rates will increase the demand for air travel.

2.3.2 Airport Service Area

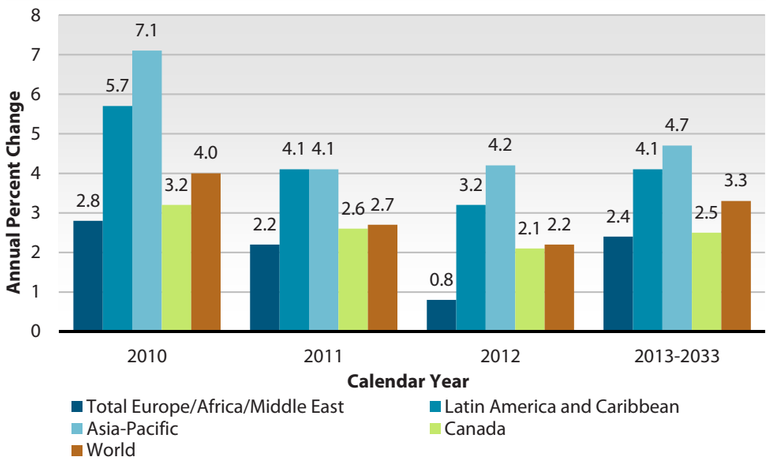
The SFO service area is defined as the San Jose-San Francisco-Oakland Combined Statistical Area (referred to herein as the Bay Area CSA[3]). The U.S. Census Bureau defines the Bay Area CSA as the 12 counties of Alameda, Contra Costa, Marin, Napa, San Benito, San Francisco, San Joaquin,[4] San Mateo, Santa Clara, Santa Cruz, Solano, and Sonoma.

Two other international commercial passenger service airports are located in the Bay Area CSA. OAK is located 11 miles to the northeast, across the San Francisco Bay from SFO. OAK is a focus airport for Southwest Airlines. SJC is the smallest of the three Bay Area commercial service airports and is located in Silicon Valley, 32 miles southeast of SFO. Because of the proximity of SJC, OAK, and SFO, it is essential to understand local socioeconomic trends in the broader regional context. **Exhibit 2.3-2** shows the Bay Area CSA and the locations of the three primary Bay Area airports.

3 A combined statistical area (CSA) is the collection of two or more Metropolitan Statistical Areas. According to the U.S. Census Bureau, these metro or micro areas consist of one or more counties that have a high degree of social and economic integration.

4 San Joaquin County was added to the CSA in 2013. To maintain consistency with past years, it was excluded from this analysis.

Exhibit 2.3-1 | Changes in Real Gross Domestic Product by World Region

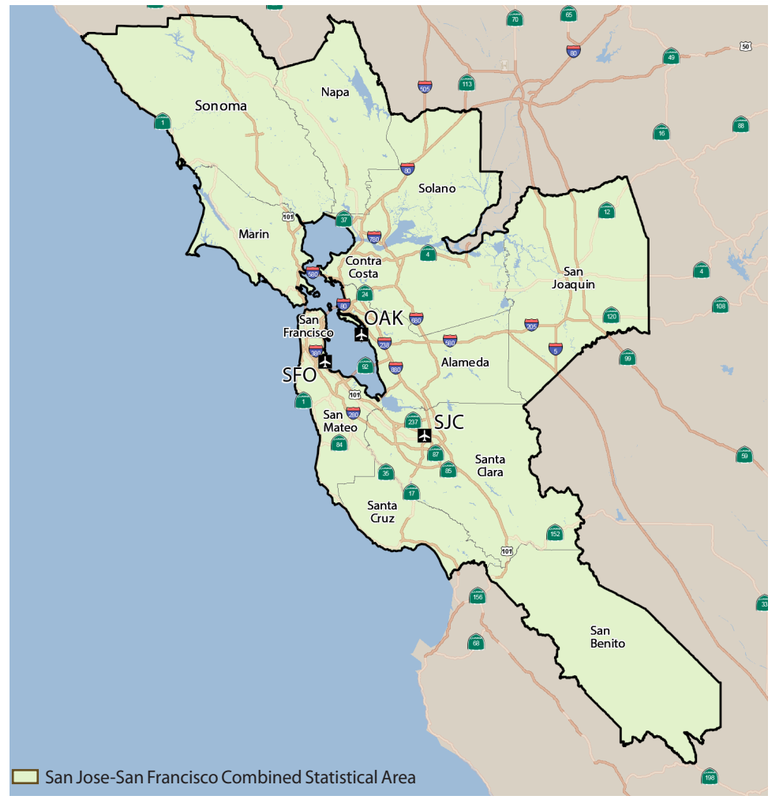


Source: FAA Aerospace Forecast Fiscal Years 2013–2033, released March 6, 2013

2.3.3 Bay Area Socioeconomic Trends

This section summarizes recent trends and future projections of population, per capita personal income (PCPI), gross regional product (GRP), and employment for the United States, the State of California, and the Bay Area CSA. Airline yield information is also provided. Historical and forecast socioeconomic variables were obtained from Woods & Poole Economics, Inc., of Washington, D.C. Woods & Poole developed projections yearly from 2013 through 2020 and at 5-year intervals until 2040. All economic variables are presented in constant dollars to eliminate distortion in the data resulting from inflation.

Exhibit 2.3-2 | San Francisco Bay Area



Source: San Mateo County, U.S. Census Bureau, SFO Bureau of Planning and Environmental Affairs, 2016.

Population

According to the U.S. Census Bureau, the Bay Area CSA was ranked as the fifth most populated of the 169 CSAs in the United States in 2015. The CSA has shown steady population growth since 1990, at an average rate of 0.9 percent annually through 2014. In 2015, the Bay Area CSA had an estimated population of approximately 8.7 million. The CSA is expected to experience steady population growth over the planning horizon at a rate of 0.8 percent annually, slightly lower than the population growth forecast for the State of California and the United States (see **Table 2.3-1**).

Employment

Growth in employment is an important indicator of the overall health of the local economy. Population changes and employment changes tend to be closely correlated as people migrate into and out of areas largely depending on their ability to find work in the local economy.

Employment in the Bay Area CSA grew at nearly the same rate as in the nation from 1990 through 2014, at a compound annual growth rate (CAGR) of 1.0 percent (see **Table 2.3-2**). From 2000 to 2013, employment in the Bay Area CSA declined slightly, then rebounded to 2000 levels. Bay Area CSA employment is forecast to increase at a CAGR of 1.3 percent from 2015 through 2023, which is slightly slower than forecast growth for the state and the country.

2.4 HISTORICAL AVIATION ACTIVITY

This section presents SFO's historical role in the region and the U.S. transportation system in terms of serving aviation demand, enplaned passengers, the passenger airline aircraft fleet mix, passenger airline market shares, air cargo tonnage, and aircraft operations. The information in this section provides a context for the forecast. Although the past is not a perfect predictor of the future, analysis of historical data provides the opportunity to understand factors that have affected traffic and how those factors may influence air travel in the future.

While the socioeconomic base for air traffic is one of the fundamental underpinnings of the forecasts, demand cannot be realized without the provision of airline service at a price that satisfies demand. The historical relationships between the economy and aviation activity at SFO forms the basis for the forecasts.

2.4.1 SFO's Role

SFO is one of the busiest airports in the United States. It is one of 29 U.S. airports at which at least 1.0 percent of total U.S. passengers are enplaned and is consequently designated by the FAA as a "Large Hub Primary Commercial Service Airport."[5] SFO was the 7th busiest airport in North America in 2014 in terms of total enplaned and deplaned passengers (see **Table 2.4-1**), the 60th busiest airport in the world in terms of total passengers, and the 21st busiest in North America in terms of cargo tonnage.

Described as the "gateway to the Pacific," SFO serves as a major point of entry to the United States for passengers originating in Asia. SFO serves as a hub for United Airlines and is the principal base of operations for Virgin America.

SFO is located 12 miles south of downtown San Francisco. In 2015, SFO accommodated 50.1 million passengers, 459,468 metric tons of air cargo (including mail), and 429,815 total aircraft operations. Weekly airline service was provided from SFO to 74 domestic and 39 international destinations.

5 FAA National Plan of Integrated Airport Systems (NPIAS), 2013

Table 2.3-1 | Historical and Projected Population Trends (in Thousands)

Year		Bay Area CSA	California	United States
Historical				
	1990	6,814	29,960	249,623
	1995	7,168	31,697	266,278
	2000	7,680	33,988	282,162
	2005	7,781	35,828	295,517
	2010	8,173	37,334	309,326
Estimate	2015	8,588	39,007	321,449
Forecast				
	2018	8,787	40,131	330,383
	2023	9,127	42,068	345,892
CAGR				
	1990-2014	0.9%	1.1%	1.0%
	2015-2023	0.8%	0.9%	0.9%

Notes: *CAGR = Compound Annual Growth Rate*
CSA = Combined Statistical Area
Woods & Poole developed forecasts for every year until 2020 and at 5-year intervals thereafter until 2040. Intermediate values were interpolated.

Source: Woods & Poole Economics, Inc., 2015

Table 2.3-2 | Employment Trends (in Thousands of Jobs)

Year		Bay Area CSA	California	United States
Historical				
	1990	4,192	16,835	138,331
	1995	4,296	16,940	147,916
	2000	4,974	19,281	165,371
	2005	4,792	20,256	172,557
	2010	4,755	19,806	173,045
Estimate	2015	5,360	22,139	188,033
Forecast				
	2018	5,587	23,149	196,418
	2023	5,962	24,823	210,275
CAGR				
	1990-2014	1.0%	1.1%	1.2%
	2015-2023	1.3%	1.4%	1.4%

Notes: *CAGR = Compound Annual Growth Rate*
CSA = Combined Statistical Area
Woods & Poole developed forecasts for every year until 2020 and at 5-year intervals thereafter until 2040. Intermediate values were interpolated.

Source: Woods & Poole Economics, Inc., 2015

Table 2.4-1 | North American Airports Ranked by 2014 Passengers

Rank	Airport Code	City	Passengers
1	ATL	Atlanta	96,178,899
2	LAX	Los Angeles	70,663,265
3	ORD	Chicago	69,999,010
4	DFW	Dallas/Fort Worth	63,554,402
5	DEN	Denver	53,472,514
6	JFK	New York	53,254,533
7	**SFO**	**San Francisco**	**47,114,631**
8	CLT	Charlotte	44,279,504
9	LAS	Las Vegas	42,869,517
10	PHX	Phoenix	42,134,662

Source: Airports Council International, 2014 World Annual Traffic Report, 2015

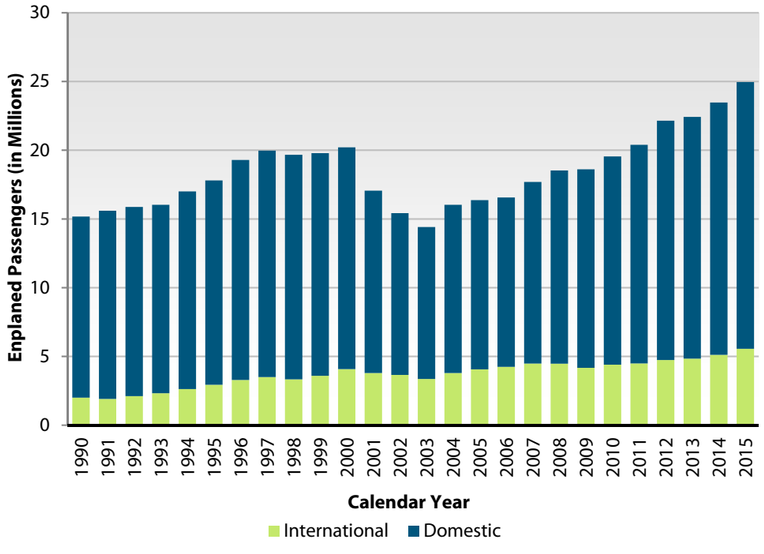
2.4.2 Historical Enplaned Passengers

The number of enplaned passengers at SFO has generally increased over time, driven in large part by growth in international passenger traffic (see **Exhibit 2.4-1**). The number of international enplaned passengers at SFO has more than doubled from 2.0 million in 1990 to more than 5.6 million in 2015, a CAGR of 4.2 percent. The number of domestic enplaned passengers at SFO has increased at a CAGR of 1.6 percent since 1990, from 13.2 million in 1990 to 19.4 million in 2015.

The total number of enplaned passengers at SFO increased from 15.2 million in 1990 to 25.0 million in 2015, at a CAGR of 2.0 percent. The 2001-2002 economic recession, the September 11, 2001 terrorist attacks, the 2003 Iraq invasion, and the 2002-2003 Severe Acute Respiratory Syndrome (SARS) outbreak all served to dampen demand for air travel at SFO and nationwide between 2001 and 2003. However, these factors generally had a transitory effect on air travel. SFO weathered the 2007-2008 global economic recession well, with flat traffic in 2008 and 2009 and then a resumption of strong growth by 2010.

Table 2.4-2 provides a comparison of the numbers of O&D and connecting passengers from 1990. Since then, the number of O&D passengers has increased faster than the number of connecting passengers (2.2 percent CAGR vs. 1.3 percent CAGR).

