CHAPTER TWO

Airport Facility Requirements

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AIRPORT FACILITY REQUIREMENTS

To properly plan for the future of Livermore Municipal Airport, it is necessary to translate forecast aviation demand into the specific types and quantities of facilities that can adequately serve the identified demand. This chapter uses the Federal Aviation Administration (FAA) approved forecasts, as well as established planning criteria, to determine the airside (i.e., runways, taxiways, navigational aids, marking and lighting) and landside (i.e., hangars, aircraft parking apron, and automobile parking) facility requirements.

The objective of this effort is to identify, in general terms, the adequacy of the existing airport facilities and outline what new facilities may be needed, and when these may be needed to accommodate forecast demands. A recommended airport layout concept will be presented that consolidates all facility requirements into a single development concept for the airport.

DESIGN CRITERIA

The FAA publishes Advisory Circular (AC) 150/5300-13A, Airport Design, to guide airport planning. The AC provides guidance on various design elements of an airport intended to maintain or improve safety at airports. The design standards include airport elements such as runways, taxiways, safety areas, and separation distances. According to the AC, "airport planning should consider both the present and potential aviation needs and demand associated with the airport." Consideration should be given to planning runway and taxiway locations that will meet future separation requirements even if the width, strength, and length must increase later. Such decisions should be supported by the aviation demand forecasts, coordinated with the FAA, and shown on the Airport Layout Plan (ALP).

FAA AC 150/5300-13A, *Airport Design* was published on September 28, 2012. It replaces AC 150/5300-13, *Airport Design* which was dated September 29, 1989. The latter was subject to 18 published changes over 23 years.

The previous Airport Design AC established the design standards based primarily on the Airport Reference Code (ARC). Paragraph 4 defined the ARC as "*a coding system used to relate airport design criteria to the operational and physical characteristics of the airplanes intended to operate at the airport."*

In the current AC, the definition of the Airport Reference Code is found in Paragraph 102.i. and reads, *"An airport designation that signifies the airport's highest Runway Design Code (RDC), minus the third (visibility) component of the RDC. The ARC is used for planning and design only and does not limit the aircraft that may be able to operate safely on the airport."*

The RDC is defined in Paragraph 102.mmm. as, *"A code signifying the design standards to which the runway is to be built."* Paragraph 105.c. indicates that the Aircraft Approach Category (AAC), the Airplane Design Group (ADG), and the approach visibility minimums combine to form the RDC of a particular runway. These provide the information needed to determine certain design standards that apply.

The current Airport Design AC introduces not only the RDC, but also the Runway Reference Code (RRC). The RRC is defined as, *"A code signifying the current operational capabilities of a runway and associated parallel taxiway."* Like the RDC, the RRC is composed of the same three components: the AAC, ADG, and runway visibility minimums. The RDC, however, is based upon planned development with no operational component, while the RRC describes the current operational capabilities of a runway where no special operating procedures are necessary. The RRC for a runway is established based upon the minimum runway to taxiway centerline separation.

DESIGN AIRCRAFT

The selection of appropriate FAA design standards for the development and location of airport facilities is based primarily upon the characteristics of the aircraft which are currently using or are expected to use the airport. The critical design aircraft is used to define the design parameters for the airport. In most cases, the design aircraft is a composite aircraft representing a collection of aircraft classified by three parameters: Aircraft Approach Category (AAC), Airplane Design Group (ADG), and Taxiway Design Group (TDG). In the case of an airport with multiple runways, a design aircraft is selected for each runway. The first consideration is the safe operation of aircraft likely to use the airport. Any operation of an aircraft that exceeds design criteria of the airport may result in either an unsafe operation or a lesser safety margin unless air traffic control Standard operating Procedures (SOPs) are in place for those operations; however, it is not the usual practice to base the airport design on an aircraft that uses the airport infrequently.

The design aircraft is defined as the most demanding category of aircraft, or family of aircraft, which conducts at least 500 operations per year at the airport. Planning for future aircraft use is of particular importance since the design standards are used to plan separation distances between facilities. These future standards must be considered now to ensure that short term development does not preclude the long range potential needs of the airport.

Exhibit 2A summarizes representative design aircraft categories. As shown on the exhibit, the airport does not currently, nor is it expected to, regularly serve larger commercial transport aircraft such as Boeing 737, 747, 757, or 767. Large transport aircraft are used by commercial carriers which do not currently use, nor are they expected to use, the airport through the planning period. However, some of the largest business jets, such as the Gulfstream V are capable of operating at the airport under certain conditions.

In order to determine airfield design requirements, a design aircraft, or group of aircraft with similar characteristics, is determined for each runway. This determination begins with a review of aircraft currently using the airport and those expected to use the airport in the future planning period.

RUNWAY DESIGN CODE (RDC)

The AAC, ADG, and approach visibility minimums are combined to form the RDC of a particular runway. The RDC provides the information needed to determine certain design standards that apply. The first component, depicted by a letter, is the AAC and relates to aircraft approach speed (operational characteristics). The second component, depicted by a Roman numeral, is the ADG and relates to either the aircraft wingspan or tail height (physical characteristics) - whichever is most restrictive. The third component relates to the visibility minimums expressed by runway visual range (RVR) values in feet of 1,200, 1,600, 2,400, 4,000 and 5,000. The third component should read “VIS” for runways designed for visual approach use only. Generally, runway standards are related to aircraft approach speed, aircraft wingspan, and designated or planned approach visibility minimums. **Table 2A** presents the RDC parameters.

TAXIWAY DESIGN GROUP (TDG)

The TDG relates to the undercarriage dimensions of the design aircraft. Taxiway/taxilane width and fillet standards, and in some instances, runway to taxiway and taxiway/taxilane separation requirements are determined by TDG. It is appropriate for taxiways to be planned and built to different TDG standards based on expected use.

