



**NORMAN Y. MINETA SAN JOSE INTERNATIONAL AIRPORT
RUNWAY INCURSION MITIGATION/AIRFIELD DESIGN STANDARDS ANALYSIS**

DRAFT TECHNICAL MEMORANDUM

**UPDATED AIRPORT CAPACITY AND FACILITY
REQUIREMENTS ANALYSIS**

City of San Jose
September 13, 2017

The work program for the SJC Runway Incursion Mitigation/Design Standards Analysis Study includes an assessment of the ability of the Airport to accommodate projected aviation demand as updated in a previous study task. This master planning-level assessment is needed prior to the analysis and selection of an airfield configuration alternative to confirm the overall capability of the airfield and landside development areas, as depicted in the current SJC Master Plan and Airport Layout Plan, is sufficient to serve the new 20-year demand projections. This technical memorandum provides a summary of the capacity analysis/facility requirements findings.

A. AIRFIELD FACILITY CAPACITY AND REQUIREMENTS

The airfield capacity analysis update relies primarily on the methodology contained in FAA Advisory Circular AC150-5060.5, *Airport Capacity and Delay* (commonly referred to as the Airport Capacity and Delay Manual). The analysis conducted for SJC assesses both a 2-runway scenario (as currently operated) and a 3-runway scenario (with reactivation of west side Runway 11/29 as set forth in the current Airport Master Plan and Airport Layout Plan).

The methodology contained in the Airport Capacity and Delay Manual utilizes various typical airfield layout diagrams and general operational parameters that are assumed to be generally representative of most, but not all airfield configurations and operational situations. The typical airfield layout most closely approximating that of SJC is identified as the starting point of the capacity analysis. Applying the general airfield layout, the internal operational parameters in the methodology, along with other required input data, allows for the development of three airfield capacity measures:

- **Annual Service Volume (ASV)**, which is the maximum number of aircraft operations an airfield can accommodate in a one-year period without excessive delay. ASV does not represent an absolute limit of operational capability of an airfield, but is indicative of a level of service. Many airports operate above their calculated ASV.
- **Hourly Capacity**, which is the maximum number of aircraft operations an airfield can accommodate under continuous demand in a one-hour period given the runway use configuration, aircraft fleet mix, and weather. Hourly capacity is calculated for both Visual Flight Rules (VFR) and Instrument Flight Rules (IFR) conditions, and can be used to identify peak-period constraints on a given day.
- **Average Aircraft Delay**, which combines hourly airfield capacity and ASV with the assumed volume of operational demand to measure the average delay time per aircraft operation basis. It should be noted that there will be periods during any given day where delay levels will exceed the average calculated delay per operation (peak hour demand under IFR conditions, for example) as well as periods of where little if any operational delay occurs.

Inputs to the Demand/Capacity Analysis

The Airport Capacity and Delay Manual requires the following data inputs:

Aircraft Fleet Mix Index – Ratio of the classes of aircraft serving an airport, based upon four aircraft weight-based categories specified in the advisory guidance;

Runway-Use Configuration – Number and orientation of the active runways. As mentioned earlier, this analysis for SJC used a two closely-spaced runway scenario and a three closely-spaced runway scenario;

Percentage of Aircraft Arrivals – Ratio of landing operations to total operations;

Touch and Go Factor – Ratio of landings with an immediate takeoff (generally affiliated with training activity), to total operations;

Location of Exit Taxiways – Number of exit taxiways available to an aircraft within a given distance from the arrival end of a runway and tied to the calculated mix index;

Meteorological Conditions – Percentages of times an airfield experiences VFR, IFR and PVC (Poor Visibility) conditions.

Built into the calculations contained in the Airport Capacity and Delay Manual are air traffic assumptions including minimum separation times between two in-trail departing or arriving aircraft along with wake turbulence considerations. These assumptions are based on “typical” conditions and capabilities, and pre-date the Wake Turbulence Recategorization that has recently been implemented at SJC.

While the Airport Capacity and Delay Manual provides an accepted method for high-level capacity analysis, the general nature of the typical airfield layouts and the operational assumptions that are built into the capacity calculation model may not account for airport-specific conditions, such as at SJC. Several adjustments were therefore made to the methodology, as highlighted below.