Exhibit 2.4-1 | SFO Historical Enplaned Passengers



Source: SFO Year End Traffic Reports, 2015

Table 2.4-2 | SFO Historical Enplaned Passengers by Segment

Calendar Year	Originating Passengers			Connecting Passengers			Total Enplaned Passengers		
	Domestic	International	Total	Domestic	International	Total	Domestic	International	Total
1990	9,726,530	1,487,229	11,213,759	3,449,157	512,030	3,961,187	13,175,687	1,999,259	15,174,946
1991	10,093,080	1,360,258	11,453,338	3,599,557	545,000	4,144,557	13,692,637	1,905,258	15,597,895
1992	9,957,850	1,494,359	11,452,209	3,801,224	616,910	4,418,134	13,759,074	2,111,269	15,870,343
1993	10,042,010	1,646,580	11,688,590	3,658,011	675,220	4,333,231	13,700,021	2,321,800	16,021,821
1994	9,950,060	1,919,648	11,869,708	4,427,022	706,090	5,133,112	14,377,082	2,625,738	17,002,820
1995	10,538,170	2,171,642	12,709,812	4,327,055	761,890	5,088,945	14,865,225	2,933,532	17,798,757
1996	11,295,130	2,408,858	13,703,988	4,711,014	871,560	5,582,574	16,006,144	3,280,418	19,286,562
1997	11,879,460	2,618,419	14,497,879	4,588,409	876,520	5,464,929	16,467,869	3,494,939	19,962,808
1998	11,806,860	2,601,321	14,408,181	4,525,445	725,360	5,250,805	16,332,305	3,326,681	19,658,986
1999	11,998,930	2,862,701	14,861,631	4,194,881	726,810	4,921,691	16,193,811	3,589,511	19,783,322
2000	12,258,500	3,201,319	15,459,819	3,874,966	873,240	4,748,206	16,133,466	4,074,559	20,208,025
2001	9,512,850	2,941,926	12,454,776	3,750,783	846,140	4,596,923	13,263,633	3,788,066	17,051,699
2002	8,346,560	2,786,500	11,133,060	3,425,029	863,290	4,288,319	11,771,589	3,649,790	15,421,379
2003	7,912,720	2,596,872	10,509,592	3,147,023	756,600	3,903,623	11,059,743	3,353,472	14,413,215
2004	8,771,380	2,908,177	11,679,557	3,462,434	883,560	4,345,994	12,233,814	3,791,737	16,025,551
2005	9,071,520	3,135,038	12,206,558	3,237,448	919,460	4,156,908	12,308,968	4,054,498	16,363,466
2006	9,063,560	3,263,390	12,326,950	3,252,887	978,170	4,231,057	12,316,447	4,241,560	16,558,007
2007	9,833,650	3,448,706	13,282,356	3,378,902	1,025,410	4,404,312	13,212,552	4,474,116	17,686,668
2008	10,936,850	3,459,097	14,395,947	3,122,357	1,009,970	4,132,327	14,059,207	4,469,067	18,528,274
2009	11,499,980	3,281,615	14,781,595	2,950,166	879,510	3,829,676	14,450,146	4,161,125	18,611,271
2010	11,929,210	3,422,366	15,351,576	3,216,666	971,450	4,188,116	15,145,876	4,393,816	19,539,692
2011	12,412,490	3,559,324	15,971,814	3,486,833	930,070	4,416,903	15,899,323	4,489,394	20,388,717
2012	13,164,220	3,721,223	16,885,443	4,251,066	1,011,680	5,262,746	17,415,286	4,732,903	22,148,189
2013	13,501,594	3,840,376	17,341,970	4,075,679	1,000,136	5,075,815	17,577,273	4,840,512	22,417,785
2014	14,148,406	4,071,415	18,219,821	4,208,951	1,035,656	5,244,607	18,357,357	5,107,071	23,464,428
2015	14,907,093	4,527,305	19,434,398	4,493,286	1,027,335	5,520,621	19,400,379	5,554,640	24,955,019
CAGR									
1990–2000	2.3%	8.0%	3.3%	1.2%	5.5%	1.8%	2.0%	7.4%	2.9%
2000–2015	1.3%	2.3%	1.5%	1.0%	1.1%	1.0%	1.2%	2.1%	1.4%
1990–2015	1.7%	4.6%	2.2%	1.1%	2.8%	1.3%	1.6%	4.2%	2.0%

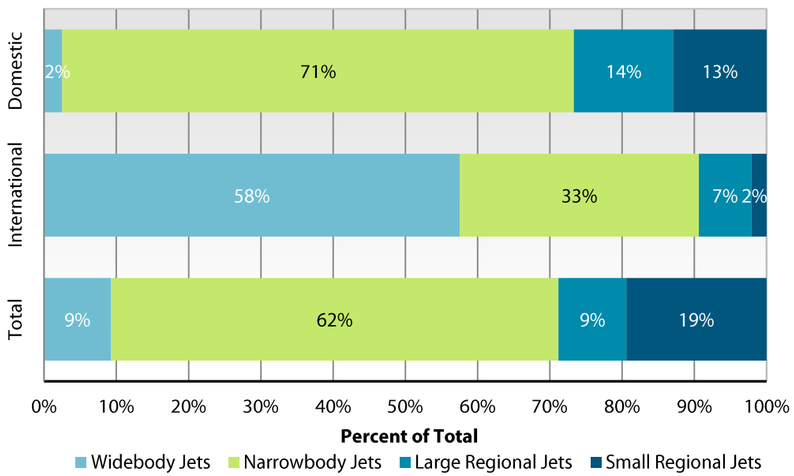
Note: CAGR = Compound Annual Growth Rate

Sources: SFO Year End Traffic Reports, 2015; U.S. Department of Transportation, Air Passenger Origin-Destination Survey, 2015

2.4.3 Passenger Airline Aircraft Fleet Mix

Exhibit 2.4-2 presents the share of scheduled passenger flights by aircraft classification for domestic, international, and total traffic. Airlines providing scheduled passenger service at SFO primarily operate narrowbody aircraft, which accounted for 62 percent of total scheduled passenger flights and 71 percent of scheduled domestic passenger flights in 2015. Widebody aircraft accounted for 2 percent of domestic passenger aircraft operations in 2015. The remaining 27 percent of 2015 domestic operations were operated using regional aircraft. International scheduled passenger service is primarily provided using widebody aircraft, which accounted for 58 percent of international passenger flights at SFO in 2015, while narrowbody aircraft accounted for 33 percent. No passenger flights were operated by turboprop aircraft.

Exhibit 2.4-2 | SFO 2015 Passenger Aircraft Fleet Mix Share by Classification



Note: Small regional jets have 50 seats or less. Large regional jets generally have 60 to 90 seats.

Source: Official Airline Guide for 2015

2.4.4 Passenger Airline Market Shares

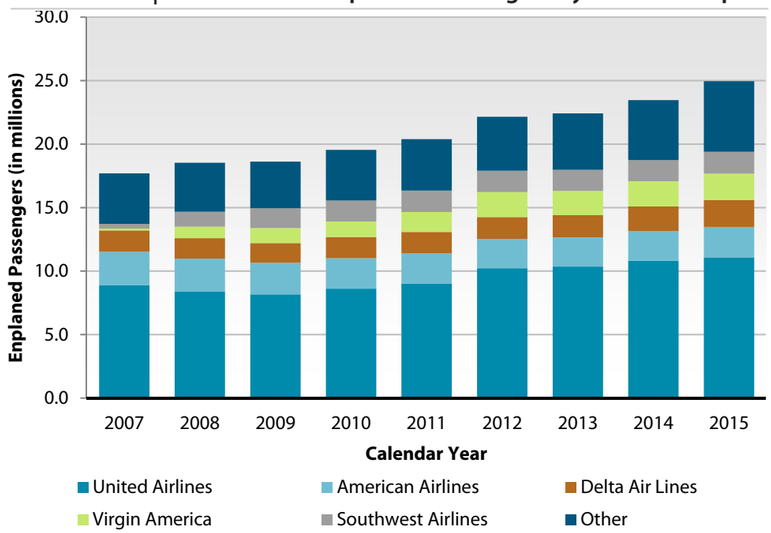
United Airlines maintains a hub at SFO and is the busiest airline at the Airport in terms of enplaned passengers. In 2015, United Airlines enplaned 11.1 million passengers at SFO, accounting for 44.4 percent of total enplaned passengers. The airline operated flights to 66 domestic destinations and 22 international destinations in Canada, Europe, Latin America, Oceania, and Asia. In 2015, 83.2 percent of United Airlines passengers were domestic and 16.8 percent were international.

Virgin America began commercial service on August 8, 2007, flying from New York and Los Angeles to SFO. Virgin America is the fastest growing airline at SFO in terms of enplaned passengers. In 2015, Virgin America enplaned 2.4 million passengers at SFO, accounting for 8.4 percent of total passenger traffic. In 2015, Virgin America operated flights to 16 domestic destinations and 3 international destinations in Mexico. In 2015, 97.7 percent of Virgin America's passengers were domestic and 2.3 percent were international.

In 2015, American Airlines[6] accounted for 2.4 million enplaned passengers, representing 9.6 percent of total enplaned passenger traffic at SFO. Other airlines with significant traffic at SFO in 2015 included Delta Air Lines (8.4 percent of total enplaned passengers), and Southwest Airlines (7.4 percent).

6 American Airlines and US Airways completed a merger in October 2015. This section combines the two airlines' traffic prior to October.

Exhibit 2.4-3 | SFO Historical Enplaned Passengers by Airline Group



Notes: Other = "Other Airlines"
American Airlines includes US Airways
Delta Air Lines includes Northwest Airlines
United Airlines includes Continental Airlines
Southwest Airlines includes AirTran Airways

Source: SFO Monthly Comparative Traffic Reports, 2007-2015

Exhibit 2.4-3 displays the enplaned passengers per airline group[7] at SFO from 2007 through 2015. The total number of enplaned passengers on United Airlines increased from 8.9 million in 2007 to 11.1 million in 2015, representing a CAGR of 2.8 percent. United Airlines' passenger traffic has grown since 2007 as a result of increased service and its merger with Continental Airlines. However, United's overall market share at SFO declined during this period because of strong growth in passengers enplaned by other airlines, including the introduction of service by new entrant airlines such as Virgin America and Southwest Airlines. United Airlines' share of total enplaned passengers at SFO declined from 50.3 percent in 2007 to 44.4 percent in 2015.

2.4.5 Historical Air Cargo Tonnage

For purposes of this forecast, air cargo is segmented into two types, air mail and air freight, and two shipping methods, belly cargo and freighter.

Most passenger airlines accommodate air cargo as a by-product of their primary activity of carrying passengers. Cargo fills belly space in passenger aircraft that would otherwise be empty. The incremental costs of carrying cargo in a passenger aircraft are negligible, and include only ground handling expenses and a modest increase in fuel consumption.

Table 2.4-3 summarizes historical cargo tonnage at SFO. Total air cargo tonnage peaked in 2000 at 872,252 metric tons, decreased to a low of 363,794 metric tons in 2013, and rebounded over the next two years, reaching 459,467 metric tons in 2015.

Truck substitution has been a major factor in the decline in air cargo in recent years, particularly since the price of oil spiked in 2008. Trucks have nearly replaced regional air freight service because of cost savings and increased efficiency using trucks. These trucking services have expanded to provide the transport of freight to gateway airports for consolidation. Many on-airport air cargo facilities are operating as truck terminals to a greater extent than in the past, yet requirements to report truck-to-truck traffic are minimal. The growth of truck-to-truck traffic makes it more difficult to know the space requirements for air cargo facilities.

The majority of cargo at SFO is carried in the belly compartments of passenger aircraft, versus freighter aircraft, which are dedicated to the carriage of cargo only. In 2015, 51.1 percent of domestic cargo was carried in the belly compartment of passenger aircraft, up from 47.1 percent in 2008. For international cargo, 86.8 percent was carried on passenger aircraft. The share of international belly cargo is higher than domestic belly cargo because of the larger aircraft used on international routes, particularly to Asia. **Exhibit 2.4-4** displays the historical belly cargo/freighter split at SFO for domestic flights. **Exhibit 2.4-5** shows the same information for international cargo.

7 An airline group includes a major carrier and, if applicable, its regional carriers and/or merger partner.

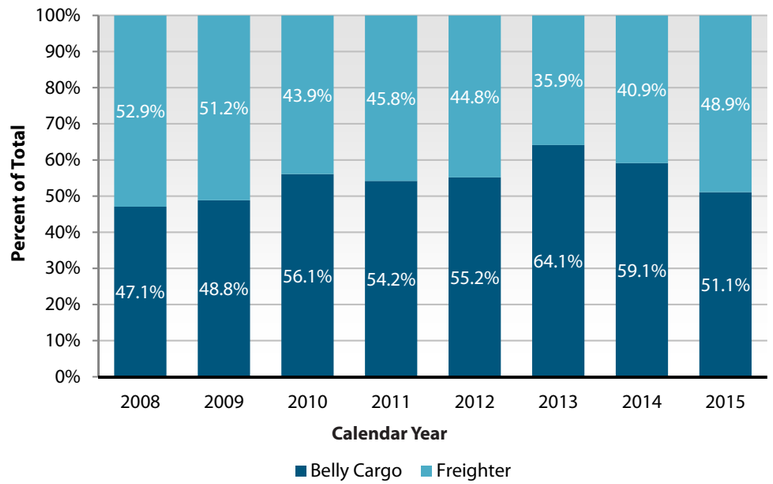
Table 2.4-3 | Historical Air Cargo Tonnage (in Metric tons)

Calendar Year	Freight			Mail			Total
	Domestic	International	Total	Domestic	International	Total	
1998	245,013	353,567	598,580	146,782	26,672	173,454	772,034
1999	269,811	385,598	655,409	163,349	23,457	186,806	842,215
2000	264,175	431,083	695,259	150,662	26,332	176,994	872,253
2001	191,900	325,224	517,124	96,357	22,523	118,880	636,004
2002	189,263	316,820	506,083	65,587	24,287	89,874	595,957
2003	200,839	282,574	483,413	63,787	26,323	90,110	573,523
2004	211,222	278,554	489,776	51,555	21,543	73,098	562,874
2005	236,347	284,039	520,386	48,611	21,560	70,171	590,557
2006	239,990	289,313	529,303	36,385	29,169	65,554	594,857
2007	217,696	286,203	503,899	22,970	36,064	59,034	562,933
2008	176,604	253,308	429,912	28,606	33,632	62,238	492,150
2009	141,246	215,020	356,266	24,608	27,228	51,836	408,102
2010	126,981	257,198	384,179	22,437	20,108	42,545	426,724
2011	115,705	225,061	340,766	23,251	18,002	41,253	382,019
2012	127,423	209,933	337,356	26,455	16,979	43,434	380,790
2013	110,083	215,699	325,782	26,679	11,333	38,012	363,794
2014	116,242	233,343	349,585	35,658	15,372	51,030	400,615
2015	141,095	248,839	389,934	44,294	25,239	69,533	459,467
CAGR							
1998-2005	-0.5%	-3.1%	-2.0%	-14.6%	-3.0%	-12.1%	-3.8%
2005-2015	-5.0%	-1.3%	-2.8%	-0.9%	1.6%	-0.1%	-2.5%
1998-2015	-3.2%	-2.0%	-2.5%	-6.8%	-0.3%	-5.2%	-3.0%

Note: CAGR = Compound Annual Growth Rate

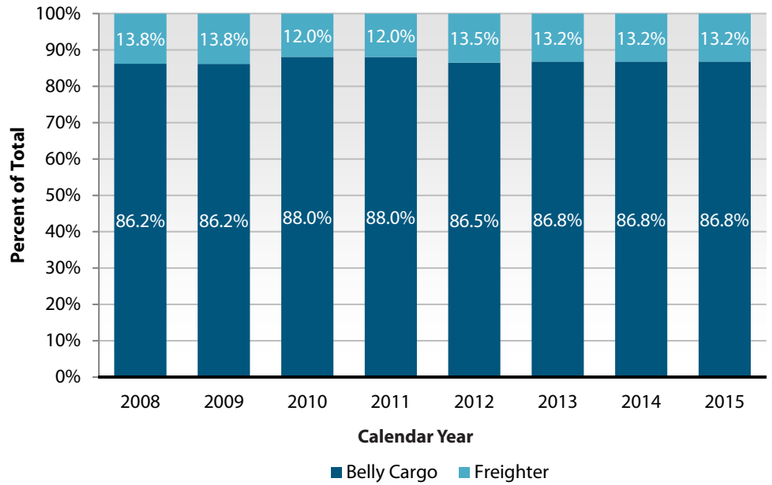
Source: SFO Year End Traffic Reports, 2015

Exhibit 2.4-4 | SFO Domestic Belly Cargo/Freighter Split



Source: SFO Year End Traffic Reports, 2015

Exhibit 2.4-5 | SFO International Belly Cargo/Freighter Split



Source: SFO Year End Traffic Reports, 2015

2.4.6 Historical Aircraft Operations

For purposes of developing the aircraft operations forecast, historical aircraft operations at SFO were classified into five segments: (1) commercial passenger; (2) all-cargo (freighter); (3) non-commercial air taxi; (4) general aviation; and (5) military. **Table 2.4-4** presents historical aircraft operations at SFO from 2007 through 2015.