The TDG standards are based on the Main Gear Width (MGW) and the Cockpit to Main Gear (CMG) distance. The taxiway design elements determined by the application of the TDG include the taxiway width, taxiway edge safety margin, taxiway shoulder width, taxiway fillet dimensions, and in some cases, the separation distance between parallel taxiways/taxilanes. Other taxiway elements such as the taxiway safety area (TSA), taxiway/taxilane object free area (TOFA), taxiway/taxilane separation to parallel taxiway/taxilanes or fixed or movable objects, and taxiway/taxilane wingtip clearances are determined solely based on the wingspan (ADG) of the design aircraft utilizing those surfaces.

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A-I

- Beech Baron 55
- **Beech Bonanza**
- Cessna 150
- Cessna 172
- Cessna Citation Mustang
- Eclipse 500/550
- Piper Archer
- Piper Seneca

B-I

- Beech Baron 58
- Beech King Air 100
- Cessna 402
- **Cessna 421**
- Piper Navajo
- Piper Cheyenne
- Swearingen Metroliner
- Cessna Citation I (525)

B-II

- Super King Air 200
- Cessna 441
- DHC Twin Otter
- Super King Air 350
- Beech 1900
- Citation Excel (560), Sovereign (680)
- Falcon 50, 900, 2000
- **Citation Bravo (550)**
- Embraer 120

A-III, B-III

- DHC Dash 7
- **DHC Dash 8**
- DC-3
- Convair 580
- Fairchild F-27
- ATR 72
- ATP

C-I, D-I

- Beech 400
- **Lear** 31, **35,** 45, 60
- Israeli Westwind

C-II, D-II

- **Cessna Citation X (750)**
- Gulfstream 100, 200,300
- Challenger 300/600
- ERJ-135, 140, 145
- CRJ-200/700
- Embraer Regional Jet
- Lockheed JetStar
- Hawker 800

C-III, D-III *less than 100,000 lbs.*

- ERJ-170
- CRJ 705, 900
- Falcon 7X
- **Gulfstream 500**, 550, 650
- Global Express, Global 5000
- Q-400

C-III, D-III *over 100,000 lbs.*

- ERJ-90
- Boeing Business Jet
- B-727
- **B-737**-300, **700,** 800
- MD-80, DC-9
- A319, A320

C-IV, D-IV

- **B-757**
- B-767
- C-130 Hercules
- DC-8-70
- MD-11

D-V

- **B-747-400**
- B-777
- B-787
- A-330, A-340

Note: Aircraft pictured is identified in bold type.

Exhibit 2A
AIRCRAFT REFERENCE CODES

TABLE 2A
Runway Design Code Parameters

Aircraft Approach Category (AAC)		
Category	**Approach Speed**	
A	less than 91 knots	
B	91 knots or more but less than 121 knots	
C	121 knots or more but less than 141 knots	
D	141 knots or more but less than 166 knots	
E	166 knots or more	
Airplane Design Group (ADG)		
Group #	**Tail Height (ft)**	**Wingspan (ft)**
I	<20	<49
II	20-<30	49-<79
III	30-<45	70-<118
IV	45-<60	118-<171
V	60-<66	171-<214
VI	66-<80	214-<262
Visibility Minimums		
RVR (ft)	**Flight Visibility Category (statute miles)**	
VIS	3-mile or greater visibility minimums	
5,000	Lower than 3 miles but not lower than 1-mile	
4,000	Lower than 1-mile but not lower than ¾-mile (APV ≥ ¾ but < 1-mile)	
2,400	Lower than ¾-mile but not lower than ½-mile (CAT-I PA)	
1,600	Lower than ½-mile but not lower than ¼-mile (CAT-II PA)	
1,200	Lower than ¼-mile (CAT-III PA)	

RVR: Runway Visual Range
APV: Approach Procedure with Vertical Guidance
PA: Precision Approach
Source: FAA AC 150/5300-13A, Airport Design

CRITICAL DESIGN AIRCRAFT

The critical design aircraft is defined as the most demanding category of aircraft which conduct 500 or more itinerant operations at the airport each year. In some cases, more than one specific make and model of aircraft comprises the airport's critical design aircraft. One category of aircraft may be the most critical in terms of approach speed, while another is most critical in terms of wingspan and/or tail height, which affects runway/taxiway width and separation design standards. The critical design aircraft for a general aviation airport may be a specific aircraft model or it can be a combination of several aircraft within the same design code that, when combined, exceed the 500 operations threshold.

A critical design aircraft will be determined for each runway. The largest design aircraft in terms of approach speed and airplane design group will determine the appropriate design standards for primary Runway 7L-25R and the associated taxiways. Parallel Runway 7R-25L may have the same or a different design aircraft. The first determination is the most critical design aircraft for Runway 7L-25R.

General aviation aircraft using the airport include a variety of single and multi-engine piston-powered aircraft, turboprops, business jets, and helicopters. While the airport is used by helicopters, they are not included in this determination as they are not assigned an approach speed or an airplane design group.

Based Aircraft

The determination of the design aircraft (or family of aircraft) will first examine the types of based aircraft followed by an analysis of itinerant activity. The majority of the based aircraft are single and multi-engine piston-powered aircraft which fall within approach categories A and B and ADG I and II. These smaller aircraft are often used for local operations which are not included in the critical aircraft determination.

The next step is to identify the larger based aircraft including turboprops and business jets that may contribute to meeting the itinerant operations threshold of 500 annual operations. These aircraft types typically have higher utilization rates than smaller aircraft and rarely perform local operations. These aircraft types can represent the critical aircraft on their own, due to high utilization, or in combination with other aircraft with similar characteristics.

Airport management provided a list of aircraft N-numbers of those aircraft based at the airport. The characteristics of the largest based aircraft are provided on **Table 2B**.