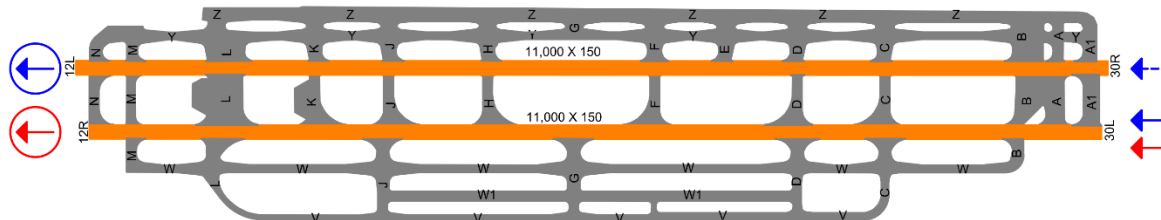
The model includes a typical configuration that best reflects SJC’s two closely-spaced 11,000 foot-long parallel runways at SJC. That is not the case when the closely-spaced parallel 4,600 foot-long Runway 11/29, is added to the model. Runway 11/29, if operational, is limited to use by propeller-driven aircraft and light turbo-props and would be unavailable during IFR conditions, while the majority of operations conducted at SJC are by aircraft that can only use the two longer runways.

SJC airspace is constrained by the proximity of San Francisco International Airport (SFO) to the north as well as by rising terrain to the east and west. These constraints limit north and south flow departures at SJC to a single departure heading in each direction. The single departure heading funnels all departing aircraft, regardless of runway, along the same departure route, requiring increased spacing that would not be necessary if the airspace accommodated divergent departure headings. The required spacing (4, 5 and 6 nautical miles depending upon size of aircraft) between sequential departures significantly increases the required minimum departure-to-departure separation time that is assumed in the AC 150/5060-5 methodology.

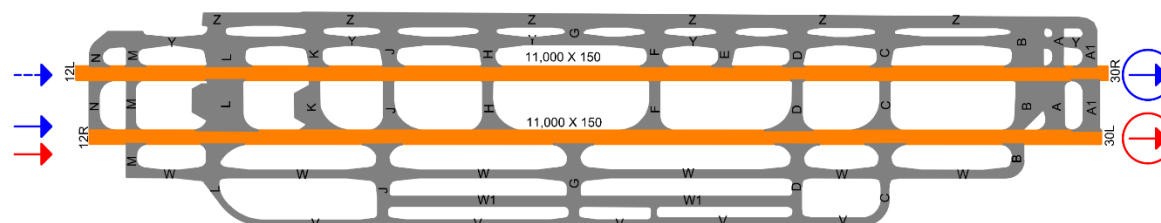
Because the time interval between aircraft departures increases due to airspace constraints, there results a corresponding reduction in the overall hourly operational capacity that the airfield can achieve. This impacts the current two-runway system and negates any significant capacity increase from the former and potential reactivated three- runway system. As a result, an adjustment to the hourly capacity output obtained using the Airport Capacity and Delay manual methodology was necessary to reasonably reflect the reality of the airspace characteristics at SJC. **Figure 1** presents the runway operating configurations for the SJC airfield, followed by specific inputs to the FAA methodology.

Figure 1 - SJC Runway Operating Configurations

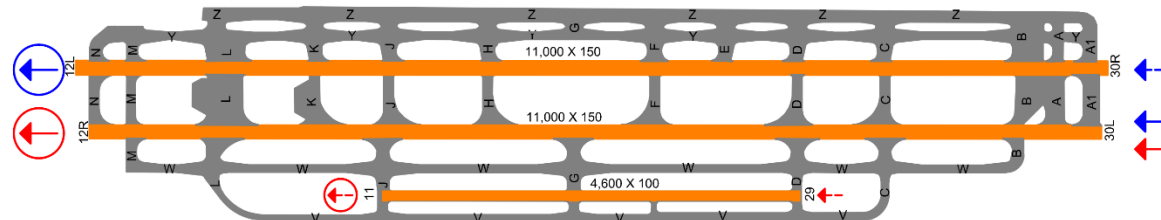
2 Runways, North Flow:



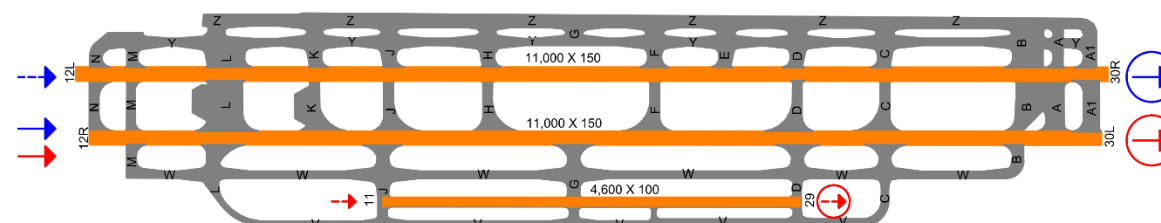
2 Runways, South Flow:







3 Runways, North Flow:



3 Runways, South Flow:



	Runway Pavement
	Taxiway Pavement
	Primary General Aviation & Air Taxi Arrival
	Secondary General Aviation & Air Taxi Arrival
	Primary Commercial Arrival
	Secondary Commercial Arrival
	Primary General Aviation & Air Taxi Departure
	Secondary General Aviation & Air Taxi Departure
	Commercial Departure

Aircraft Fleet Mix Index

The Airport Capacity Manual classifies aircraft into four classes (Class A through D) based upon the weight of the aircraft. Class A and B consists of aircraft of 12,500-pound maximum takeoff weight (MTOW) or less, Class C are aircraft of between 12,500 pounds and 300,000 pounds, and Class D consists of aircraft greater than 300,000 pounds. As shown in **Table 1**, the Mix Index consists only of Class C and D aircraft, with the percentage of Class D aircraft weighted by a factor of 3 and added to the percentage of Class C aircraft in the fleet.

Table 1 – SJC Class C and D Aircraft Fleet Mix Percentages

Classification (lbs.)	2016		2037	
	VFR	IFR	VFR	IFR
C (12,500-300,000)	88%	92%	92%	94%
D (300,000+)	3%	3%	3%	3%
Index	97	101	101	103

Source: Airport Activity Statistic, 2017 Aviation Activity Forecasts

Runway-Use Configuration and Meteorological Conditions

Table 2 presents the percentages of activity for both VFR and IFR conditions. The airport operates in north flow 86 percent of the time and south flow 14 percent of the time. Based on ten years of weather data, SJC is in VFR conditions 96 percent of the time and IFR conditions 4 percent of the time.

Table 2 – SJC Runway Use by Weather Condition

Traffic Flow	Weather Conditions	Usage
North Flow	VFR	83%
North Flow	IFR	3%
South Flow	VFR	13%
South Flow	IFR	1%

Source: FAA ASPM Database 2001 – 2010, SJC Airfield Simulation Assumptions Document
 NOAA hourly observed weather data, 2006 - 2016

Percentage of Aircraft Arrivals and Touch and Go Factor

The percentage of arrivals to total operations at SJC is 50 percent. SJC activity reports and discussions with the SJC Air Traffic Control Tower indicate that touch-and-go activity is approximately 1 percent of all operations annually.

Number and Location of Exit Taxiways from Runway Threshold

Airfield capacity is affected by the ability of aircraft to efficiently and expeditiously exit the runway upon landing. As a result, the number and location (distance from the runway landing threshold) is a key factor. The Airport Capacity and Delay Manual identifies the optimum distances for exit taxiways based on the mix index and, also establishes values based on whether there are no exits, one exit or two or more exits within the optimum distance. For Runways 12R/30L and 12L/30R, the optimum exit location is between 5,000 feet and 7,000 feet from each landing threshold. For Runway 11/29,

the optimum exit location is between 2,000 feet and 4,000 feet from each landing threshold. Based on this, the following exit values were identified.