The total number of aircraft operations at SFO increased from 379,500 in 2007 to 429,815 in 2015, representing a CAGR of 1.6 percent. During this period, commercial passenger airline aircraft operations increased the fastest, at a CAGR of 2.1 percent. Military aircraft operations at SFO remained relatively flat during the period, while all-cargo, air taxi, and GA aircraft operations decreased.

Table 2.4-4 | SFO Historical Aircraft Operations

Calendar Year	Commercial Passenger	All-Cargo	Non-Commercial Air Taxi	General Aviation	Military	Total
2007	330,114	7,140	20,463	19,150	2,633	379,500
2008	344,834	6,420	18,303	15,478	2,675	387,710
2009	342,658	7,084	14,938	12,293	2,778	379,751
2010	349,420	7,036	15,512	12,570	2,710	387,248
2011	365,372	6,782	16,059	12,711	2,640	403,564
2012	387,416	6,274	15,596	12,561	2,719	424,566
2013	386,416	5,920	14,475	12,213	2,376	421,400
2014	395,306	6,132	14,759	12,623	2,813	431,633
2015	391,214	6,098	16,395	13,686	2,422	429,815
CAGR						
2007-2014	2.1%	-2.0%	-2.7%	-4.1%	-1.0%	1.6%

Note: CAGR = Compound Annual Growth Rate

Sources: SFO Monthly Comparative Traffic Reports, 2007-2015; Landrum & Brown, Inc., 2016

2.5 ENPLANED PASSENGER FORECAST

The forecasts of enplaned passengers at SFO reflect the economic outlook for the local, national, and global economies, historical airline activity trends, the demographic base for air travel demand, and other factors that may affect the demand for air travel at SFO through the planning horizon.

The enplaned passenger forecasts provide a basis for evaluating the airside, terminal, landside, and access roadway facilities and environmental impacts. They represent the basis for developing the commercial passenger airline aircraft operations forecasts. The enplaned passenger forecasts are presented for the 2018, 2023, Base Constrained, and High Constrained demand levels.

Forecast Assumptions

The enplaned passenger forecasts for SFO are based on the following assumptions:

- Economic and demographic indicators such as population, employment, and PCPI in the Bay Area will continue to grow.
- SFO will continue to accommodate the major share of airline activity in the Bay Area.
- Economic growth in the Middle East, Asia, and Latin America will drive continued growth in international air travel.
- Key businesses headquartered in the Bay Area CSA will continue to grow.
- The San Francisco tourism industry will continue to be robust, resulting in increasing demand for airline travel by visitors to the region.
- There will be no significant, long-term disruption in air travel at SFO due to an act of terrorism, war, or for reasons of public health and safety.
- In the Base Constrained and High Constrained demand levels, growth in enplaned passengers will be derived by increasing aircraft gauge and load factors.

Impact Factors

Forecasting aviation activity is inexact because many factors may influence future demand, both industry-wide and at SFO. The factors or trends that could affect activity at SFO over the planning horizon are listed below:

- **Growth in the Asian and Latin American economies** – This growth will drive continued growth in international air travel at SFO.
- **Low-cost carriers** – When low-cost carriers enter airport markets, prices tend to decline, and travel (especially leisure travel) increases. Low-cost carriers account for significant market share at SFO and are expected to continue to influence prices over the planning horizon.
- **New aircraft types** – The principal new aircraft expected to operate at SFO in the foreseeable future are the Boeing 787 and Airbus A350. These aircraft are targeted to replace aging Boeing 767-200 and Boeing 767-300 aircraft. Introduction of the Boeing 787 and Airbus A350 will not materially affect passenger demand. This replacement started on a small scale in 2014. The Boeing 767-300 aircraft are expected to remain a part of the aircraft fleet industry-wide throughout the planning horizon.
- **Market share competition** – United Airlines and Virgin America, the busiest airlines at SFO in terms of enplaned passengers, have increasingly added service to compete for market share over the past few years. This market share competition slowed down in 2012 and 2013. Nevertheless, competition between airlines operating at SFO and the Airport's significant low-cost carrier base will result in lower fares at SFO than fares offered at SJC and OAK.
- **Economic upturns and downturns** – Air travel varies with the health of the economy. The forecast was developed to reflect long-term trends and variations, and was not based on short-term economic spurts and recessions. These short-term events contribute to variability within the long-term trends identified in the forecasts. History has shown that air travel tends to recover after short-term economic and political events.
- **Facility constraints** – When airside facilities are constrained, aircraft gauge and load factors need to be increased to accommodate additional passengers and cargo at the Airport.

2.5.1 Domestic Originating Passengers

Development of the domestic originating passenger forecasts used an econometric approach that quantifies the relationship between local domestic passengers and independent demographic and economic variables. The forecast models were developed using the multilinear regression approach, with the dependent variable (domestic originating passengers per year) expressed by a linear function.

The methodology for developing the originating passenger forecasts recognizes that parameters such as population and GRP will change over time. However, it assumes that the fundamental relationships between the independent variables and domestic originating passenger traffic will persist.

The first step in developing the domestic passenger forecast model was to test the independent, or explanatory, variables against the dependent variables. A 24-year history (1990 to an estimate for 2013) of domestic originating passengers at SFO and in the region was used in the regression models. Several regressions of various combinations of the independent variables were tested, but were ultimately rejected for various reasons, such as:

- Inadequate test statistics (i.e., low R-squared values or other nonsignificant regression statistics), which indicate that the independent variables are not good predictors of SFO traffic.
- Poor forecast results. Regression models produce "forecasts" of historical data. A satisfactory model will generate results that are close to historical values.
- Theoretical contradictions (e.g., the model indicates that GDP growth is negatively correlated with traffic growth).
- Overly aggressive or conservative forecast results that are incompatible with historical averages.

After running various regression models for SFO and the region, the dependent variable used in the final model was the sum of domestic originating passengers for the three Bay Area airports, rather than SFO alone. This dependent variable produced more consistent, significant results when compared to historical data. The resulting forecast was then disaggregated to the individual airports with a market share analysis.

The associated independent variables were employment as expressed in jobs within the Bay Area CSA and a dummy variable. A dummy variable is used to represent the absence or presence of some categorical effect that may be expected to shift the outcome and cannot be explained by the other variables. In this instance, the dummy variable was used to signify the sharp decline in demand in 2001–2003 that occurred after the September 11, 2001, terrorist attacks. The regression inputs used in the model are displayed in **Table 2.5-1**.

Table 2.5-1 | Regression Inputs

Calendar Year	Dependent Variable	Independent Variables	
	SFO, OAK, SJC Domestic O&D Passengers	Employment	Dummy
1990	14,171,720	3,978,000	0
1991	14,728,630	3,996,000	0
1992	14,619,220	4,015,000	0
1993	15,636,380	4,034,000	0
1994	16,760,860	4,053,000	0
1995	18,253,680	4,072,000	0
1996	19,467,920	4,201,000	0
1997	19,841,950	4,335,000	0
1998	19,882,950	4,473,000	0
1999	20,719,310	4,615,000	0
2000	21,701,460	4,762,000	0
2001	19,089,170	4,716,000	1
2002	18,010,400	4,503,000	1
2003	17,864,560	4,436,000	1
2004	19,011,830	4,446,000	0
2005	19,511,510	4,491,000	0
2006	19,477,110	4,567,000	0
2007	20,315,000	4,693,000	0
2008	19,490,550	4,678,000	0
2009	18,551,260	4,504,000	0
2010	18,846,700	4,489,000	0
2011	19,219,980	4,581,000	0
2012	20,194,410	4,689,000	0
2013	20,363,238	4,747,000	0

Note: Employment reflects the 11-county CSA definition prior to the addition of the Stockton-Lodi MSA, which consists of San Joaquin County. This definition was changed in 2013.

Sources: U.S. Department of Transportation, Air Passenger Origin-Destination Survey, 2013; Woods & Poole Economics, Inc., 2013; Landrum & Brown, Inc., 2014

The summary output from the regression model is shown in **Table 2.5-2** and **Table 2.5-3**. The model exhibits relatively strong regression statistics (R-Squared, T-Statistics, and P-Values) compared to the models with other combinations of independent variables. **Exhibit 2.5-1** illustrates the model fit when plotted against the actual historical traffic at the Bay Area airports. The model-predicted traffic compares well to actual traffic, especially for 1998 through 2013.

The regression statistics and model-predicted traffic comparison indicate that the model provides a reasonable basis from which to forecast passenger traffic for the Bay Area airports.

Employment forecasts for the Bay Area CSA were input to the regression equation to extrapolate the region's domestic originating passenger demand.

A market share analysis of historical domestic originating passengers at SFO, OAK, and SJC was used to forecast the future market share at SFO. The results of the Bay Area regression model and the market share analysis were combined to derive the forecast of SFO domestic originating passengers.

Exhibit 2.5-2 displays the historical market shares of domestic originating passengers at the Bay Area airports from 1990 through 2013. SFO has served the majority of domestic originating passengers in the Bay Area since 1990. SFO's share of the region's domestic originating passengers increased each year between 2007 and 2012, and is expected to remain the dominant airport in the region over the planning horizon.

Exhibit 2.5-3 displays the results of the domestic originating passenger forecasts. The total number of originating domestic passengers at SFO is expected to increase from 14.91 million in 2015 to 15.72 million in 2023. The total number of domestic originating passengers is forecast to be 16.65 million for the Base Constrained demand level and 19.12 million for the High Constrained demand level.

Table 2.5-2 | Regression Model Output Summary - Statistics

Test Statistic	Value
Multiple R	0.875
R-Squared	0.766
Adjusted R-Squared	0.744
Standard Error	1,020,048.230
Observations	24

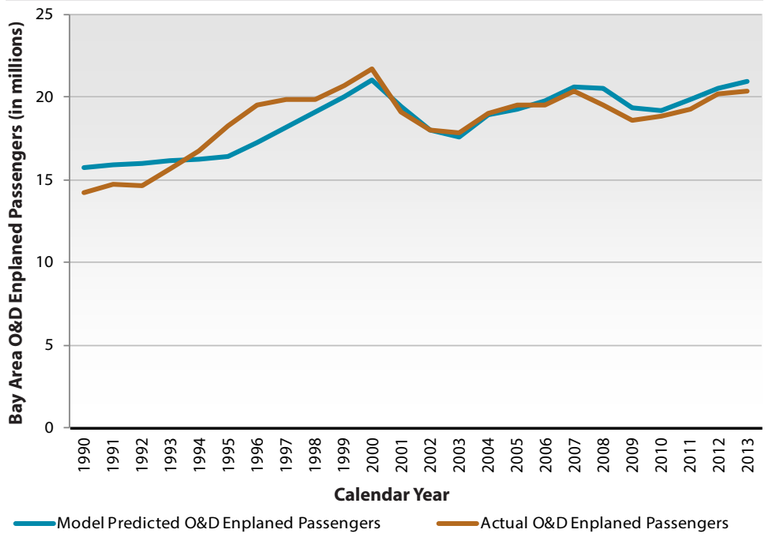
Sources: Landrum & Brown, Inc., 2014

Table 2.5-3 | Regression Model Output Summary - Coefficients

Variable	Coefficient	Standard Error	T-Statistic	P-Value
Intercept	-10998894.287	3580309.278	-3.072	0.006
Employment	6.728	0.813	8.285	< 0.001
Dummy	-1301930.895	641404.893	-2.03	0.055

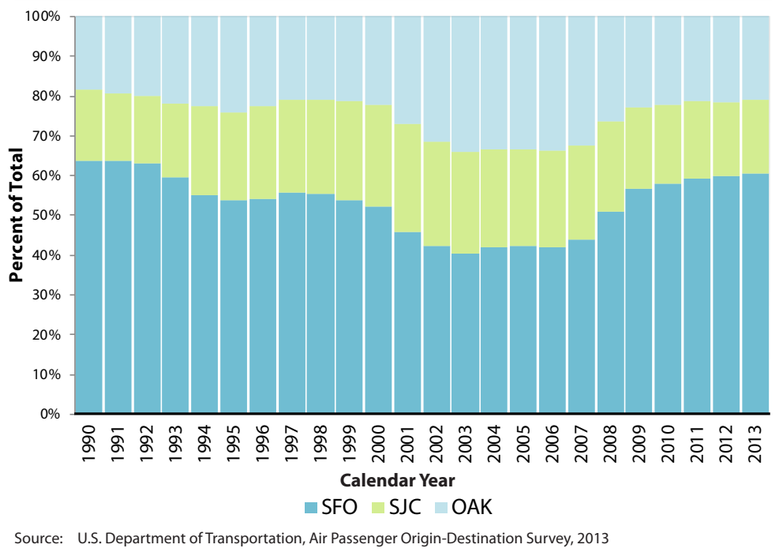
Sources: Landrum & Brown, Inc., 2014

Exhibit 2.5-1 | Bay Area Domestic Originating Passenger Regression Model



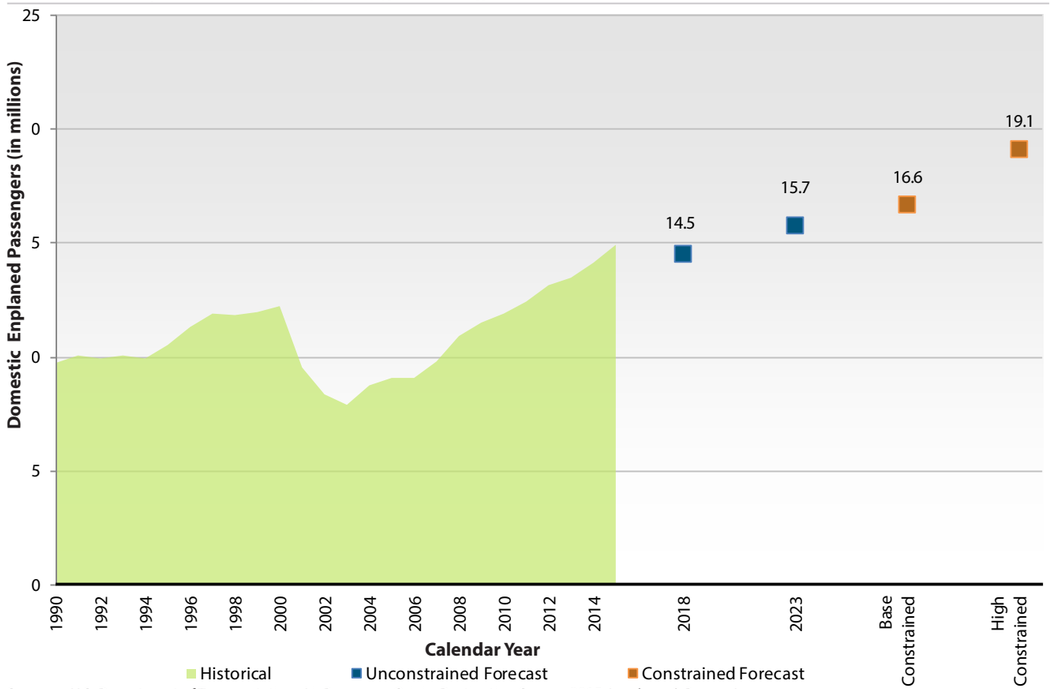
Sources: U.S. Department of Transportation, Air Passenger Origin-Destination Survey, 2013; Woods & Poole Economics Inc., 2013; Landrum & Brown, Inc., 2014

Exhibit 2.5-2 | Bay Area Domestic Originating Passenger Market Shares



Source: U.S. Department of Transportation, Air Passenger Origin-Destination Survey, 2013

Exhibit 2.5-3 | Domestic Originating Passenger Forecast Results



Sources: U.S. Department of Transportation, Air Passenger Origin-Destination Survey, 2015; Landrum & Brown, Inc.,

2.5.2 International Originating Passengers

International originating passengers are passengers traveling from the Bay Area that board a flight from SFO to an international destination. Similar to the analysis for the domestic originating passenger forecasts, a regression analysis was conducted to determine the historical relationship between international originating passengers and a series of independent variables.