TABLE 2B
Based Turboprops and Business Jets
Livermore Municipal Airport

Aircraft Type	Engine Type	AAC	ADG	TDG
Pilatus (3)	Turboprop	B	II	1
Cessna 510 Mustang	Jet	B	I	1
Dassault Falcon 50	Jet	B	II	2
Lear 25	Jet	C	I	1
Gulfstream II (1159A)	Jet	C	II	3

AAC: Aircraft Approach Category
ADG: Aircraft Design Group
TDG: Taxiway Design Group

Source: Airport records; Aircraft specification.

There are three Pilatus single engine turboprop aircraft based at the airport. These aircraft fall within AAC-B and ADG-II. The based Dassault Falcon 50 business jet also falls in AAC-B and ADG-II. The based Lear 25 falls in AAC C and ADG I, meaning this aircraft has a faster approach speed and shorter wingspan than the Falcon 50. The based Gulfstream II (1159A) falls within ACC C and ADG II. The Cessna Mustang is a light jet and falls in ACC B and ADG I. All of these aircraft are known to be active at the airport.

Itinerant Aircraft

The FAA maintains the *Traffic Flow Management System Counts* (TFMSC) database which documents certain aircraft operations at certain airports. Information is added to the TFMSC database when pilots file flight plans and/or when flights are detected by the National Airspace System, usually via radar. It includes documentation of commercial traffic (air carrier and air taxi), general aviation, and military aircraft. Due to factors such as incomplete flight plans and limited radar coverage, TFMSC data cannot account for all aircraft activity at an airport. Therefore, it is likely that there are more operations at an airport than are captured by this methodology. Nonetheless, this information provides a reasonable estimate of certain activity.

Since business jets are larger and faster, they will typically have a greater impact on airport design standards than smaller aircraft. The following analysis will focus on itinerant activity by jets at Livermore Municipal Airport. The TFMSC database is the primary source for business jet activity at the airport. A secondary source, www.airportiq.com, was also consulted.

Exhibit 2B presents the TFMSC jet activity at Livermore Municipal Airport from 2003 through November of 2012. As can be seen, most types and sizes of business jets can and do operate at the airport. From 2003 through 2012, the airport has averaged 2,184 annual business jet operations. The range of operations has been fairly narrow with a low of 1,550 operations in 2012 and a high of 2,880 operations in 2007.

The slight decline in business jet operations since 2007 can almost certainly be attributed to the significant economic recession that began in late 2007 and ran through late 2009. The recovery since emerging from the recession has been slow to date; however, many airports are beginning to see reversals as of late 2012.

The exhibit also shows the breakout of these business jets by approach category and airplane design group. On average, over the last decade, 52 percent of the business jet activity was by aircraft in approach category B, accounting for 1,145 annual operations. Business jets in approach category C have represented 31 percent of annual operations and averaged 675 operations annually. Approach category D activity has represented 17 percent of operations annually and averaged 363 operations annually.

Runway 7L-25R Design Criteria

Livermore Municipal Airport experiences frequent business jet operations and should be designed and planned to accommodate these types of aircraft to the greatest extent possible. Over the last 10 years, the airport has averaged more than 500 operations by aircraft in ACC C and ADG II. The airport has not exceeded the 500 operations threshold for AAC D and/or ADG III. While no single aircraft model in ACC C and ADG II has accounted for 500 operations on its own, a representative aircraft would be the Cessna Citation X (750). Therefore, the current design aircraft for Runway 7L-25R is represented as C-II-3. The last figure designates the taxiway design group for the Citation X aircraft and indicates that associated airfield taxiways should be at least 50 feet wide.

The current ALP identifies the Falcon 900B as the critical design aircraft and is therefore the design aircraft for Runway 7L-25R. The design aircraft, as defined in the new AC, would be B-II-3. Thus, there is a difference between the reference code associated with the design aircraft today (C-II-3), as defined by actual activity, and that of the design aircraft on the current ALP (B-II-3).

A change in the design aircraft can have a significant impact on how the airport is planned for the future. For example, to meet C-II-3 design standards, the parallel taxiway to Runway 7L-25R separation would need to be no less than 400 feet, centerline to centerline, where the cur-

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JET OPERATIONS BY AIRPORT REFERENCE CODE (Minimum)