- Runways 12R/30L and 12L/30R: North Flow = 3 exits, South Flow = 1 exit
- Runway 11/29: North or South Flow - 1 exit

The preceding inputs into the capacity calculation methodology generate the following numerical findings:

Table 3 - SJC Weighted Hourly Capacity (Operations)

Configuration	2016	2037
2 Runway Scenario	74	73
3 Runway Scenario	82	81

Source: Kimley Horn Analysis

Table 4 – SJC Annual Service Volume (Operations)

Configuration	2016	2037
2 Runway Scenario	240,363	241,700
3 Runway Scenario	265,693	267,003

Source: Kimley Horn Analysis

Table 5 – SJC Average Aircraft Delay

Configuration	2016	2017
2 Runway Scenario	0.50 minutes	2.25 minutes
3 Runway Scenario	0.40 minutes	1.30 minutes

Source: Kimley Horn Analysis

The above analysis indicates that the SJC airfield can sufficiently accommodate projected 2037 demand levels. The calculated ASV for both the 2-runway and 3-runway scenarios (Table 4) is higher than the projected total demand of 237,710 annual operations. The calculated Average Aircraft Delay for both the 2-runway and 3-runway scenarios (Table 5) is well within the “acceptable” range. Practical airfield capacity typically only becomes an issue of concern when average delay begins to exceed 4-6 minutes.

B. LANDSIDE FACILITY CAPACITY AND REQUIREMENTS

The landside capacity analysis update develops summary estimates of spatial and facility needs to accommodate the projected long-term aviation demand based on general airport planning principles, guidelines, and the existing facility layout at SJC. The analysis separately addresses passenger terminal, air cargo, general aviation, and aviation support facilities.

Passenger Terminal Facilities

- **Passenger Terminal Building**

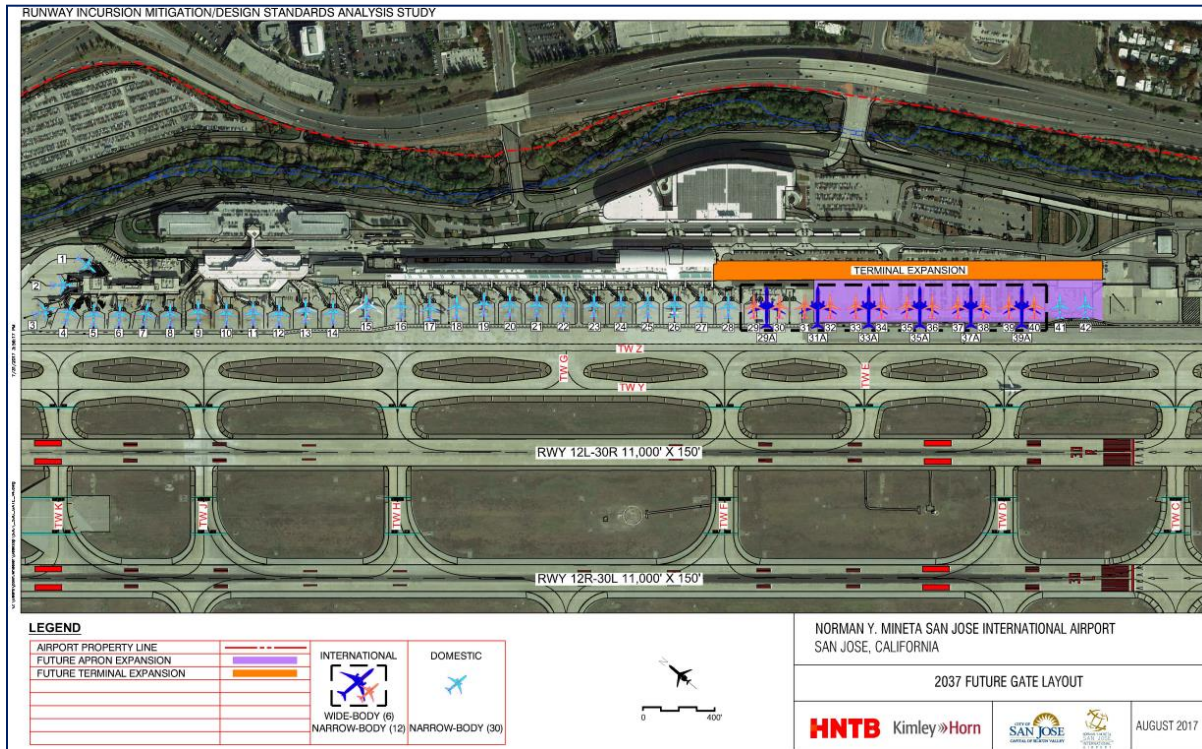
The existing passenger terminal building at SJC is comprised of 28 airline gates and a total area of approximately 1,050,000 square feet. Terminal A has 16 gates and approximately 450,000 square feet of operational space (including hold rooms, ticket counter lobby, security checkpoints, baggage claim, the Federal Inspection Services facility for international arrivals, and concession, office, and support space), which equates to an average of 28,100 square feet of building space per gate. The newer Terminal B comprises 12 airline gates and a total area of approximately 600,000 square feet of operational space (inclusive of all building functions), which equates to an average of 50,000 square feet of building space per gate. A temporary addition of two gates with a passenger concourse connected to the south end of Terminal B is currently being constructed in response to recent growth in activity, but is not considered a permanent facility in this analysis.