SJC and OAK have limited international service so the regression model was only constructed using SFO passengers. Several model specifications were developed using world GDP, Developing Asia GDP, and Emerging and Developing Countries GDP as independent variables. Population, personal income, and GDP yielded the highest test statistics, but the results were deemed to be too conservative when compared to the recent growth at the Airport and the potential available for increased international air service. Using world GDP demonstrated the best fit; however, the results were also too conservative and did not reflect recent growth in Asia traffic.

Due to the regression models' inadequate results, industry forecasts developed by The Boeing Co. and Airbus S.A.S. were used as reference for future international passenger growth for the international originating passenger forecast model. The Boeing *Current Market Outlook 2013-2032* and the Airbus *Global Market Forecast 2013-2032* growth rates were compared by world region to develop the international originating passenger forecasts. **Exhibit 2.5-4** displays the forecast growth rates by world region published in the documents listed above.

The historical growth in numbers of international originating passengers by world region was analyzed to determine the applicability of the Boeing and Airbus forecasts to SFO (see **Table 2.5-4**). Growth in the world regions is in line with the Boeing and Airbus forecasts. Therefore, the international industry growth rates from Boeing and Airbus were slightly adjusted and applied to historical data by world region. The Boeing growth rates for the Canada, Europe, and Latin American were applied to their respective regions. Two-thirds of Boeing's growth rate for Asia was applied to the Asia/Middle East region while half of Boeing's growth rate for Oceania was applied to the Oceania region. The growth rates for these regions were adjust in order to more closely resemble the historical growth rates seen at the Airport.

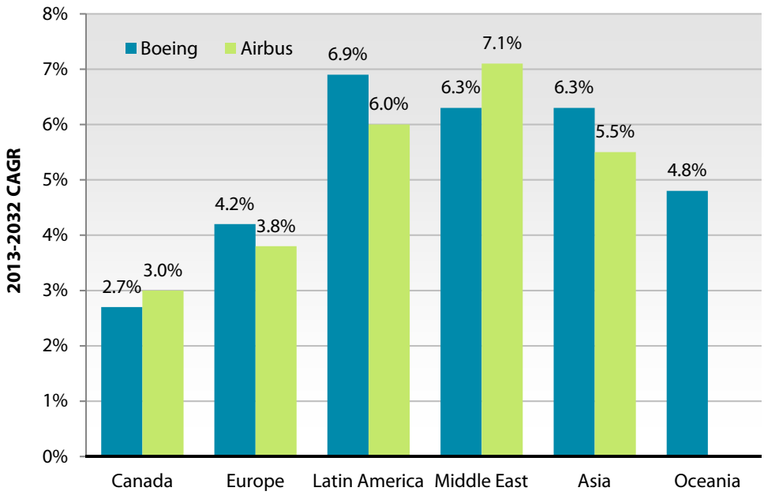
Table 2.5-4 | International Originating Passengers by World Region

Region	2004	2009	2010	2011	2012	2013	CAGR 2009-2013
Enplaned Passengers by World Region							
Canada	270,404	590,829	659,199	645,398	626,625	641,562	2.1%
Europe	545,284	1,096,353	1,080,551	1,194,763	1,247,285	1,355,498	5.4%
Latin America	167,540	358,340	369,024	395,686	525,551	514,286	9.5%
Asia/Middle East	911,567	1,881,184	2,064,828	2,050,168	2,140,592	2,116,696	3.0%
Oceania	73,596	234,419	220,214	203,247	192,850	212,470	-2.4%
Total	1,968,391	4,161,125	4,393,816	4,489,262	4,732,903	4,840,512	3.9%
Percent of Enplaned International Passengers by World Region							
Canada	13.7%	14.2%	15.0%	14.4%	13.2%	13.3%	
Europe	27.7%	26.3%	24.6%	26.6%	26.4%	28.0%	
Latin America	8.5%	8.6%	8.4%	8.8%	11.1%	10.6%	
Asia/Middle East	46.3%	45.2%	47.0%	45.7%	45.2%	43.7%	
Oceania	3.7%	5.9%	5.0%	4.5%	4.1%	4.4%	
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	

Note: *CAGR = Compound Annual Growth Rate*

Source: SFO Year End Traffic Reports, 2009-2013

Exhibit 2.5-4 | Industry Forecasts



Note: *The Oceania industry outlook was combined with Asia ("Asia-Pacific") in the Airbus forecasts.*

Sources: Boeing, Current Market Outlook 2013-2032; Airbus, Global Market Forecast 2013-2032

Exhibit 2.5-5 displays the international originating passenger forecast results. The total number of international originating passengers at SFO is forecast to increase at a CAGR of 4.8 percent, from 4.53 million in 2015 to 6.58 million in 2023. The total number of originating international passengers is forecast to increase to 7.41 million at the Base Constrained demand level and to 8.39 million at the High Constrained demand level.

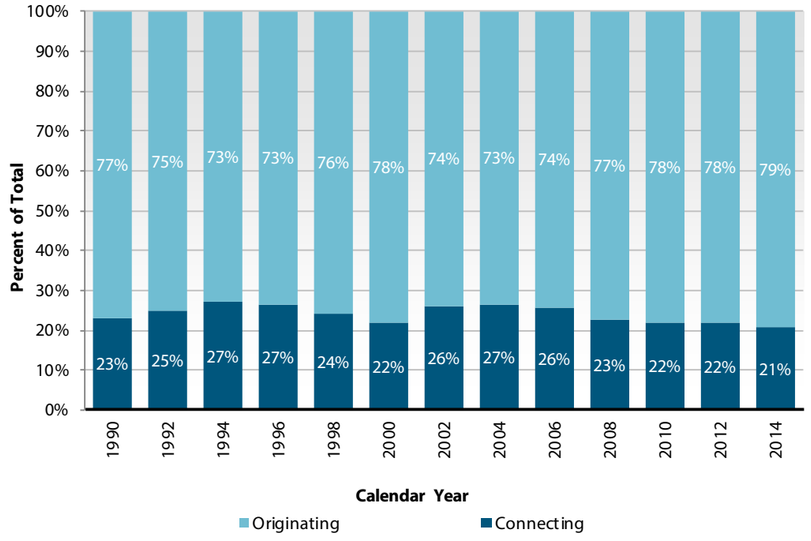
2.5.3 Connecting Passengers

The historical number of connecting passengers at SFO was examined to forecast future connecting passenger traffic at the Airport. The number of connecting passengers is largely a result of airline network management strategies and the airport's location rather than any unique characteristics of the Airport's local market. The geographic location of SFO limits domestic-to-domestic connecting activity except for Hawaii and small airports along the West Coast, but it makes an ideal connection point between domestic markets and Asia.

The historical analysis determined that the ratio of connecting passengers to originating passengers has remained consistent, so the connecting passenger forecasts were derived in part from the originating passenger forecasts. As the total number of international passengers is forecast to increase more rapidly than the number of domestic passengers, the number of international connecting passengers is forecast to increase more rapidly as well.

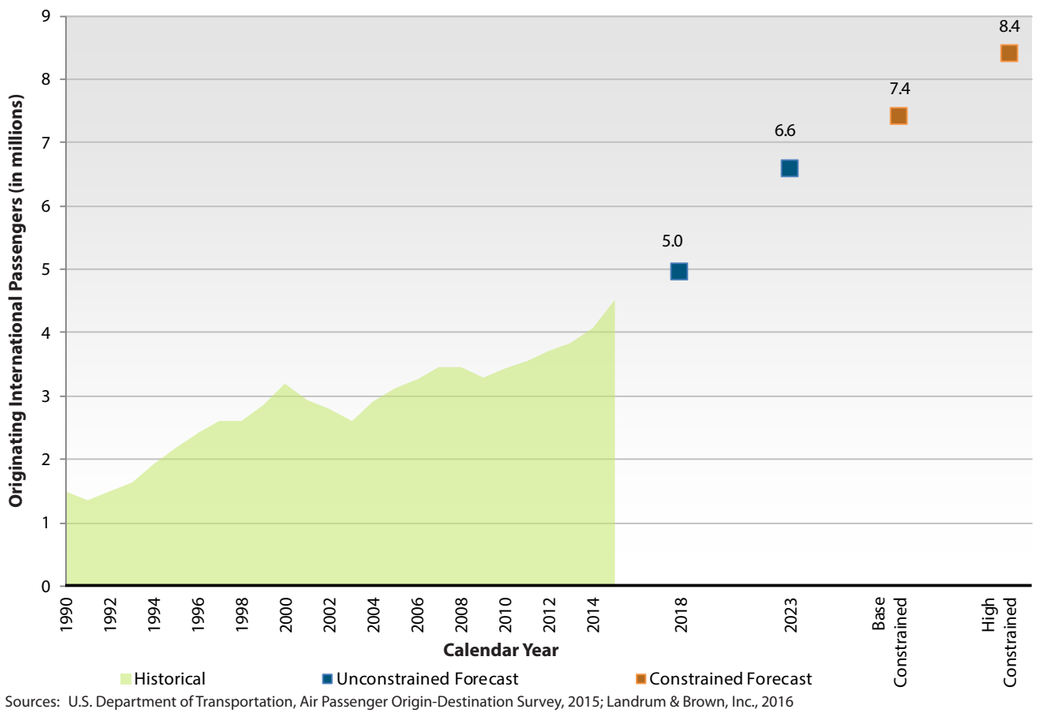
Exhibit 2.5-6 displays the total connecting passenger forecast results. Overall, the total number of connecting passengers is forecast to increase at a CAGR of 2.1 percent, from 5.52 million in 2015 to 6.53 million in 2023. The Base Constrained volume of total connecting passengers is forecast to increase to 7.05 million and the High Constrained volume of forecast to increase to 8.03 million. **Exhibit 2.5-7** shows the split between originating and connecting passenger traffic at the Airport.

Exhibit 2.5-7 | Originating vs. Connecting Passenger Split



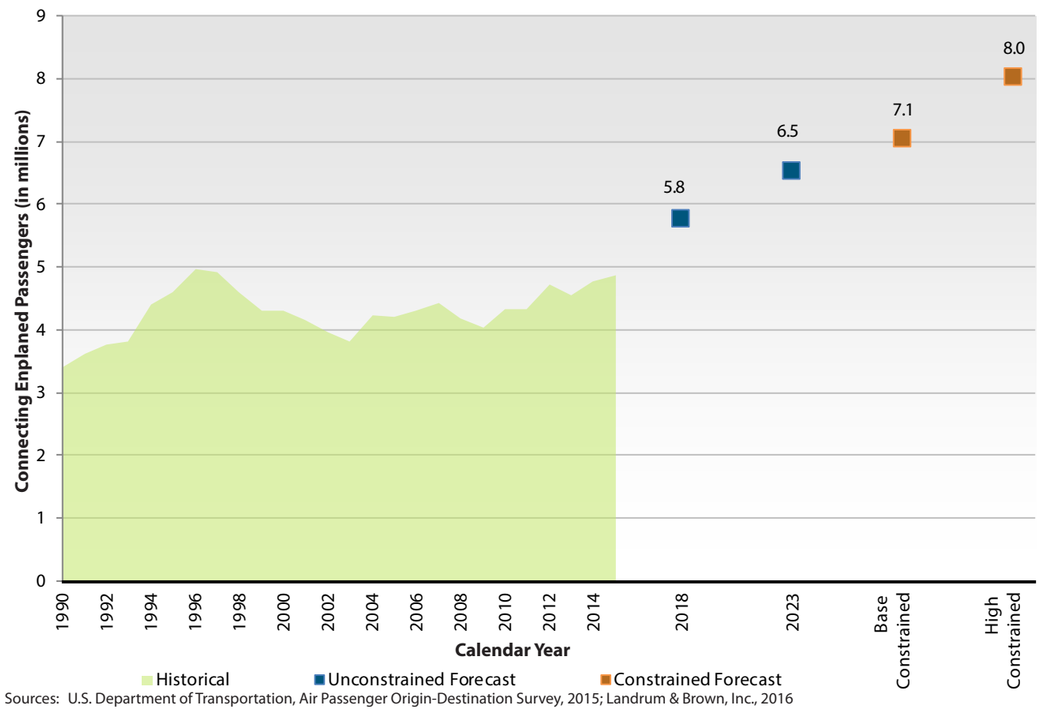
Sources: U.S. Department of Transportation, Air Passenger Origin-Destination Survey, 2015; Landrum & Brown, Inc., 2016

Exhibit 2.5-5 | International Originating Passenger Forecast Results



Sources: U.S. Department of Transportation, Air Passenger Origin-Destination Survey, 2015; Landrum & Brown, Inc., 2016

Exhibit 2.5-6 | Connecting Passenger Forecast Results



Sources: U.S. Department of Transportation, Air Passenger Origin-Destination Survey, 2015; Landrum & Brown, Inc., 2016

2.5.4 Passenger Activity Forecast Summary

The sum of the forecast of domestic and international originating and connecting passenger demand yields the forecast of total enplaned passenger demand for SFO. International originating passengers are forecast to increase, reflecting recent historical trends and a relatively strong economic growth forecast for Asia, the Middle East, and Latin America. Overall, the total number of enplaned passengers at SFO is forecast to increase from 24.96 million in 2015 to 28.83 million in 2023, at a CAGR of 1.8 percent. The Base Constrained demand for total enplaned passengers is forecast to increase to 31.11 million and the High Constrained demand for total enplaned passengers is forecast to increase to 35.54 million (see **Table 2.5-5** and **Exhibit 2.5-8**).