ARC	Aircraft Type	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
B-I	Eclipse 500	-	-	-	-	-	20	22	32	28	32
	Premier 390	-	8	24	24	64	12	12	26	22	18
	Beechjet 400/T-1/Hawker 400	268	268	312	484	470	320	130	88	66	68
	Cessna 500/Citation I	14	24	26	12	8	-	-	2	2	8
	Cessna 501/Citation I/SP	6	14	6	18	18	10	6	8	18	8
	Cessna Mustang 510	-	-	-	-	6	38	68	48	146	194
	Cessna 525 CitationJet/CJ1	108	124	78	62	44	24	20	32	42	30
	Embraer Phenom 100	-	-	-	-	-	-	4	14	32	58
	Falcon 10	34	18	2	6	36	16	8	6	2	4
	Mitsubishi MU-300	12	8	-	4	4	-	-	-	-	-
	Rockwell Saber 40/60	8	8	4	2	-	-	-	2	2	-
Total B-I		**450**	**472**	**452**	**612**	**650**	**440**	**270**	**258**	**360**	**420**
B-II	Cessna 525A (CJ2)	28	32	40	40	22	12	6	-	8	10
	Cessna 525B (CJ3)	-	-	16	60	10	20	20	18	20	12
	Cessna Citation II Bravo 550/551	136	182	210	96	118	66	32	48	26	16
	Cessna Citation V/Ultra/Encore 560	158	308	272	280	280	204	124	88	132	126
	Cessna 560 XLS	94	158	160	206	322	214	156	178	178	186
	Cessna Citation III/VI/VII 650	84	60	48	54	18	30	22	18	6	12
	Cessna Citation Sovereign 680	-	-	16	16	36	36	62	56	38	54
	Embraer Phenom 300	-	-	-	-	-	-	-	-	22	12
	Falcon 20	24	6	10	12	6	12	8	6	2	-
	Falcon 50	56	78	44	82	54	28	32	42	56	18
	Falcon 900	20	18	38	40	48	30	26	22	50	30
	Falcon 2000	26	42	30	48	52	34	16	48	58	74
Total B-II		**626**	**884**	**884**	**934**	**966**	**686**	**504**	**524**	**596**	**550**
C-I	BAe HS 125-1/2/3/400/600	22	8	18	10	2	-	-	-	-	-
	BAe HS 125/700-800/Hawker 800	158	108	190	280	320	202	118	106	86	86
	Learjet 23/24	10	18	4	2	-	2	-	4	-	6
	Learjet 25/28	50	64	54	22	18	38	50	68	44	26
	Learjet 31 A/B	14	40	46	30	30	6	8	8	6	2
	Learjet 55	20	18	46	8	8	22	20	30	2	28
	IAI Westwind	48	76	102	76	36	16	8	6	4	6
Total C-I		**322**	**332**	**460**	**428**	**414**	**286**	**204**	**222**	**142**	**154**
C-II	IAI Astra 1125	14	6	18	14	24	4	2	-	-	4
	IAI Galaxy/Gulfstream G200	6	24	26	24	38	18	22	14	12	28
	Cessna Citation 750 (X)	118	126	100	92	114	112	60	108	72	62
	Challenger 300	-	2	32	30	56	114	110	186	200	168
	Challenger 600/604	174	108	94	96	114	86	84	78	60	34
	Lockheed 1329 Jetstar	-	2	-	-	-	-	-	-	-	-
	Gulfstream III/G300	40	78	86	90	78	28	62	56	32	28
	Hawker 800XP, 1000, 4000	40	20	10	6	-	2	4	-	-	6
	Falcon 900EX & F-Series	-	-	-	-	-	-	-	-	-	2
Total C-II		**392**	**366**	**366**	**352**	**424**	**364**	**344**	**442**	**376**	**332**
C-III	Global Express/5000	6	6	2	18	14	6	4	-	8	10
	Gulfstream V/G-500/G550	14	16	26	48	52	24	22	32	44	22
Total C-III		**20**	**22**	**28**	**66**	**66**	**30**	**26**	**32**	**52**	**32**
D-I	Learjet 35/36	104	218	183	162	136	118	140	92	52	24
	Learjet 45	60	84	112	100	86	46	54	26	44	36
	Learjet 60	36	62	86	70	42	22	12	56	46	24
Total D-I		**200**	**364**	**381**	**332**	**264**	**186**	**206**	**174**	**142**	**84**
D-II	Gulfstream G150	-	-	-	-	12	22	24	42	26	14
	Gulfstream II (G200)	12	12	2	10	2	-	6	8	6	2
	Gulfstream IV/G400	92	100	92	82	82	80	44	60	74	114
Total D-II		**104**	**112**	**94**	**92**	**96**	**102**	**74**	**110**	**106**	**130**
Total Jet Activity		**2,114**	**2,552**	**2,665**	**2,816**	**2,880**	**2,094**	**1,628**	**1,762**	**1,774**	**1,702**

TOTAL JET OPERATIONS BY APPROACH CATEGORY AND AIRPLANE DESIGN GROUP

Aircraft Approach Category	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
B	1,076	1,356	1,336	1,546	1,616	1,126	774	782	956	970
C	734	720	854	846	904	680	574	696	570	518
D	304	476	475	424	360	288	280	284	248	214
Airplane Design Group										
I	972	1,168	1,293	1,372	1,328	912	680	654	644	658
II	1,122	1,362	1,344	1,378	1,486	1,152	922	1,076	1,078	1,012
III	20	22	28	66	66	30	26	32	52	32

Source: Traffic Flow Management System Counts (TFMSC) - FAA activity database.

Exhibit 2B
BUSINESS JET ACTIVITY

rent separation is 250 feet. To accommodate a parallel taxiway at this distance, the northwest flood control berm would have to be relocated, portions of the golf course would have to be acquired, and approximately 115 feet of the main apron would be unusable in order to accommodate the taxiway object free area. The runway safety areas (RSA) beyond each runway end would increase from 600 feet to 1,000 feet. At this length, both RSAs would have penetrations (the golf course to the west and water treatment plant to the east).

Due to the significant obstacles to meeting the design standards associated with a change in the design aircraft, **the design aircraft for Livermore Municipal Airport is recommended to remain B-II-3.** Continued utilization of this design aircraft is recognition that while the airport does experience frequent activity by larger aircraft, this airport cannot reasonably be improved to such a level to fully meet design standards intended for a larger design aircraft. Since airport sponsors cannot legally prohibit any aircraft from using the airport, future improvements should be planned to meet C-II-3 design standards to the greatest extent practicable.

The RDC for each runway is the design standard to which the runway is planned to be built. The RDC is a planning standard that considers the AAC, ADG and the RVR. The RDC for Runway 7L-25R is based on a critical design aircraft in B-II-3 would be B-II-2400. Since the airport cannot reasonably be improved to meet C-II-2400, the future RDC is planned to remain B-II-2400.

The RRC is differentiated from the RDC in that it reflects the current operational capability of both the runway and associated parallel taxiway. In essence, the RRC is the design standard that the airfield (runways/taxiway system) layout currently meets. With the availability of a CAT-I instrument approach and Taxiway A located at a separation distance of 250 feet from the runway, the current RRC for Runway 7R-25L is B-II-4000/B-I-2400. This means that the runway and taxiway system meets design standards for B-II aircraft with a 1-mile instrument approach and for B-I aircraft with a ½-mile instrument approach.