Based on the projected 2037 design day passenger and airline operations demand, a total of 42 airline gates would be needed (14 more than the existing 28). The current Airport Master Plan calls for terminal expansion to be provided in a Terminal B “south concourse”. Applying existing Terminal B’s 50,000 square feet of building space per gate translates into an additional 700,000 square feet of terminal space, resulting in an overall terminal building size of 1,750,000 square feet, as summarized in **Table 1** below.

Table 1. Passenger Terminal Facility Requirements					
	Existing Terminal A	Existing Terminal B	Existing Total	Projected Expansion	Total 2037
Gates	16	12	28	14	42
Area (sf)	450,000	600,000	1,050,000	700,000	1,750,000
<i>Sources: SJC Airport, Kimley-Horn.</i>					

A graphic depicting a future conceptual layout of the expansion of the SJC terminal is displayed in **Figure 1**. Based on this conceptual layout, the expanded passenger terminal building would extend through existing open ramp, two of the interim surface public parking lots, and the existing airline belly-cargo facility (designated in the current Airport Master Plan for relocation outside the future expanded terminal zone).

Figure 1. Future Conceptual Terminal Expansion



- **Vehicle Parking**

Vehicle parking requirements for the passenger terminal consist of garages and surface lots for the public, employees, and rental cars. The Airport currently has facilities providing a capacity for approximately 6,600 public parking spaces, 1,500 terminal area employee parking spaces, and 2,000 rental car ready/return spaces.

Based on planning metrics identified in Airport Cooperative Research Program (ACRP) Report 25, *Airport Passenger Terminal Planning and Design*, as well as review of other airports with varying passenger activity, peaking, and airline hubbing characteristics, a range of parking space requirements were developed, with the median values used as the requirements, as presented in **Table 2** below. It should be noted that this analysis has not attempted to factor in the recent introduction and growing public acceptance of Transportation Network Companies (such as Lyft and Uber), nor the potential future introduction of self-driving vehicles, which are evolving trends which will likely impact traditional airport parking requirements.

The current Airport Master Plan designates locations for additional parking garages in the terminal zone, including opposite the future expansion to Terminal B, that would appear capable of adequately serving projected public and employee parking demand. The existing Rental Car Garage, which is designed to accommodate up to 2,000 rental car spaces (plus additional vehicle storage) is sufficient to serve rental car demand in the long term.

Table 2. Terminal Area Auto Parking Requirements

	Existing (2016)	Projected 2037	
		Range	Recommended
Public Parking:			
Spaces per million originating enplanements	--	900-1,400	1,150
Total Spaces	6,600	9,600-14,900	12,300
Employee Parking:			
Spaces per million enplanements	--	250-400	325
Total Spaces	1,500	2,800-4,500	3,700
Rental Car Ready/Return:			
% of design hour destination deplanements	--	30%-60%	45%
Total Spaces	2,000	1,100-2,100	1,600
<i>Sources: SJC Airport, ACRP Report 25, Kimley-Horn.</i>			

Air Cargo Facilities

- All-Cargo Airline Facilities**

SJC currently has approximately 300,000 square feet of cargo airline facilities, divided into two areas, one on the northeast side of the airfield used by FedEx and one on the southeast side of the airfield used by UPS. Each area provides aircraft parking apron space and associated loading/unloading, ground vehicle movement, equipment staging, and office and support space. Cargo airline building and landside space requirements are typically driven by the projected volume of cargo tonnage handled, while apron space requirements are based on the number of projected design hour cargo operations and aircraft size.