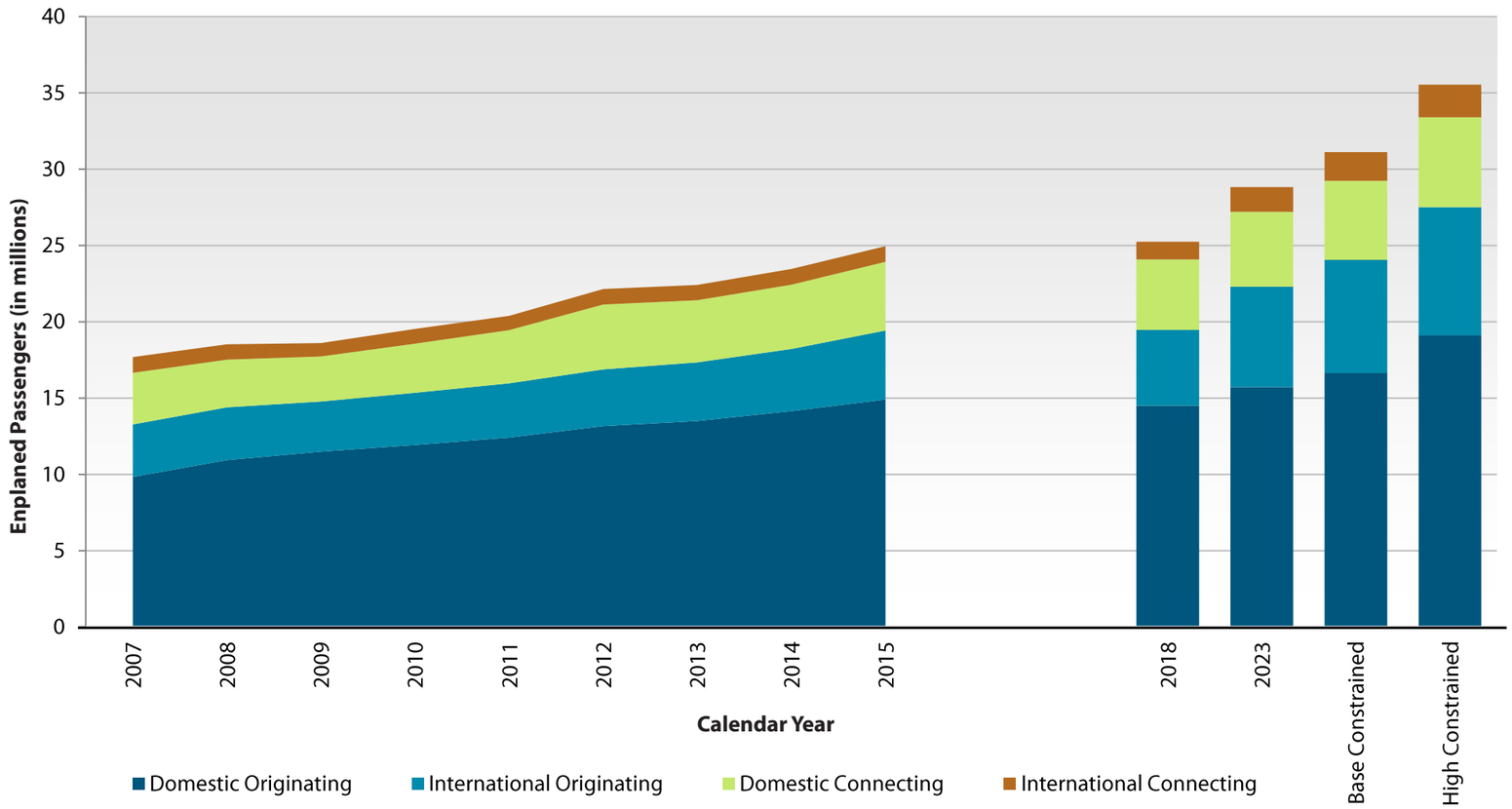
Table 2.5-5 | Total Enplaned Passenger Forecasts

Calendar Year	Originating Passengers			Connecting Passengers			Total Enplaned Passengers		
	Domestic	International	Total	Domestic	International	Total	Domestic	International	Total
Historical									
2000	12,258,500	3,201,319	15,459,819	3,874,966	873,240	4,748,206	16,133,466	4,074,559	20,208,025
2001	9,512,850	2,941,926	12,454,776	3,750,783	846,140	4,596,923	13,263,633	3,788,066	17,051,699
2002	8,346,560	2,786,500	11,133,060	3,425,029	863,290	4,288,319	11,771,589	3,649,790	15,421,379
2003	7,912,720	2,596,872	10,509,592	3,147,023	756,600	3,903,623	11,059,743	3,353,472	14,413,215
2004	8,771,380	2,908,177	11,679,557	3,462,434	883,560	4,345,994	12,233,814	3,791,737	16,025,551
2005	9,071,520	3,135,038	12,206,558	3,237,448	919,460	4,156,908	12,308,968	4,054,498	16,363,466
2006	9,063,560	3,263,390	12,326,950	3,252,887	978,170	4,231,057	12,316,447	4,241,560	16,558,007
2007	9,833,650	3,448,706	13,282,356	3,378,902	1,025,410	4,404,312	13,212,552	4,474,116	17,686,668
2008	10,936,850	3,459,097	14,395,947	3,122,357	1,009,970	4,132,327	14,059,207	4,469,067	18,528,274
2009	11,499,980	3,281,615	14,781,595	2,950,166	879,510	3,829,676	14,450,146	4,161,125	18,611,271
2010	11,929,210	3,422,366	15,351,576	3,216,666	971,450	4,188,116	15,145,876	4,393,816	19,539,692
2011	12,412,490	3,559,324	15,971,814	3,486,833	930,070	4,416,903	15,899,323	4,489,394	20,388,717
2012	13,164,220	3,721,223	16,885,443	4,251,066	1,011,680	5,262,746	17,415,286	4,732,903	22,148,189
2013	13,501,594	3,840,376	17,341,970	4,075,679	1,000,136	5,075,815	17,577,273	4,840,512	22,417,785
2014	14,148,406	4,071,415	18,219,821	4,208,951	1,035,656	5,244,607	18,357,357	5,107,071	23,464,428
2015	14,907,093	4,527,305	19,434,398	4,493,286	1,027,335	5,520,621	19,400,379	5,554,640	24,955,019
Forecast									
2018	14,506,134	4,961,833	19,467,967	4,615,596	1,157,637	5,773,233	19,121,730	6,119,470	25,241,200
2023	15,722,166	6,578,966	22,301,132	4,906,120	1,620,948	6,527,068	20,628,286	8,199,914	28,828,200
Base Constrained	16,645,860	7,414,440	24,060,300	5,179,515	1,872,585	7,052,100	21,825,375	9,287,025	31,112,400
High Constrained	19,117,065	8,394,870	27,511,935	5,887,695	2,137,575	8,025,270	25,004,760	10,532,445	35,537,205
CAGR									
2000–2015	1.3%	2.3%	1.5%	1.0%	1.1%	1.0%	1.2%	2.1%	1.4%
2015–2023	0.7%	4.8%	1.7%	1.1%	5.9%	2.1%	0.8%	5.0%	1.8%

Note: CAGR = Compound Annual Growth Rate

Sources: SFO Year End Traffic Reports, 2015; Landrum & Brown, Inc., 2016

Exhibit 2.5-8 | Enplaned Passenger Forecast Results



Sources: SFO Year End Traffic Reports, 2015; Landrum & Brown, Inc., 2016

2.6 AIR CARGO ACTIVITY FORECASTS

The forecasts of air cargo activity at SFO are discussed in this section. Estimates of the modal split between cargo carried in the belly compartments of passenger aircraft and dedicated freighter aircraft are also presented.

2.6.1 Air Cargo Outlook

Industry market outlooks were researched to gain a better understanding of the expected growth in air cargo traffic, in particular the North American and Asia-Pacific regions, which primarily affect cargo activity at SFO. The Boeing *World Air Cargo Forecast 2012-2031* and *Airbus Global Market Forecast 2012-2031* forecast growth rates are displayed in **Table 2.6-1**.

Table 2.6-1 | Industry Outlook – Forecast Cargo Growth Rates

Industry Market	Airbus	Boeing
Within North America		
2012–2021	2.8%	2.2%
2022–2031	2.3%	2.2%
North America to Asia-Pacific		
2012–2021	5.5%	6.0%
2022–2031	4.4%	6.0%
Asia-Pacific to North America		
2012–2021	6.0%	5.7%
2022–2031	4.9%	5.7%

Sources: Boeing, *World Air Cargo Forecast 2012-2013, 2012*; Airbus, *Global Market Forecast 2012-2031*, 2012

2.6.2 Air Cargo Activity

The cargo tonnage forecasts are based on the assumption that the structural changes in the air cargo industry discussed in Section 2.4.5 are permanent and that emerging trends related to air cargo security will continue. Additionally, it was assumed that long-term economic growth in the Bay Area CSA and the broader U.S. economy will increase demand for the shipment of goods.

While historical air cargo tonnage has a key role in defining the economic relationships used to forecast future growth, broader industry trends, economic analysis, and a review of peer forecasts also have a role in forecasting future cargo activity. The key factors underlying the domestic and international air cargo forecasts are:

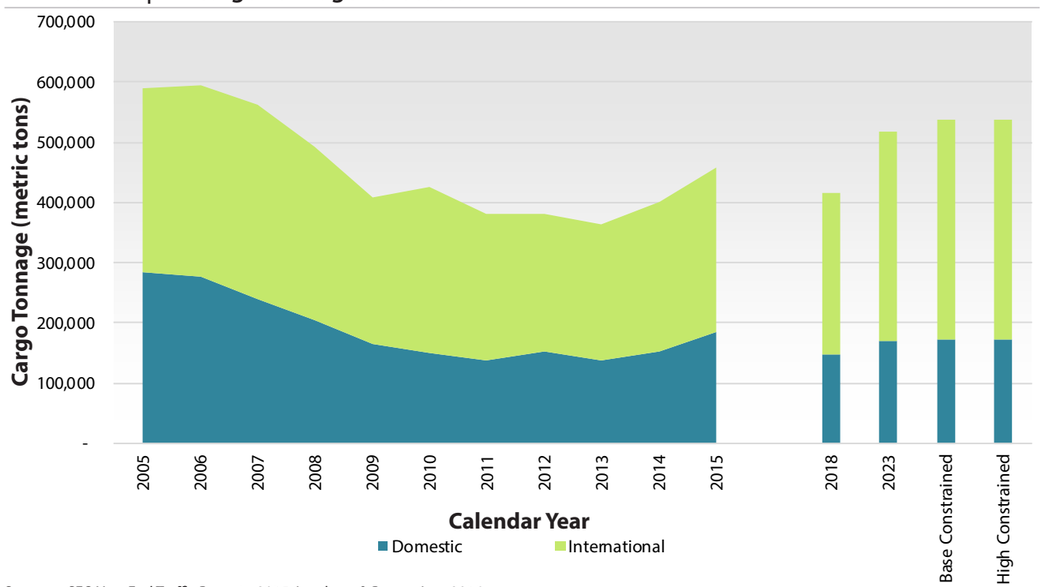
- Economic growth in North America, the Asia-Pacific region, and around the world is expected to continue to support growth in air cargo demand at SFO.
- Cargo tonnage is expected to remain flat until 2015 and then increase at a CAGR of 4.2 percent over the remainder of the planning horizon.
- The domestic cargo tonnage forecast is based on growth rates from the Airbus forecasts within North America. The international cargo tonnage forecast is based on the Asia-Pacific region growth rates from the Airbus forecast, as the majority of international cargo is from that region.
- The belly cargo-to-freighter ratio is expected to remain relatively constant from 2014 throughout the planning horizon.
- Mail is expected to increase at the same rate as freight.
- The share of domestic cargo tonnage carried by the integrated carriers[8] is expected to continue to increase. However, the expected increase in time-definite second and third day delivery may temper growth in integrated all-cargo operations, with more freight moving by truck.

Exhibit 2.6-1 summarizes historical and forecast cargo tonnage at SFO. Domestic air cargo tonnage at SFO is forecast to decrease from 185,389 metric tons in 2015 to 169,000 metric tons in 2023, at a CAGR of -1.2 percent (see **Table 2.6-2**). International cargo tonnage is forecast to increase at CAGR of 3.0 percent over the same period, from 274,048 metric tons in 2015 to 347,800 metric tons in 2023, as a result of forecast growth in Asia. The Base Constrained and High Constrained demand for domestic cargo tonnage is forecast to be 172,800 metric tons and the constrained demand for international cargo tonnage is forecast to be 363,900 metric tons.

To evaluate the need for dedicated cargo facilities and apron areas at SFO, the total forecast air cargo tonnage was allocated between cargo handled in dedicated freighter aircraft and cargo carried in the belly compartments of passenger aircraft (see **Table 2.6-3**). Belly cargo tonnage growth rates were assumed to remain constant for domestic cargo. As a result of the faster growth in international cargo, the percentage of international belly cargo is forecast to increase from 78 percent in 2013 to 79 percent in 2023. Belly cargo is forecast to remain at 79 percent of cargo tonnage for the Base and High Constrained demand levels.

8 An integrated freight company, or integrator, combines all operations of freight shipping into one business, including road carriage, freight forwarding, and air transport.

Exhibit 2.6-1 | Air Cargo Tonnage Forecasts



Sources: SFO Year End Traffic Reports, 2015; Landrum & Brown, Inc., 2016

Table 2.6-2 | Air Cargo Tonnage Forecasts by Origin/Destination

Calendar Year	Cargo Tonnage (metric tons)		
	Domestic	International	Total
Historical			
1998	391,795	380,239	772,034
1999	433,160	409,055	842,215
2000	414,837	457,415	872,252
2001	288,257	347,748	636,005
2002	254,850	341,107	595,957
2003	264,626	308,897	573,523
2004	262,777	300,097	562,874
2005	284,958	305,599	590,557
2006	276,375	318,482	594,857
2007	240,666	322,267	562,933
2008	205,210	286,940	492,150
2009	165,854	242,248	408,102
2010	149,418	277,306	426,724
2011	138,956	243,063	382,019
2012	153,878	226,912	380,790
2013	136,762	227,032	363,794
2014	151,900	248,715	400,615
2015	185,389	274,078	459,467
Forecast			
2018	148,600	268,500	417,100
2023	169,000	347,800	516,800
Base Constrained	172,800	363,900	536,700
High Constrained	172,800	363,900	536,700
CAGR			
2015–2023	-1.2%	3.0%	1.5%

Note: CAGR = Compound Annual Growth Rate

Sources: SFO Year End Traffic Reports, 2015; Landrum & Brown, Inc., 2016

Table 2.6-3 | Air Cargo Tonnage Forecasts by Carriage Type

Calendar Year	Metric Tons			Percent of Total		
	Belly	Freighter	Total	Belly	Freighter	Total
Historical						
1998	No Data					
1999	No Data					
2000	No Data					
2001	No Data					
2002	No Data					
2003	No Data					
2004	339,751	223,123	562,874	60%	40%	100%
2005	343,911	246,646	590,557	58%	42%	100%
2006	346,436	248,421	594,857	58%	42%	100%
2007	335,898	227,035	562,933	60%	40%	100%
2008	343,830	148,320	492,150	70%	30%	100%
2009	289,701	118,401	408,102	71%	29%	100%
2010	327,909	98,815	426,724	77%	23%	100%
2011	289,232	92,787	382,019	76%	24%	100%
2012	281,098	99,692	380,790	74%	26%	100%
2013	284,670	79,124	363,794	78%	22%	100%
2014	305,591	95,024	400,615	76%	24%	100%
2015	332,513	126,954	459,467	72%	28%	100%
Forecast						
2018	328,241	88,859	417,100	79%	21%	100%
2023	410,127	106,673	516,800	79%	21%	100%
Base Constrained	426,533	110,167	536,700	79%	21%	100%
High Constrained	426,533	110,167	536,700	79%	21%	100%
CAGR						
2015–2023	2.7%	-2.2%	1.5%			

Note: CAGR = Compound Annual Growth Rate

Sources: SFO Year End Traffic Reports, 2015; Landrum & Brown, Inc., 2016

2.7 AIRCRAFT OPERATIONS FORECASTS

This section describes the forecasts of aircraft operations at SFO by category. Aircraft operations, defined as the sum of arrivals and departures, were forecast separately for the five major categories of users: (1) commercial passenger; (2) all-cargo; (3) non-commercial air taxi; (4) general aviation; and (5) military.