Runway 7R-25L Design Criteria

Runway 7R-25L is the parallel runway which is situated 500 feet, centerline to centerline, from the primary runway, and is 2,699 feet long and 75 feet wide. This runway is unlit and is considered the training runway. The current ALP classifies this runway as ARC B-I (small aircraft) and identifies the Beech C99 Airliner as the representative aircraft. The length of this runway effectively limits the utilization of this runway to light twin-engine aircraft and smaller. In fact, the current length is less than what the FAA recommends for small aircraft with 10 or more passenger seats, such as the Beech C99 Airliner (up to 4,200 feet). **The current design aircraft classification for this runway is B-I-1 (small aircraft).** Analysis of the adequacy of the current runway length will be presented later in this chapter under the heading Runway Length.

Runway 7R-25L is currently available for visual daytime operations only; therefore, the current RDC is B-I-VIS (small). The RRC for Runway 7R-25L is B-II-4000 because the runway and parallel taxiway meet the design standards for B-II aircraft with an instrument approach as low as ¾-mile (although not currently available). An instrument approach with visibility minimums down to 1-mile are considered for this runway in the future. The same design standards, including the size of the RPZ, are the same whether the runway is for visual operations or instrument operations with not lower than 1-mile visibility minimums. It should be noted that instrument approaches with visibility minimums lower than 1-mile or a change in design aircraft would necessitate a larger RPZ which would introduce new incompatibilities to the RPZ. As a result, improvements to the runway that would alter the size of the RPZ are not planned.

Table 2C presents the runway design criteria for each runway. With this information, the applicable design standards can be applied to various airfield elements such as runway safety area (RSA), object free area (OFA), and separation standards.

TABLE 2C
Runway Design Criteria
Livermore Municipal Airport

	Existing Runway 7L-25R	Existing Runway 7R-25L	Future Runway 7R-25L
Design Aircraft	B-II-3*	B-I-1 (small)	B-I-1 (small)
Example Aircraft	Falcon 900B/Citation 750*	Beech C99 Airliner	Beech C99 Airliner
Runway Design Code	B-II-2400	B-I-VIS	B-I-5000
Runway Reference Code	B-II-4000/B-I-2400	B-II-4000	B-II-4000
Visibility Minimums	Visual (7L)/½-Mile(25R)	Visual	1 Mile

* Composite aircraft with Falcon 900B representing AAC/ADG and Citation 750 representing TDG

AIRFIELD REQUIREMENTS

As indicated earlier, airport facilities include both airfield and landside components. Airfield facilities include those facilities that are related to the arrival, departure, and ground movement of aircraft. These components include:

- Runway Configuration
- Safety Area Design Standards
- Runways
- Taxiways
- Navigational Approach Aids
- Lighting, Marking, and Signage

RUNWAY CONFIGURATION

The airport is currently served by two parallel runways. Primary Runway 7L-25R is 5,253 feet long and is orientated in an east/west manner. Parallel Runway 7R-25L is 2,699 feet in length and situated 500 feet to the south of the primary runway. By standard, the minimum separation for parallel runways to accommodate simultaneous VFR operations is 700 feet. Since the runways are only 500 feet apart, the airport operates as a single runway system.

For the operational safety and efficiency of an airport, it is desirable for the primary runway to be oriented as close as possible to the direction of the prevailing wind. This reduces the impact of wind components perpendicular to the direction of travel of an aircraft that is landing or taking off.

FAA Advisory Circular 150/5300-13A, *Airport Design,* recommends that a crosswind runway be made available when the primary runway orientation provides for less than 95 percent wind coverage for specific crosswind components. The 95 percent wind coverage is computed on the basis of the crosswind component not exceeding 10.5 knots (12 mph) for RDC A-I and B-I, 13 knots (15 mph) for RDC A-II and B-II, and 16 knots (18 mph) for RDC A-III, B-III, C-I through C-III, and D-I through D-III. At Livermore Municipal Airport, the parallel runway system provides for 97.79 percent wind coverage at 10.5 knots and above 99 percent for higher wind speeds; therefore, a crosswind runway is not recommended.

RUNWAY DESIGN STANDARDS

The FAA has established several imaginary surfaces to protect aircraft operational areas and keep them free from obstructions that could affect their safe operation. These include the runway safety area (RSA), runway object free area (ROFA), runway obstacle free zone (ROFZ), and runway protection zone (RPZ).

The entire RSA, ROFA, and ROFZ must be under the direct ownership of the airport sponsor to ensure these areas remain free of obstacles and can be readily accessed by maintenance and emergency personnel. The RPZ should also be under airport ownership. An alternative to outright ownership of the RPZ is the purchase of avigation easements (acquiring control of designated airspace within the RPZ) or having sufficient land use control measures in places which ensure the RPZ remains free of incompatible development. The various airport safety areas are presented on **Exhibit 2C**.

Dimensional standards for the various safety areas associated with the runways are a function of the type of aircraft expected to use the runways as well as the instrument approach capability. **Table 2D** presents the FAA design standards as they apply to the runways at Livermore Municipal Airport.

Runway Safety Area (RSA)

The RSA is defined in FAA AC 150/5300-13A, *Airport Design,* as a "surface surrounding the runway prepared or suitable for reducing the risk of damage to airplanes in the event of undershoot, overshoot, or excursion from the runway." The RSA is centered on the runway and dimensioned in accordance to the approach speed of the critical design aircraft using the runway. The FAA requires the RSA to be cleared and graded, drained by grading or storm sewers, capable of accommodating the design aircraft and fire and rescue vehicles, and free of obstacles not fixed by navigational purpose such as runway edge lights or approach lights.