For cargo airline buildings, the industry guideline is to apply a square foot per cargo ton ratio, ranging from 0.50 square feet of building per ton at smaller airports up to 1.0 square feet of building per ton at larger airports. For SJC, a factor of 0.575 square feet of building per ton (slightly more than the median) was used. For landside vehicle movement and parking, the industry guideline is to apply 110 percent of the calculated building space requirement.

Apron space for aircraft parking is determined by applying the number of design hour operations to the footprint of the largest aircraft anticipated to be in operation (for SJC, a Boeing 767-300), with a 25-foot buffer between aircraft for wingtip clearance. Apron space for aircraft movement and maneuvering is assumed at approximately 75 percent of the aircraft parking area, and an additional 10 percent of the apron space subtotal is needed for ground support equipment (GSE) staging and storage. **Table 3** below summarizes these calculated facility requirements.

Table 3. Cargo Airline Facility Requirements		
Element	Existing (2016)	Projected 2037
Cargo tonnage (enplaned and deplaned)	43,826	57,252
Cargo building space (0.575 sq. ft. per ton)		33,000 sq.ft.
Truck/auto parking and maneuvering (110% of building space)		36,200 sq.ft.
Design hour all-cargo operations	4	6
Design aircraft footprint (767-300)	28,500 sq.ft.	
Aircraft parking apron including wingtip buffer space		207,200 sq.ft.
Aircraft maneuvering and GSE apron space		191,700 sq.ft.
Total cargo airline space	300,000 sq.ft.	468,100 sq.ft.
Acres	6.9	10.7
<i>Sources: SJC Airport, Kimley-Horn.</i>		

As shown, it is projected that approximately 10.7 acres will be needed for all-cargo airline facilities by 2037. Although the existing two cargo airline facility sites are considered somewhat inefficiently configured, the current Airport Master Plan anticipated that all-cargo airline demand and associated space requirements (at a higher volume than now projected) could be accommodated through expanded and reconfigured facilities at or adjacent to the existing cargo airline operational areas.

- **Belly Cargo Facilities**

Belly cargo facilities for the passenger airlines include similar building, landside parking/movement, and apron operational and GSE storage space requirements as the all-cargo airlines with the major exception of aircraft parking/maneuvering (as the loading and unloading of belly-cargo is typically performed at the aircraft parking positions at the terminal gates). The existing belly-cargo facility at SJC, used by multiple airlines, totals approximately 85,000 square feet in area, including a 22,000-sq.ft. building, although some cargo-related activity is conducted in other buildings leased by individual airlines.

The projection of belly-cargo facility requirements was performed using similar industry guidelines as for the all-cargo airline facilities, as well as from review of cargo operations at other airports. For building space, a factor of 0.575 square feet per ton of building per ton was used, augmented by an additional 15% contingency factor to account for belly-cargo handling that might be conducted at multiple sites. Landside vehicle movement and parking was assumed to be 110 percent of the calculated building space requirement. Apron space requirements for GSE storage, staging, and movement was determined to be twice the calculated building space. **Table 4** below summarizes these facility requirements.

Table 4. Belly Cargo Facility Requirements		
Element	Existing (2016)	Projected 2037
Cargo tonnage (enplaned and deplaned)	16,534	42,903
Cargo building space (0.575 sq.ft. per ton + 15%)		28,400 sq.ft.
Truck/auto parking and maneuvering (110% of building space)		31,200 sq.ft.
Apron space (200% of building space)		56,800 sq.ft.
Total belly-cargo space	85,000 sq.ft.	116,400 sq.ft.
Acres	2.0	2.7
<i>Sources: SJC Airport, Kimley-Horn.</i>		

As shown, it is projected that approximately 2.7 acres will be needed for airline belly-cargo facilities by 2037. The current Airport Master Plan anticipated that the existing belly-cargo facility would be relocated and moderately expanded to a similar size on the east side of the Airport.

General Aviation Facilities

General aviation facilities include aprons and hangars for based and itinerant aircraft parking, storage, and movement, as well as FBO terminal space, aircraft fueling and maintenance areas, and landside vehicle parking. SJC currently consists of approximately 80 acres of general aviation facilities on the west side of the Airport comprising five FBO leaseholds plus individual aircraft hangar and tiedown spaces managed by the Airport. Future facility requirements were generated through general airport planning principles and guidelines applied primarily to the projections of based aircraft and operational fleet mix demand.