Aircraft operations at SFO are forecast based on the following factors:

- The forecast of total aircraft operations was developed from information about airline aircraft fleet plans, scheduling strategies at down-line hubs, increasing load factors and aircraft gauge, and assumptions about mergers and competitive strategies.
- The unconstrained forecast of passenger airline aircraft operations (2018 and 2023 demand levels) was derived from the passenger forecast. Because airlines have a wide choice of aircraft and experience different load factors, many different aircraft operations totals can correspond to one set of passenger forecasts.
- The constrained forecast of passenger airline aircraft operations was based on simulation analysis results and improvements that decrease aircraft delays and/or increase aircraft efficiencies.
- The air cargo tonnage forecast for the all-cargo aircraft operators were used to derive the all-cargo aircraft operations forecast based on assumptions regarding the average amount of air cargo tonnage carried per flight. Historical all-cargo aircraft operations by aircraft type were analyzed to better understand the fleet mix for the all-cargo carriers at SFO.
- The general aviation, military, and air taxi aircraft operations forecasts are based on historical factors, industry trends, and the *FAA Aerospace Forecasts*.

2.7.1 Passenger Airline Aircraft Operations

The number of commercial passenger aircraft operations at an airport depends on three factors: total passengers, average aircraft size, and average load factor (percent of seats occupied). The relationship is shown in the equation below.

$$\textit{Total Operations} = \frac{\textit{Total Passengers}}{\textit{Average Load Factor} * \textit{Average Aircraft Size}}$$

This relationship permits infinite combinations of load factors, average aircraft sizes, and operations to accommodate a given number of passengers. To develop reasonable load factor and aircraft gauge assumptions, commercial passenger aircraft operations were disaggregated into domestic and international traffic.

The passenger airline operation forecast is further classified between mainline air carriers and commuter airlines. The "commuter" designation is primarily based on the individual airline's mode of operation (i.e., providing regional feed to its major airline partners) and certification with the FAA. These commuter airlines typically operate turboprop and jet aircraft with fewer than 90 seats.

The fundamental approach to deriving the passenger airline aircraft operations forecasts is the same at all airports. However, the underlying assumptions for each airport are inherently different because of differences in how airlines choose to serve the demand for travel to, from, and over each airport. These differences may result, for example, from a strategic focus on unit revenue versus unit costs, or an emphasis on a hub-and-spoke system versus a point-to-point operation.

Table 2.7-1 | Average Aircraft Seats per Departure Assumptions

Calendar Year	Domestic		International	
	Mainline	Commuter	Mainline	Commuter
Historical				
2007	156.2	41.0	246.3	66.0
2008	152.4	40.9	254.8	66.0
2009	154.3	43.2	250.3	62.7
2010	155.8	45.8	248.9	61.5
2011	155.9	46.5	248.5	61.0
2012	152.6	47.3	246.0	61.1
2013	153.0	48.1	247.5	60.5
2014	151.8	50.0	249.9	60.5
2015	159.8	61.2	257.3	68.6
Forecast				
2018	152.0	64.4	251.4	64.9
2023	152.1	69.6	266.8	66.0
Base Constrained	156.9	70.0	274.0	76.0
High Constrained	161.0	70.0	282.1	76.0

Note: International includes precleared markets as of April 2014.

Sources: U.S. Department of Transportation, Schedule T-100 data, 2015; Official Airline Guide, Inc., 2015; Landrum & Brown, Inc., 2016

A number of sources were used to develop the historical passenger operations, load factor, and aircraft gauge data. Official Airline Guide schedule; FAA Air Traffic Activity Data System (ATADS); and U.S. Department of Transportation Schedule T-100 data were used to develop total departures and seats for each segment. The average seats per departure (ASPD) for each major group (domestic mainline air carrier, domestic commuter, international mainline air carrier, and international commuter) of passenger activity were calculated from total departures and total departing seats. Aircraft load factors were calculated for each group of passenger airline aircraft operations by dividing the total number of enplaned passengers by the total number of departing seats. To calculate the total number of aircraft operations, the number of departures was multiplied by two.

Table 2.7-1 and **Table 2.7-2** present the historical and forecast ASPD and load factors for mainline air carrier and commuter aircraft. The assumptions underlying the forecasts are discussed in the following subsections.

Table 2.7-2 | Load Factor Assumptions

Calendar Year	Domestic		International	
	Mainline	Commuter	Mainline	Commuter
Historical				
2007	79.3%	74.1%	78.2%	83.7%
2008	78.9%	72.8%	79.4%	79.4%
2009	80.3%	76.2%	81.4%	77.9%
2010	82.2%	79.0%	84.1%	84.3%
2011	83.0%	79.1%	84.7%	86.1%
2012	86.6%	81.3%	85.0%	87.6%
2013	86.5%	82.3%	85.5%	89.9%
2014	86.5%	82.3%	85.5%	89.5%
2015	86.5%	85.4%	82.8%	89.8%
Forecast				
2018	86.5%	82.5%	85.9%	89.5%
2023	86.9%	82.9%	86.0%	89.9%
Base Constrained	88.0%	88.0%	88.0%	88.0%
High Constrained	95.0%	95.0%	95.0%	95.0%

Note: International includes precleared markets as of April 2014.

Sources: U.S. Department of Transportation, Schedule T-100, 2013; Official Airline Guides, Inc., 2015; Landrum & Brown, Inc., 2016

2.7.1.1 Domestic Passenger Airline Aircraft Operations

This section presents information on domestic passenger airline aircraft operations and assumptions regarding the operations forecasts.

2.7.1.1.1 Domestic Mainline Air Carrier Service

Between 2007 and 2015, domestic passenger airline aircraft operations at SFO grew from 281,540 in 2007 to 335,642 in 2015. Domestic mainline air carrier aircraft service accounted for more than 63 percent of total passenger airline aircraft operations at SFO in 2015.

United Airlines accounted for 40 percent of scheduled domestic mainline air carrier service at SFO in 2015. United primarily operates Airbus A320/319 and Boeing 737, 757, and 767 aircraft for domestic mainline air carrier service. United is updating its fleet by ordering similarly sized aircraft. United has confirmed orders for 100 Boeing 737-700 and 61 Boeing 737-900ER, as well as 10 A319 and 8 A320 aircraft.[9] It was assumed that United's Boeing 757 aircraft will be replaced by 2019.

Virgin America accounted for 14 percent of the scheduled domestic mainline air carrier service at SFO in 2015. SFO is the primary base of operations for Virgin America. Virgin America currently operates Airbus A320 (74 percent) and A319 (26 percent) aircraft. To maintain its low-cost carrier cost structure, Virgin America has ordered and is expected to continue operating exclusively the A320 family of aircraft.

Domestic mainline air carrier ASPD are forecast to change from 159.8 in 2015 to 156.9 under the Base Constrained forecast and to 161.0 under the High Constrained forecast. The reduction in domestic mainline ASPD from 2013 until the High Constrained demand level is the result of commuter aircraft being replaced by small mainline aircraft. The net effect of this substitution across all domestic airline aircraft operations is an increase in ASPD.

9 Boeing and Airbus websites, Orders and Deliveries (as of February 2014).

2.7.1.1.2 Domestic Commuter Service

Domestic commuter aircraft operations accounted for an increasing share of domestic passenger airline aircraft operations from 2004 to 2015, as the legacy airlines transferred a high percentage of service to their regional affiliates. However, based on the enplaned passenger forecasts, the increase in commuter ASPD, and load factor assumptions, commuter operations at SFO are forecast to increase at a lower rate than domestic mainline air carrier activity. The domestic commuter ASPD is forecast to increase from 61 in 2014 to 70 under the Base Constrained and High Constrained demand levels.

2.7.1.2 International Passenger Airline Aircraft Operations

This section presents information on international passenger airline aircraft operations and assumptions underlying the operations forecasts. ASPD and fleet mix were forecast for each of four world regions while load factors were forecast for international activity as a whole.

Approximately 55,572 international passenger airline aircraft operations were reported at SFO in 2015. Of those operations, 26.8 percent were to/from Canada, 16.9 percent were to/from Mexico and Latin America, 19.9 percent were to/from Europe, and 36.4 percent were to/from Asia, Oceania, and the Middle East. As with historical domestic activity, these operations are divided into mainline air carrier and commuter services.

2.7.1.2.1 International Mainline Air Carrier Service

In 2015, 50,540 international mainline air carrier operations were reported at SFO. The regions of Mexico/Latin America, Europe, and Asia/Oceania/Middle East were served exclusively by mainline air carrier aircraft (i.e., no commuter aircraft).

Mexico/Latin America

Mainline air carrier aircraft operations between SFO and Mexico/Latin America are forecast to increase at a CAGR of 4.7 percent over the planning horizon as a result of this region's growing demand for air travel from its increasing population and economy.

Europe

Service between SFO and Europe is provided exclusively by widebody aircraft. The ASPD for European operations is forecast to increase.

Asia/Oceania/Middle East

Service between SFO and the Asia/Oceania/Middle East region is also exclusively provided by widebody aircraft. The ASPD for Asia/Oceania/Middle East operations is forecast to remain relatively constant throughout the planning horizon.

Canada

Mainline air carrier service between SFO and Canada is forecast to be primarily provided by narrowbody aircraft. The ASPD for Canadian mainline air carrier aircraft operations is forecast to increase.

2.7.1.2.2 International Commuter Service

In 2014, more than 5,000 scheduled international commuter aircraft operations were reported at SFO. Commuter activity between SFO and Canada accounts for all of the reported historical activity, and this is not expected to change over the planning horizon.

In 2015, the ASPD for international commuter aircraft operations was 68.6. The ASPD is forecast to change to 66.0 in 2019 and to remain constant through 2023 as a result of fleet changes. The ASPD is forecast to increase to 76.0 for the Base Constrained and High Constrained demand levels.

2.7.1.3 Total Passenger Airline Aircraft Operations

Table 2.7-3 presents the results of the domestic and international passenger airline aircraft operations forecasts by segment. Domestic passenger airline aircraft operations are forecast to increase from an estimated 335,642 in 2015 to 374,300 in 2023. The Base Constrained demand for domestic passenger airline aircraft operations is forecast to increase to 373,100 and the High Constrained demand for domestic passenger airline aircraft operations is forecast to increase to 379,600.

International passenger airline aircraft operations are forecast to increase at a CAGR of 4.3 percent from an estimated 55,572 in 2015 to 77,600 in 2023. The Base Constrained demand for international passenger airline aircraft operations is forecast to increase to 82,300 and the High Constrained demand for international passenger airline aircraft operations is forecast to increase to 83,500.

Total passenger airline aircraft operations are forecast to increase from an estimated 391,214 in 2015 to 451,900 in 2023, at a CAGR of 1.8 percent. The Base Constrained demand for total passenger airline aircraft operations is forecast to increase to 455,400 and the High Constrained demand for total passenger airline aircraft operations is forecast to increase to 463,100.

Table 2.7-3 | Passenger Airline Aircraft Operations Forecasts by Segment

Calendar Year	Domestic			International			Total		
	Mainline	Commuter	Total	Mainline	Commuter	Total	Mainline	Commuter	Total
Historical									
2007	191,240	90,300	281,540	45,638	2,936	48,574	236,878	93,236	330,114
2008	213,102	84,136	297,238	43,002	4,594	47,596	256,104	88,730	344,834
2009	210,202	87,236	297,438	39,492	5,728	45,220	249,694	92,964	342,658
2010	210,196	93,310	303,506	40,684	5,230	45,914	250,880	98,540	349,420
2011	216,958	101,498	318,456	41,264	5,652	46,916	258,222	107,150	365,372
2012	232,866	105,422	338,288	43,966	5,162	49,128	276,832	110,584	387,416
2013	235,100	101,760	336,860	44,422	5,134	49,556	279,522	106,894	386,416
2014	241,616	101,160	342,776	47,042	5,488	52,530	288,658	106,648	395,306
2015	246,716	88,926	335,642	50,540	5,032	55,572	297,256	93,958	391,214
Forecast									
2018	252,900	92,900	345,800	56,600	5,400	62,000	309,500	98,300	407,800
2023	279,200	95,100	374,300	70,900	6,700	77,600	350,100	101,800	451,900
Base Constrained	280,200	92,900	373,100	76,300	6,000	82,300	356,500	98,900	455,400
High Constrained	295,400	84,200	379,600	77,900	5,600	83,500	373,300	89,800	463,100
CAGR									
Base Constrained	280,200	92,900	373,100	76,300	6,000	82,300	356,500	98,900	455,400
High Constrained	295,400	84,200	379,600	77,900	5,600	83,500	373,300	89,800	463,100
2007–2015	3.2%	-0.2%	2.2%	1.3%	7.0%	1.7%	2.9%	0.1%	2.1%
2015–2023	1.6%	0.8%	1.4%	4.3%	3.6%	4.3%	2.1%	1.0%	1.8%

Note: International includes precleared markets as of April 2014.
CAGR = Compound Annual Growth Rate

Sources: U.S. Department of Transportation, Schedule T-100, 2015; Official Airline Guides, Inc., 2015; Landrum & Brown, Inc., 2016

2.7.1.4 Commercial Passenger Airline Aircraft Fleet Mix

The fleet mix forecasts were developed to match the aggregate ASPD targets for each of the four categories (domestic mainline air carrier, domestic commuter, international mainline air carrier, and international commuter) of commercial passenger airline aircraft operations presented in the previous sections. The fleet mix forecasts also allowed for the calibration of ASPD and load factor assumptions and, where appropriate, modifications were made prior to finalizing the ASPD and load factor assumptions.

The allocation of commercial passenger airline operations by aircraft type is shown in **Table 2.7-4** for domestic operations and in **Table 2.7-5** for international operations. The total of **Table 2.7-4** and **Table 2.7-5** equals the peak period passenger operations presented in **Table 2.10-3**.