The FAA has placed a higher significance on maintaining adequate RSA at all airports. Under Order 5200.8, effective October 1, 1999, the FAA established the *Runway Safety Area Program.* The Order states, "The objective of the Runway Safety Area Program is that all RSAs at federally-obligated airports…shall conform to the standards contained in Advisory Circular 150/5300-13, *Airport Design*, to the

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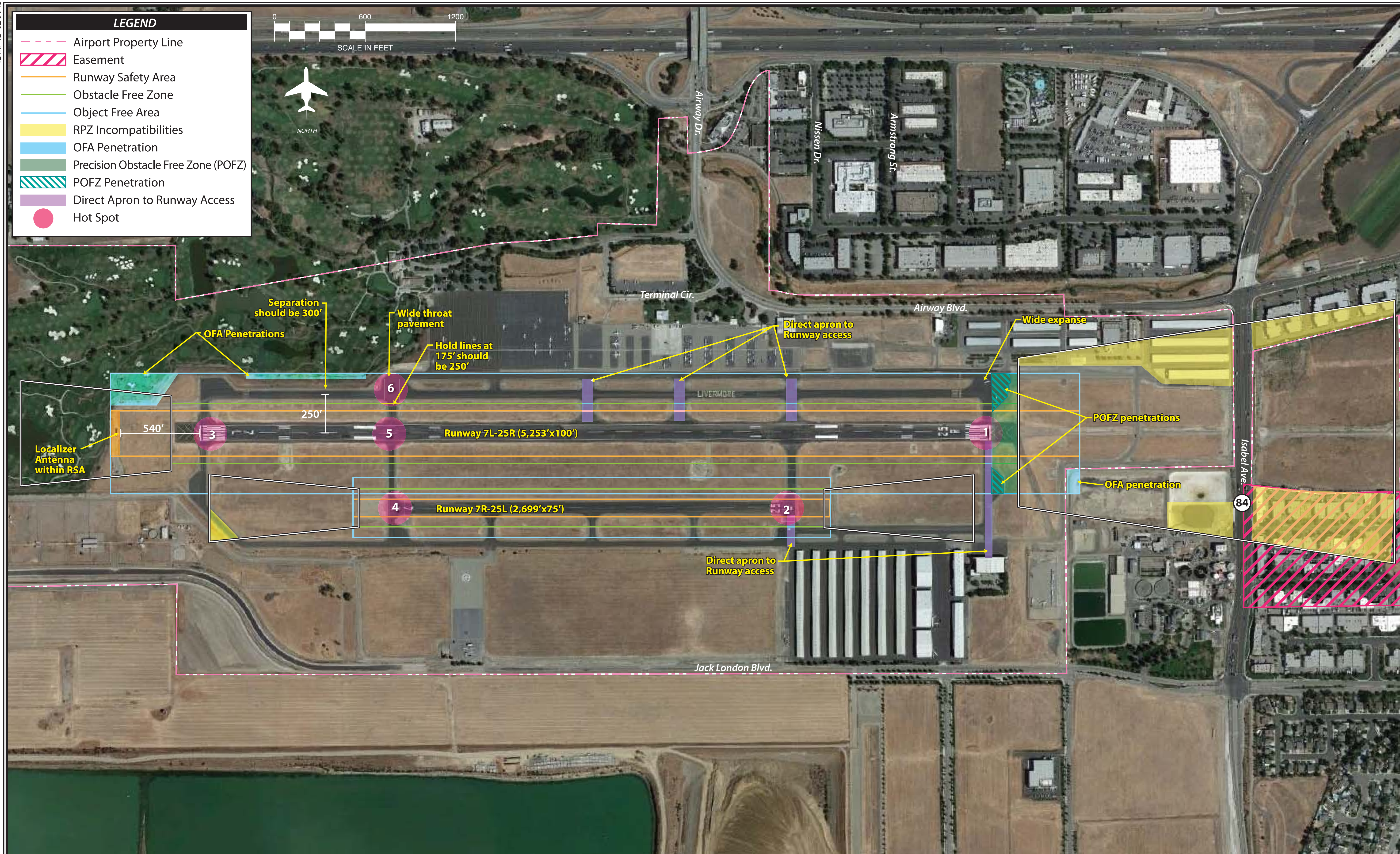

Exhibit 2C
SAFETY AREAS/AREAS OF CONCERN

extent practicable." Each Regional Airports Division of the FAA is obligated to collect and maintain data on the RSA for each runway at the airport and perform airport inspections.

TABLE 2D
Runway Design Standards
Livermore Municipal Airport

	Runway 7L-25R	Runway 7R-25L
Design Aircraft	**B-II-3***	**B-I-1 (small)**
Example Aircraft	**Falcon 900B/ Citation X (750)***	**Beech C99 Airliner**
Runway Design Code (RDC)	**B-II-2400**	**B-I-VIS**
Runway Reference Code (RRC)	**B-II-4000/B-I-2400**	**B-II-4000**
Visibility Minimums	**Visual (7L)/½-Mile(25R)**	**Visual (1-mile - Ult)**
RUNWAY DESIGN		
Runway Width	100	60
Runway Shoulder Width	10	10
RUNWAY PROTECTION		
Runway Safety Area (RSA)		
Width	300	120
Length Beyond Departure End	600	240
Length Prior to Threshold	600	240
Runway Object Free Area (ROFA)		
Width	800	250
Length Beyond Departure End	600	240
Length Prior to Threshold	600	240
Runway Obstacle Free Zone (ROFZ)		
Width	400	250
Length Beyond End	200	200
Precision Obstacle Free Zone (POFZ)		
Width	800	NA
Length	200	NA
Approach Runway Protection Zone (RPZ)		
Length	1,000 (7L)/2,500 (25R)	1,000
Inner Width	5007L)/1,000(25R)	250
Outer Width	700(7L)/1,750(25R)	450
Departure Runway Protection Zone (RPZ)		
Length	1,000	1,000
Inner Width	500	250
Outer Width	700	450
RUNWAY SEPARATION		
Runway Centerline to:		
Parallel Runway (dual visual approaches)	700	700
Holding Position	250	125
Parallel Taxiway	300	150
Aircraft Parking Area	400	125

* Composite aircraft with Falcon 900B representing AAC/ADG and Citation X (750) representing TDG
Note: All dimensions in feet
Source: FAA AC 150/5300-13A, Airport Design

For Runway 7L-25R, the RSA is 300 feet wide and extends 600 feet beyond the runway ends. The FAA owned localizer antenna is situated within the Runway 7L RSA, 540 feet from the runway threshold. Localizer antenna are typically not considered "fixed by function" and have been relocated at airports across the country in order to provide full RSA. The localizer antenna at Livermore Municipal Airport should be relocated outside the RSA by the owner.