- **Based Aircraft Storage and Transient Aircraft Parking**

The area requirements for the storage of based aircraft and parking of transient aircraft utilized the aircraft size and storage/parking facility assumptions shown in **Table 5** below. As applied to the projected based aircraft, fleet mix, and design day operations at SJC, it was determined that approximately 806,700 square feet of space would be required to store the projected 164 based aircraft in 2037, and an additional 543,300 square feet of space would be required to park the projected 82 transient aircraft that may be on the ground at the same time.

Table 5. Aircraft Storage Planning Metrics/Assumptions						
Aircraft Type	Aircraft Footprint (sq.ft.)	Based Aircraft			Transient Aircraft	
		% Tiedown	% T-Hangar	% Conventional Hangar	% Tiedown	% Conventional Hangar
Single-Piston	2,000	35%	60%	5%	85%	15%
Multi-Piston	2,500	10%	70%	20%	75%	25%
Turboprop	2,500	--	--	100%	50%	50%
Jet (small)	5,000	--	--	100%	50%	50%
Jet (large)	10,050	--	--	100%	50%	50%
Rotorcraft	1,250	20%	--	80%	50%	50%
<i>Source: Kimley-Horn Analysis.</i>						

• **Other General Aviation Facilities**

Aircraft movement areas and taxilanes were assumed to be equal to the total area calculated for based and transient aircraft storage and parking. Terminal building space was assumed to be 15% of total conventional hangar space. Aircraft maintenance space was also assumed to be 15% of total conventional hangar space, while aircraft fueling facility and operational space was assumed to be 5% of the total area calculated for based and transient aircraft storage and parking. Vehicle parking for general aviation employees, pilots, and visitors was based upon the existing ratio of vehicle parking areas to total hangar space area at SJ (82%).

Table 6 summarizes the future demand for general aviation facilities based on project demand.

Table 6. General Aviation Facility Requirements		
Element	Existing (2016)	Projected 2037
Based Aircraft Storage:		
Tie-Down		43,500 sq.ft.
T-Hangar		74,500 sq.ft.
Conventional Hangar		688,700 sq.ft.
Transient Aircraft Storage:		
Tie-Down		277,900 sq.ft.
Conventional (FBO) Hangar		265,400 sq.ft.
Other GA Facilities:		
Apron/Taxilane Movement Areas		1,350,000 sq.ft.
FBO Terminal Space		143,100 sq.ft.
Vehicle Parking		782,400 sq.ft.
Aircraft Maintenance/Fueling Areas		210,600 sq.ft.
Total General Aviation Area	3,441,240 sq.ft.	3,836,100 sq.ft.
Acres	79	88
<i>Source: Kimley-Horn Analysis.</i>		

As shown in Table 6, a total of 88 acres of general aviation facilities will be needed to accommodate the projected long-term demand. In addition to the 79 acres on the west side of the Airport currently dedicated to existing general aviation facilities, there are approximately 20 acres of vacant or non-aviation areas on the west side (comprised of three separate sites) that are designated for further general aviation development in the current Airport Master Plan. Thus, sufficient acreage is available on the west side to serve the projected demand.

Aviation Support Facilities

Facilities which support the ongoing operation of the Airport include the FAA Tower on the west side, the jet fuel storage facility on a non-contiguous site across from the northeast side of the terminal area (connected by pipeline to the airfield), and the Airport Rescue and Firefighting Facility (ARFF), flight

catering, and Airport and airline maintenance and equipment storage areas in various buildings and operational areas on the southeast side of the Airport. Although some of these facilities would need to expand to adequately serve projected demand, sufficient space appears to be available. The jet fuel storage facility, for example, which currently operates with three tanks capable of storing 2 million gallons of jet fuel, has unused space available to add a fourth large tank and is fed by pipeline from an off-site major storage terminal. While the total available area on the southeast side of the Airport, will decrease with the future south expansion of Terminal B, the current Airport Master Plan already anticipates a redevelopment and reconfiguration of expanded facilities to more efficiently utilize that area. Moreover, some aviation support functions may be feasible to relocate to sites on the west side of the Airport not needed for general aviation.