Table 2.7-4 | Design Day Domestic Passenger Airline Aircraft Fleet Mix

Aircraft	Seats	2013	2018	2023	Base	High
Widebody Jet						
333	300	0	0	4	4	4
332	290	2	2	4	4	4
777	269	7	18	18	35	19
764	237	2	0	0	0	0
763	232	14	0	0	0	0
788	230	0	6	6	11	27
762	168	4	0	0	0	0
Subtotal		29	26	32	54	54
Narrowbody Jet						
321	183	16	27	36	87	169
739	175	50	57	98	61	70
757	171	133	30	0	0	0
MD90	160	2	0	0	0	0
738	153	129	134	146	210	300
320	145	171	263	277	221	149
737	143	118	110	136	102	104
319	121	96	99	103	106	42
Subtotal		715	720	796	787	834
Large Regional Jet						
CR9/E175/MRJ	76	18	84	129	111	76
DH4	76	6	111	77	81	92
CR7	67	66	74	0	0	0
Subtotal		90	269	206	192	168
Small Regional Jet						
CRJ/NGT	50	86	5	76	87	85
EM2	30	122	0	0	0	0
Subtotal		208	5	76	87	85
Total Mainline		744	746	828	841	888
Total Commuter		298	274	282	279	253
Total – All Aircraft		1,042	1,020	1,110	1,120	1,141

Note: Totals are based on the peak period forecasts.

Sources: Official Airline Guides, Inc. 2013; Landrum & Brown, Inc., 2015

Table 2.7-5 | Design Day International Passenger Airline Aircraft Fleet Mix

Aircraft	Seats	2013	2018	2023	Base	High
Widebody						
380	525	2	4	14	14	20
779X	400	0	0	8	8	8
748	386	0	0	4	10	10
744	374	38	32	0	0	0
351	369	0	0	26	40	41
787-10	330	0	0	16	20	19
359	315	0	4	8	4	4
346	309	2	2	0	4	4
789	302	0	2	4	2	2
333	300	0	0	4	4	4
773	294	21	28	21	22	22
772	271	8	14	12	6	4
332	264	2	0	0	0	0
343	231	4	4	0	0	0
788	218	0	0	10	2	4
763	210	4	4	0	0	0
Subtotal		81	94	127	136	142
Narrowbody Jet						
321	174	0	2	2	19	23
739	170	2	8	13	24	22
752	174	0	3	0	0	0
738	153	7	7	13	6	9
320	144	16	22	21	22	28
737	143	10	6	0	0	0
319	120	13	19	26	19	11
E90	93	8	6	8	4	0
Subtotal		56	73	83	94	93
Large Regional Jet						
CR9/E175/MRJ	76	0	3	20	18	17
CRJ 700	66	8	13	0	0	0
Subtotal		8	16	20	18	17
Small Regional Jet						
CRJ	50	4	0	0	0	0
Subtotal		4	0	0	0	0
Total Mainline		137	167	210	230	235
Total Commuter		12	16	20	18	17
Total – All Aircraft		149	183	230	248	252

Notes: Totals are based on the design day flight schedule. Includes pre-cleared markets as of April 2014.

Sources: *Official Airline Guides,* 2013; Landrum & Brown, Inc., 2015

2.7.2 All-Cargo Aircraft Operations

2.7.2.1 Total All-Cargo Aircraft Operations

The cargo tonnage forecasts for the all-cargo aircraft operators were combined with assumptions regarding the tonnage carried per operation to derive the all-cargo aircraft operations forecast. The tonnage per operation forecasts are a function of the type of all-cargo aircraft in operation now and forecast to operate at SFO in the future. The forecast for cargo tonnage per all-cargo aircraft operation is presented in **Table 2.7-6**.

Domestic tonnage per operation declined between 2007 and 2015, from 57 tons to 25 tons. Domestic tonnage per operation is forecast to continue decreasing, then stabilize at 18 tons by 2023.

International tonnage per operation also declined, but at a lower rate – from 17 tons in 2007 to 14 tons in 2015. The international tonnage per operation is forecast to remain at approximately 13 tons. Average tonnage across all operations is forecast to remain at approximately 16 tons.

2.7.2.2 All-Cargo Aircraft Fleet Mix

Historical all-cargo operations by aircraft type were analyzed to better understand the fleet mix for the all-cargo carriers at SFO. Additionally, aircraft orders for the busiest all-cargo carriers (Korean Air Cargo, Nippon Cargo Airlines, and Cathay Pacific Cargo) were analyzed to determine how the cargo fleet mix might evolve. Ultimately, these analyses informed the forecasts of all-cargo operations by aircraft type.

The 2013 all-cargo aircraft fleet at SFO consisted of 73.9 percent widebody aircraft, 26.0 percent turboprops, and a minimal number of narrowbody aircraft. Since 2007, the number of widebody aircraft decreased from 88.6 percent of total all-cargo aircraft operations, while turboprops increasingly accounted for higher market shares. **Table 2.7-7** presents the historical market shares of all-cargo aircraft in the fleet mix at SFO in terms of total operations.

All-cargo aircraft operations are forecast to increase from 6,098 in 2014 to 7,000 in 2023, at a CAGR of 1.7 percent. The Base Constrained and High Constrained demand is forecast to increase to 7,100 operations (see **Table 2.7-8**).

Source: San Francisco International Airport

Table 2.7-6 | Cargo Tonnage Per All-Cargo Aircraft Operation

Average Tons per Operation (metric tons)			
Calendar Year	**Domestic**	**International**	**Combined**
Historical			
2007	57	17	32
2008	33	13	23
2009	20	12	17
2010	16	12	14
2011	16	11	14
2012	18	13	16
2013	15	11	13
2014	18	13	15
2015	25	14	21
Forecast			
2018	17	12	14
2023	18	13	15
Base Constrained	18	13	16
High Constrained	18	13	16

Sources: SFO Year End Traffic reports, 2007-2015; Landrum & Brown, Inc., 2016

Table 2.7-7 | Historical All-Cargo Aircraft Fleet Mix

	2007	2008	2009	2010	2011	2012	2013
Widebody	88.6%	91.8%	86.7%	76.2%	73.7%	70.8%	73.9%
Narrowbody	11.0%	8.0%	0.0%	0.1%	3.0%	3.2%	0.1%
Turboprop	0.1%	0.0%	13.3%	23.7%	23.3%	26.0%	26.0%
Regional Jet	0.3%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%

Source: SFO Monthly Comparative Traffic Reports, 2007-2013; Landrum & Brown, Inc. 2014

Table 2.7-8 | All-Cargo Aircraft Operations Forecasts

Calendar Year	All-Cargo Aircraft Operations
Historical	
2007	7,140
2008	6,420
2009	7,084
2010	7,036
2011	6,782
2012	6,274
2013	5,920
2014	6,132
2015	6,098
Forecast	
2018	6,200
2023	7,000
Base Constrained	7,100
High Constrained	7,100
CAGR	
2007–2015	-2.0%
2015–2023	1.7%

Note: CAGR = Compound Annual Growth rate

Sources: SFO Monthly Comparative Traffic Reports, 2007-2015; Landrum & Brown, Inc., 2016

2.8 CIVIL AIR TAXI, GENERAL AVIATION, AND MILITARY AIRCRAFT OPERATIONS FORECASTS

All operations that are not considered commercial, cargo, or military operations are referred to as "civil" aircraft operations. For purposes of this analysis, the term "civil" consists of two types of activity: noncommercial air taxi and general aviation (GA). Air taxi activity typically includes "for hire" aircraft chartered on demand for specific trips. Air taxi operations are usually conducted using larger GA aircraft, such as large turboprop aircraft and various corporate jets. General aviation activity includes recreational flying, flight training activities, business travel, news reporting, traffic observation, police patrol, emergency medical flights, and crop dusting.

Civil operations can be subdivided into two major subcategories based on FAA classifications: "itinerant" and "local". Local operations are defined by the FAA as "operations remaining in the local traffic pattern, simulated instrument approaches at the airport and operations to or from the airport and a practice area within a 20-mile radius of the tower."[10] Itinerant operations are all operations not classified as "local."

There are a number of approaches to forecasting GA operations, including econometric, trend or time series, and market share forecasts. During the development of these forecasts for the ADP, no reasonable fit of the GA operations to time or socioeconomic variables was found. Nationally, the FAA's *Aerospace Forecasts Fiscal Years 2013-2033* forecasts that "Active GA Aircraft" will increase 0.5 percent annually over the planning horizon. The FAA also forecasts the following growth rates by aircraft type:

- Single-engine piston aircraft are forecast to slowly decline in number, at an average annual rate of 0.2 percent.
- Multi-engine piston aircraft are forecast to decline in number, at an average annual rate of 0.6 percent from 2012 to 2033.
- Turboprops are forecast to increase in number, at an average annual rate of 1.7 percent.
- Jet aircraft are forecast to be the fastest growing segment, increasing in number at an average annual rate of 3.5 percent.

These national trends were applied to the aircraft fleet operating at SFO. The single-engine and multi-engine aircraft segment is forecast to decrease in number, while the jet segment is forecast to increase at the fastest rate, followed by helicopters. General aviation aircraft operations are forecast to decrease at a CAGR of 0.8 percent, from 13,686 operations in 2015 to 12,840 operations in 2023. The Base Constrained and High Constrained demand levels forecast a rebound to 12,900 GA aircraft operations.

The noncommercial air taxi category represents chartered aircraft operated by companies that operate under Part 91[11] (i.e., not certificated as a scheduled air carrier by the FAA and not covered under Part 121[12]). The primary assumptions underlying the air taxi forecasts are:

- The air taxi segment at SFO consists predominantly of turbojet aircraft used for business/corporate purposes.
- The air taxi segment is forecast to be one of the fastest growing segments in the United States by the GA Manufacturers Association and the FAA.
- Based on the FAA *Aerospace Forecasts Fiscal Years 2013-2033,* air taxi hours flown are forecast to increase 3.5 percent annually between 2012 and 2033.

These trends were applied to the air taxi operations at SFO. Air taxi operations are forecast to increase at a CAGR of 2.8 percent, from 16,395 operations in 2015 to 20,400 operations in 2023. The Base Constrained and High Constrained demand levels forecast an increase to 21,100 operations.

Historically, military aircraft operations at SFO have accounted for less than 1.0 percent of total aircraft operations. In 2015, a total of 2,422 military operations were reported at SFO. The forecast number of military aircraft operations was held flat over the planning horizon at the approximate number of operations in 2015.

Historical and forecast civil and military operations are shown in **Table 2.8-1.**

10 FAA Order 7210.3, Facility Operation and Administration, Section 2, "Airport Operations Count," updated 16 September 1993

11 14 Code of Federal Regulations Part 91, General Operating and Flight Rules

12 14 Code of Federal Regulations Part 121, Air Carrier Certification

Table 2.8-1 | Civil and Military Aircraft Operations Forecasts

Calendar Year	General Aviation Operations	Noncommercial Air Taxi Operations	Military Operations	Total Noncommercial Operations
Historical				
2007	19,150	20,463	2,633	42,246
2008	15,478	18,303	2,675	36,456
2009	12,293	14,938	2,778	30,009
2010	12,570	15,512	2,710	30,792
2011	12,711	16,059	2,640	31,410
2012	12,561	15,596	2,719	30,876
2013	12,213	14,475	2,376	29,064
2014	12,623	14,759	2,813	30,195
2015	13,686	16,395	2,422	32,503
Forecast				
2018	12,540	17,200	2,400	32,140
2023	12,840	20,400	2,400	35,640
Base Constrained	12,900	21,100	2,400	36,400
High Constrained	12,900	21,100	2,400	36,400
CAGR				
2007–2015	-4.1%	-2.7%	-1.0%	-3.2%
2015–2023	-0.8%	2.8%	-0.1%	1.2%

Notes: *CAGR = Compound Annual Growth Rate*
GA = General Aviation

Sources: SFO Year End Traffic reports, 2015; Landrum & Brown, Inc., 2016

2.9 TOTAL AIRCRAFT OPERATIONS FORECAST

Table 2.9-1 and **Exhibit 2.9-1** present the total aircraft operations forecast for SFO. Total operations at the Airport are forecast to increase at a CAGR of 1.8 percent, from 429,815 operations in 2015 to 494,531 operations in 2023. The Base Constrained demand level forecasts an increase to 498,853 total operations and the High Constrained demand level forecasts 506,571 total operations.

2.10 PEAK PERIOD FORECAST

The traffic demand patterns at an airport are subject to seasonal, monthly, daily, and hourly variations. Peaking characteristics are critical in assessing existing facilities and airfield components to determine their ability to accommodate forecast increases in passengers and operations. The objective of developing peak period forecasts is to provide a design level for sizing facilities so they are neither underutilized nor overcrowded.

The annual passenger and operations forecasts for SFO were converted into peak month, peak day, and peak hour equivalents. The peak period passenger forecasts were developed for domestic, international, and total passengers. The peak period operations forecasts were developed for domestic passenger, international passenger, air cargo, general aviation, military, and total aircraft operations.

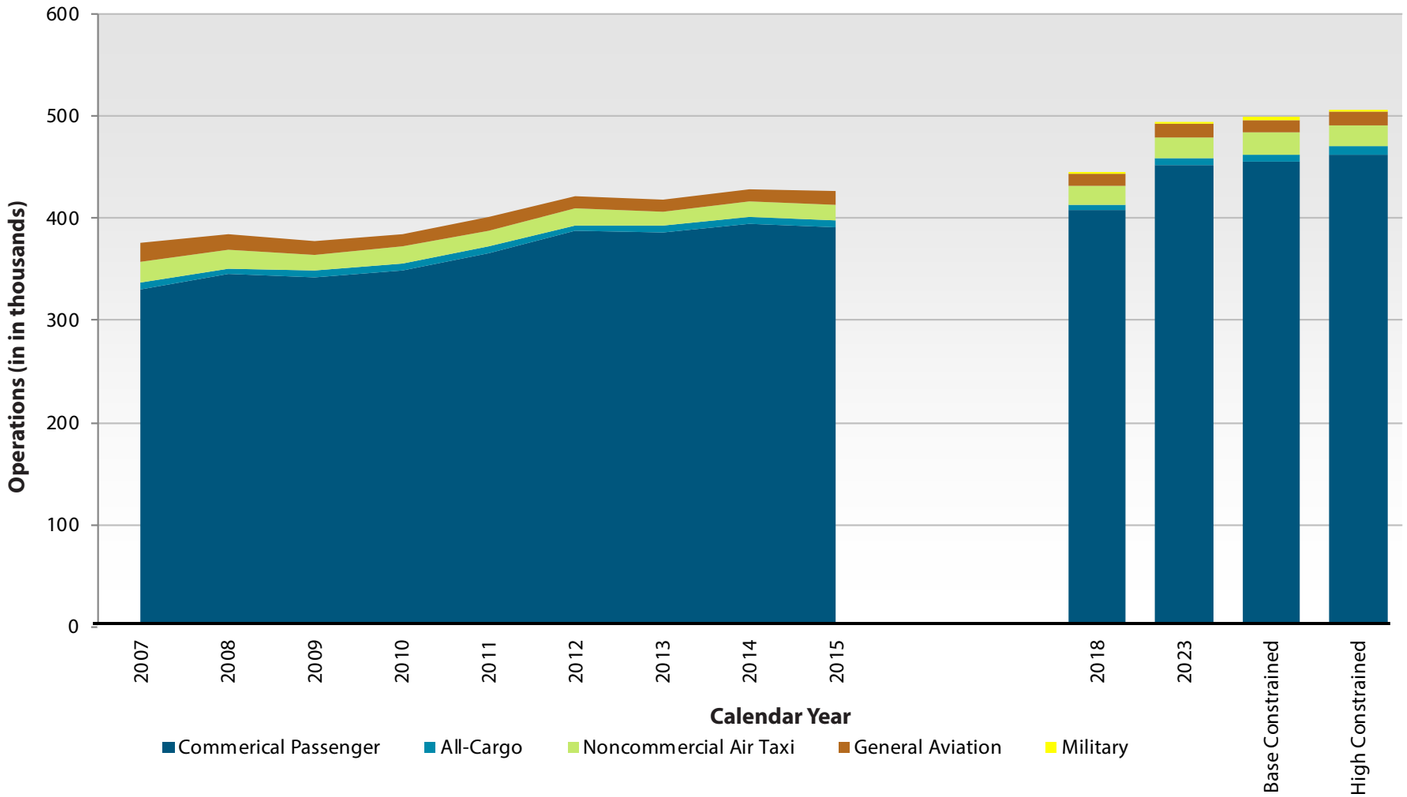
Table 2.9-1 | Total Aircraft Operations Forecast