The RSA design standard for Runway 7R-25L is 120 feet wide and 240 feet beyond the runway ends. The RSA meets the design standard and should be maintained.

Runway Object Free Area (ROFA)

The runway OFA is "a two-dimensional ground area, surrounding runways, taxiways, and taxilanes, which is clear of objects except for objects whose location is fixed by function (i.e., airfield lighting)." The OFA does not have to be graded and level like the RSA; instead, the primary requirement for the OFA is that no object in the OFA penetrates the lateral elevation of the RSA. The runway OFA is centered on the runway, extending out in accordance to the critical design aircraft utilizing the runway.

The southeast corner of the ROFA extends beyond airport property into the water treatment plant property and is penetrated by the fence surrounding this property. On the Runway 7L end, the OFA has numerous penetrations, including the berm and fence separating the airfield from the golf course and the localizer antenna. If the full OFA cannot be provided, then a modification to standard should be sought.

The OFA design standard for Runway 7R-25L is 250 feet wide and it extends 240 feet beyond the runway ends. The OFA meets design standard and should be maintained.

Runway Obstacle Free Zone (ROFZ)

The OFZ is an imaginary volume of airspace which precludes object penetrations, including taxiing and parked aircraft. The only allowance for OFZ obstructions is navigational aids mounted on frangible bases which are fixed in their location by function, such as airfield signs. The OFZ is established to ensure the safety of aircraft operations. If the OFZ is obstructed, the airport's approaches could be removed or approach minimums could be increased.

The OFZ for Runway 7L-25R is 400 feet wide as centered on the runway. The taxiway hold lines on the north side Runway 7L-25R are situated 175 feet from the runway centerline. Therefore, holding aircraft will be located within the OFZ. If feasible, the hold lines should be moved outside the OFZ.

The OFZ for runway 7R-25L is 250 feet wide and it extends 200 feet beyond the runway ends. The OFZ meets design standard and should be maintained.

A precision obstacle free zone (POFZ) is further defined for runway ends with a precision approach, such as the ILS approach to Runway 25R. The POFZ is 800 feet wide and extends from the runway threshold to a distance of 200 feet. The POFZ is in effect when the following conditions are met:

a) The runway supports a vertically guided approach.
b) Reported ceiling is below 250 feet and/or visibility is less than ¾-mile.
c) An aircraft is on final approach within two miles of the runway threshold.

When the POFZ is in effect, a wing of an aircraft holding on a taxiway may penetrate the POFZ; however, neither the fuselage nor the tail may infringe on the POFZ.

Taxiways A and J penetrate the POFZ. Appropriate taxiway markings are provided to alert pilots of the location of the POFZ when it is in effect. If feasible, the taxiway layout should be redesigned to prevent inadvertent aircraft penetration of the POFZ.

Runway Protection Zones (RPZ)

The RPZ is a trapezoidal area centered on the runway, typically beginning 200 feet beyond the runway end. The RPZ has been established by the FAA to provide an area clear of obstructions and incompatible land uses in order to enhance the protection of people and property on the ground. The RPZ is comprised of the central portion of the RPZ and the controlled activity area. The central portion of the RPZ extends from the beginning to the end of the RPZ, is centered on the runway, and is the width of the ROFA. The controlled activity area is any remaining portions of the RPZ. The dimensions of the RPZ vary according to the visibility minimums serving the runway and the type of aircraft (design aircraft) operating on the runway.

While the RPZ is intended to be clear of incompatible objects or land uses, some uses are permitted with conditions and other land uses are prohibited. According to AC 159/5300-13A, *Airport Design*, the following land uses are permissible within the RPZ:

- Farming that meets the minimum buffer requirements,
- Irrigation channels as long as they do not attract birds,
- Airport service roads, as long as they are not public roads and are directly controlled by the airport operator.
- Underground facilities, as long as they meet other design criteria, such as RSA requirements, as applicable,
- Unstaffed navigational aids (NAVAIDs) and facilities, such as required for airport facilities that are fixed-by-function in regard to the RPZ.

Any other land uses considered within RPZ land owned by the airport sponsor must be evaluated and approved by the FAA Office of Airports. The FAA has published *Interim Guidance on Land Uses within a Runway Protection Zone* (9.27.2012) which identifies several potential land uses that must be evaluated and approved prior to implementation. The specific land uses requiring FAA evaluation and approval include:

- Buildings and structures (examples include, but are not limited to: residences, schools, churches, hospitals or other medical care facilities, commercial/industrial buildings, etc.)
- Recreational land use (examples include, but are not limited to: golf courses, sports fields, amusement parks, other places of public assembly, etc.)
- Transportation facilities. Examples include, but are not limited to:
  - Rail facilities - light or heavy, passenger or freight
  - Public roads/highways
  - Vehicular parking facilities
- Fuel storage facilities (above and below ground)
- Hazardous material storage (above and below ground)
- Wastewater treatment facilities
- Above-ground utility infrastructure (i.e., electrical substations), including any type of solar panel installations.

The *Interim Guidance on Land within a Runway Protection Zone* states, "RPZ land use compatibility also is often complicated by ownership considerations. Airport owner control over the RPZ land is emphasized to achieve the desired protection of people and property on the ground. Although the FAA recognizes that in certain situations the airport sponsor may not fully control land within the RPZ, the FAA expects airport sponsors to take all possible measures to protect against and remove or mitigate incompatible land uses."