Calendar Year	Commercial Passenger Operations	All-Cargo Operations	Noncommercial Air Taxi Operations	General Aviation Operations	Military Operations	Total Operations
Historical						
2007	330,114	7,140	20,463	19,150	2,633	379,500
2008	344,834	6,420	18,303	15,478	2,675	387,710
2009	342,658	7,084	14,938	12,293	2,778	379,751
2010	349,420	7,036	15,512	12,570	2,710	387,248
2011	365,372	6,782	16,059	12,711	2,640	403,564
2012	387,416	6,274	15,596	12,561	2,719	424,566
2013	386,416	5,920	14,475	12,213	2,376	421,400
2014	395,306	6,132	14,759	12,623	2,813	431,633
2015	391,214	6,098	16,395	13,686	2,422	429,815
Forecast						
2018	407,804	6,200	17,200	12,540	2,400	446,144
2023	451,891	7,000	20,400	12,840	2,400	494,531
Base Constrained	455,353	7,100	21,100	12,900	2,400	498,853
High Constrained	463,071	7,100	21,100	12,900	2,400	506,571
CAGR						
2007–2015	2.1%	-2.0%	-2.7%	-4.1%	-1.0%	1.6%
2015–2023	1.8%	1.7%	2.8%	-0.8%	-0.1%	1.8%

Note: CAGR = Compound Annual Growth Rate

Sources: SFO Year End Traffic Reports, 2007-2015; FAA Air Traffic Activity Data System, 2015; Landrum & Brown, Inc., 2016

Exhibit 2.9-1 | Total Aircraft Operations Forecast



Sources: SFO Year End Traffic Reports, 2007-2015; FAA Air Traffic Activity Data System, 2015; Landrum & Brown, Inc., 2016

2.10.1 Peak Period Passengers

The peak period passenger forecasts are designed to represent an average or typical day in the peak month of the base year and each of the forecast demand levels. Actual monthly data on enplaned passengers at the Airport were collected to derive peak month forecasts. In 2013, August was identified as the peak month, with 9.6 percent of annual enplaned passengers. It was assumed that the relationship between annual and peak month traffic will remain largely unchanged over the planning horizon.

Scheduled seat data from Official Airline Guides, Inc., were used to determine the passenger peaking patterns at SFO. Seat data were used as a proxy for passengers because detailed historical passenger data were not available at the level of detail needed for this analysis. The peaking factors for seats were used to develop the peak month, peak month average day (PMAD), and peak hour passenger forecasts.

The estimated peak hour passenger factors were derived from the flight schedules published by Official Airline Guides, Inc. The flight schedules provide an indication of how airlines allocate their flights and seats by time of day, which allows peak periods to be identified. The distribution of seats throughout the day serves as a reasonable proxy for passenger flows. The peak hour seats for each segment (domestic, international, total) and by flow (arrivals, departures, and total) were identified and calculated as a percentage of daily activity. These factors were then applied to the daily passenger counts at SFO in 2013 to establish a baseline peak hour passenger total for SFO.

The annual, monthly, daily, and hourly peak passenger forecasts are presented in **Table 2.10-1**. Peak hour enplaned passengers, which are estimated to be 6,333 for the 2013 design day, are forecast to increase to 8,442 by 2023. The number of peak hour enplaned passengers is forecast to be 9,367 for the Base Constrained demand level and 10,549 for the High Constrained demand level.

Peak hour passenger activity defines the planning requirements for facilities such as passenger terminals. Therefore, a more detailed breakdown of the peak hour passenger forecast was developed to support the planning analyses for individual projects. The summary of the peak hour passenger demand shown in **Table 2.10-2** focuses on arriving and departing passengers categorized by boarding area. The complete listing of forecast factors used in developing the facility requirements for the ADP is included in **Appendix C, Airport Development Plan Forecast Factors.**

2.10.2 Peak Period Aircraft Operations

Peak period aircraft operations factors were developed using SFO Air Traffic Statistics reports, FAA ATADS data, FAA Enhanced Traffic Management System Counts, US DOT T-100 Air Carrier Statistics data, passenger airline schedules published by Official Airline Guides, Inc., and SFO radar data. Based on SFO Air Traffic monthly data, August was the peak month for total operations in 2010 through 2013. August 2013 was used as the basis for developing peak period forecasts for domestic passenger airline, international passenger airline, cargo, general aviation, military, and total aircraft operations.

As domestic passenger, international passenger, cargo, general aviation, and military activity occurs in different areas of the Airport, the peak hour aircraft operations forecasts were developed for each of those activity segments to allow for specific facility evaluations. Individual peak hours cannot be aggregated to derive a total peak hour as they occur at different times of the day.

Peak hour operations in the base year 2013 were developed based on data from Official Airline Guides, Inc., and Airport-provided radar data. The peak hour operations forecast was based on the assumption that peak hour activity will grow at a slower rate than annual, monthly, and daily activity. As a result, peak hour operations represent a declining proportion of daily demand.

The Base Constrained and High Constrained forecast demand for daily passenger operations was developed using operational simulation analysis. It was assumed that, under constrained conditions, daily passenger operations will not exceed 1,368 (1,120 domestic and 248 international). For the High Constrained forecast demand, an additional 25 commercial passenger operations are forecast to occur during off-peak periods. It was also assumed that these operations will have the same domestic to international split as the Base Constrained demand forecasts. Therefore, under high constrained conditions, 1,393 total passenger operations (1,141 domestic and 252 international) would occur at SFO.

Table 2.10-1 | Peak Period Passenger Forecasts

Enplaned Passengers	2013	2018	2023	Base Constrained	High Constrained	CAGR 2013-2023
Annual	22,417,785	25,241,200	28,828,200	31,112,400	35,537,205	2.5%
Peak Month % of Annual	9.6%	9.1%	9.3%	9.4%	9.4%	
Peak Month	2,154,841	2,302,882	2,694,892	2,922,680	3,338,344	2.3%
Design Day % of Peak Month	3.2%	3.2%	3.2%	3.2%	3.2%	
Design Day	69,511	74,287	86,932	94,280	107,689	2.3%
Peak Hour % of Design Day	9.1%	9.8%	9.7%	9.9%	9.8%	
Peak Hour	6,333	7,295	8,442	9,367	10,549	2.9%

Note: CAGR = Compound Annual Growth Rate

Sources: SFO Year End and Monthly Traffic Reports, 2014; Official Airline Guides, Inc., 2013; Landrum & Brown, Inc., 2015

Table 2.10-2 | Peak Hour Passenger Forecasts by Boarding Area

Peak Hour – Passengers by Boarding Area		2013	2018	2023	Base Constrained	High Constrained
Peak Hour – Total Passengers		10,543	12,721	14,852	14,852	18,020
ITB	Boarding Area A (includes Terminal 1 swing gates international passengers)		2,319	2,508	3,814	4,118
ITB	Boarding Area G (includes Terminal 3 swing gates international passengers)		2,936	2,860	4,105	4,472
ITB	Boarding Area H		0	244	239	350
Terminal 1	Boarding Area B/C		3,520	4,258	4,513	5,090
Terminal 2	Boarding Area D with United gates		2,268	2,456	2,700	3,555
Terminal 3	Boarding Area E/F (includes swing gates domestic passengers) - plus Terminal 2 United gates & B/A H		5,150	5,592	5,880	6,268
Peak Hour – Arriving Passengers		6,198	6,871	7,818	8,911	10,320
ITB	Boarding Area A (includes Terminal 1 swing gates international passengers)		1,588	1,914	3,233	3,490
ITB	Boarding Area G (includes Terminal 3 swing gates international passengers)		1,690	1,960	2,714	2,969
ITB	Boarding Area H		0	183	174	280
Terminal 1	Boarding Area B/C		2,193	2,358	2,444	2,914
Terminal 2	Boarding Area D with United gates		1,275	1,395	1,353	1,804
Terminal 3	Boarding Area E/F (includes swing gates domestic passengers) - plus Terminal 2 United gates & B/A H		2,982	2,960	3,474	3,711
Peak Hour – Departing Passengers		6,333	7,295	8,442	9,367	10,549
ITB	Boarding Area A (includes Terminal 1 swing gates international passengers)		1,404	1,462	2,592	2,798
ITB	Boarding Area G (includes Terminal 3 swing gates international passengers)		1,826	2,073	2,006	2,139
ITB	Boarding Area H		0	183	174	280
Terminal 1	Boarding Area B/C		2,283	2,497	2,663	2,912
Terminal 2	Boarding Area D with United gates		1,628	1,656	1,664	1,975
Terminal 3	Boarding Area E/F (includes swing gates domestic passengers) – plus Terminal 2 United gates & B/A H		3,353	3,327	3,567	3,858

Note: The peak hour passengers for the individual boarding areas do not occur at the same time. Therefore, the sum of the peaks for the individual boarding areas do not equal the total peak hour passengers. As such, although the peak hour passengers for Boarding Area D (Terminal 2) and Boarding Area E/F (Terminal 3) both include United gates, the total peak hour passengers does not duplicate these passengers.

Sources: SFO Year End and Monthly Traffic Reports, 2014; Official Airline Guides, Inc., 2013; Landrum & Brown, Inc., 2015

2.10.3 Peak Period Summary

The annual, monthly, daily, and hourly peak operations forecasts are presented in **Table 2.10-3**. Total operations during the peak hour are forecast to increase from 96 in 2013 to 114 in 2023, mainly driven by the domestic passenger aircraft operations peak. The total peak hour operations are forecast to be 117 at the Base Constrained demand level and 120 at the High Constrained demand level.

Cargo aircraft operations during the peak hour are forecast to increase from one operation in 2013 to two operations in 2023, then remain constant at the Base Constrained and High Constrained demand levels.

GA and Air Taxi operations are forecast to increase from nine operations in the peak hour in 2013 to 12 operations in the peak hour in 2023, and then remain constant at the Base Constrained and High Constrained demand levels.

Military aircraft operations in the peak hour are forecast to increase to two in 2018, then remain constant through the High Constrained demand level.

A further breakdown of the peak month average day operations forecast, developed to support planning analyses for individual boarding areas as well as for the overall Airport, including GA, military, air taxi, and cargo activity, is shown in **Table 2.10-4**.

Table 2.10-3 | Peak Period Operations Forecasts

Operations	2013	2018	2023	Base Constrained	High Constrained	CAGR 2013-2023
Passenger Aircraft Operations						
Annual	386,416	407,804	451,891	455,353	463,071	1.6%
Peak Month % of Annual	9.2%	9.1%	9.2%	9.3%	9.3%	
Peak Month	35,412	37,293	41,540	42,408	43,183	
Design Day % of Peak Month	3.2%	3.2%	3.2%	3.2%	3.2%	
Design Day	1,142	1,203	1,340	1,368	1,393	
Peak Hour % of Design Day	8.3%	8.1%	8.0%	7.9%	8.0%	
Peak Hour	95	98	107	108	111	
Cargo Aircraft						
Annual	5,920	6,200	7,000	7,100	7,100	1.7%
Peak Month % of Annual	8.3%	8.2%	8.3%	8.3%	8.3%	
Peak Month	491	510	580	590	590	
Design Day % of Peak Month	3.2%	3.2%	3.3%	3.2%	3.2%	
Design Day	16	16	19	19	19	
Peak Hour % of Design Day	6.3%	12.2%	10.5%	10.5%	10.5%	
Peak Hour	1	2	2	2	2	
GA and Air Taxi Aircraft						
Annual	26,688	29,740	33,240	34,000	34,000	2.2%
Peak Month % of Annual	8.3%	8.4%	8.4%	8.2%	8.2%	
Peak Month	2,215	2,500	2,800	2,800	2,800	
Design Day % of Peak Month	3.2%	3.2%	3.2%	3.2%	3.2%	
Design Day	71	81	90	90	90	
Peak Hour % of Design Day	12.6%	12.3%	13.3%	13.3%	13.3%	
Peak Hour	9	10	12	12	12	
Military Aircraft						
Annual	2,376	2,400	2,400	2,400	2,400	0.1%
Peak Month % of Annual	8.7%	8.8%	8.8%	8.8%	8.8%	
Peak Month	207	210	210	210	210	
Design Day % of Peak Month	3.4%	3.2%	3.3%	3.3%	3.3%	
Design Day	7	7	7	7	7	
Peak Hour % of Design Day	14.3%	29.5%	28.6%	28.6%	28.6%	
Peak Hour	1	2	2	2	2	
Total Aircraft Operations						
Annual	421,400	446,144	494,531	498,853	506,571	1.6%
Peak Month % of Annual	9.1%	9.1%	9.1%	9.2%	9.2%	
Peak Month	38,325	40,517	45,136	45,725	46,500	
Design Day % of Peak Month	3.2%	3.2%	3.2%	3.2%	3.2%	
Design Day	1,237	1,307	1,456	1,475	1,500	
Peak Hour % of Design Day	7.8%	7.8%	7.8%	7.9%	8.0%	
Peak Hour	96	102	114	117	120	

Note: CAGR = Compound Annual Growth Rate

Sources: Official Airline Guides, Inc., 2013; FAA Air Traffic Activity Data System, 2013; Landrum & Brown, Inc., 2015

Table 2.10-4 | Peak Month Average Day Aircraft Operations Forecasts by Boarding Area

Terminal	Boarding Area	2013	2018	2023	Base Constrained	High Constrained
ITB	A (includes Terminal 1 swing international ops)		65	68	74	76
ITB	G (includes Terminal 3 swing international ops)		75	96	110	113
ITB	H		0	10	12	16
Terminal 1	B/C		346	386	385	397
Terminal 2	D		157	190	195	194
Terminal 3	E/F (includes swing domestic ops) – plus Terminal 2 United gates & B/A H		589	652	647	657
Total Passenger Operations		1,142	1,203	1,340	1,368	1,393
Total Operations (Including GA, Military, Cargo)		1,237	1,307	1,456	1,475	1,500

Note: The sum of the individual boarding areas do not equal the Total Passenger Operations. Design day operations for and Boarding Area E/F (Terminal 3) include both Boarding Area D (Terminal 2) United gates and B/A H, as such the Total Passenger Operations do not duplicate these operations.

Sources: SFO Year End and Monthly Traffic Reports, 2014; Official Airline Guides, Inc., 2013; Landrum & Brown, Inc., 2015