Currently, the RPZ review standards are applicable to any new or modified RPZ. The following actions or events could alter the size of an RPZ, potentially introducing an incompatibility:

- An airfield project (e.g., runway extension, runway shift),
- A change in the critical design aircraft that increases the RPZ dimensions,
- A new or revised instrument approach procedure that increases the size of the RPZ,
- A local development proposal in the RPZ (either new or reconfigured).

Since the interim guidance only addresses new or modified RPZs, existing incompatibilities are essentially grandfathered under certain circumstances. While it is still necessary for the airport sponsor to take all reasonable actions to meet the RPZ design standard, FAA funding priority for certain actions, such as relocating existing roads in the RPZ, will be determined on a case by case basis.

The precision RPZ serving the approach to Runway 25R currently has several incompatibilities. These include airport hangars and taxilanes, which are on airport property, and numerous off-airport commercial buildings. The airport owns an avigation easement covering the commercial buildings on the south side of the RPZ. The commercial buildings within the RPZ on the north side are uncontrolled. In addition, a small retention pond associated with the water treatment plant is in the RPZ. On the Runway 7L end, the RPZ extends over the golf course, including a small pond. The Runway 7R RPZ extends over a portion of Taxiway H and the Runway 25L RPZ extends over Taxiway K.

The airport sponsor should make reasonable efforts to own the RPZ in fee simple if possible or obtain positive control through avigation easements or land use zoning measures.

Runway/Taxiway Separation

The design standards for the separation between runways and parallel taxiways are a function of the critical design aircraft and the instrument approach visibility minimum. The separation standard for RDC B-II with ½-mile visibility minimums is 300 feet from the runway centerline to the parallel taxiway centerline. Taxiway A is situated 250 feet from Runway 7L-25R. As discussed previously, it is impracticable to relocate Taxiway A; therefore, a modification to standard should be considered.

Taxiway L is 240 feet from Runway 7R-25L, which exceeds the design standard of 150 feet. This separation should be maintained.

Hold Lines

The design standard for taxiway hold lines for Runway 7L-25R is 250 feet from the runway centerline. The hold lines are currently at 175 feet. Meeting the design standard for hold lines is impracticable, as they would be located in the middle of the parallel taxiway. The previous ALP identified this as a non-standard condition to remain in place. The hold lines on the south side of Runway 7L-25R are 250 feet from the runway, thus meeting standard.

The hold lines for Runway 7R-25L are 125 feet from the runway centerline, which meets design standard.

Non-Standard Conditions Summary

Livermore Municipal Airport has grown from a more rural recreational airport to a thriving transportation hub and regional economic engine. At the same time, FAA design standards have evolved. As a result, there are several existing conditions at the airport that do not meet current design standards. In some cases it is not practicable to meet the design standards. If the FAA directed the airport to undertake various improvements in order to meet design standards in the future (and funded them), then more detailed planning analysis should be undertaken including an update to the airport layout plan. **Table 2E** summarizes the current non-standard conditions.

TABLE 2E
Non-Standard Conditions
Livermore Municipal Airport

Design Criteria	Location	Design Standard	Existing Condition	Disposition
Parallel Runway Separation	Rwys 7L/R-25L/R	700' separation	500' separation	Maintain current separation. ATCT provides aircraft sequencing.
Parallel Taxiway to Runway Separation	Twy A and Rwy 7L-25R	300' separation	250' separation	Maintain current separation. Not practicable to relocate taxiway.
Hold Lines	North of Rwy 7L-25R	250' from Rwy centerline	175' separation	Maintain current location. Impracticable to relocate hold lines.
RSA	West of Rwy 7L-25R	600' beyond Rwy end	540' beyond Rwy end	FAA to relocate localizer.
ROFA	West of Rwy 7L-25R	600' beyond Rwy end	540' beyond Rwy end	FAA to relocate localizer.
ROFA	Northwest of Rwy 7L-25R	800' wide	350' to perimeter fence	Maintain current condition. Obtain modification to standard.
ROFA	Southeast of Rwy 25R	600' beyond Rwy end	500' to perimeter fence	Maintain current condition. Obtain modification to standard.
RPZ Compatible Land Use	All RPZs	Maintain clear of incompatibilities	Roads, hangars, taxiways, commercial buildings	Maintain current condition. No new incompatibilities.

RUNWAYS

The adequacy of the existing runway system at Livermore Municipal Airport has been analyzed from a number of perspectives, including runway orientation and adherence to safety area standards. From this information, requirements for runway improvements were determined for the airport. Runway elements such as length, width, and strength are now presented.

Runway Length

The determination of runway length requirements for the airport is based on five primary factors:

- Mean maximum temperature of the hottest month
- Airport elevation
- Runway gradient
- Critical aircraft type expected to use the runway
- Stage length of the longest nonstop destination (specific to larger aircraft)

The mean maximum daily temperature of the hottest month for Livermore Municipal Airport is 89.1 degrees Fahrenheit (F), which occurs in July. The airport elevation is 400 feet above mean sea level (MSL). The runway elevation difference is 27 feet for Runway 7L-25R and 16 feet for Runway 7R-25L. Both runways meet gradient requirements. The RDC for Runway 7L-25R is B-II-3, and for Runway 7R-25L the RDC is B-I-1 (small aircraft). Aircraft stage length can vary, but in general, aircraft operating to and from the airport will have a regional destination. Therefore, a maximum stage length considered for runway length analysis is 1,000 miles.

Advisory Circular 150/5325-4B, *Runway Length Requirements for Airport Design*, provides guidance for determining runway length needs. Airplanes operate on a wide variety of available runway lengths. Many factors will govern the suitability of those runway lengths for aircraft such as elevation, temperature, wind, aircraft weight, wing flap settings, runway condition (wet or dry), runway gradient, vicinity airspace obstructions, and any special operating procedures. Airport operators can pursue policies that can maximize the suitability of the runway length. Policies such as area zoning and height and hazard restricting can protect an airport's runway length. Airport ownership (fee simple or easement) of land leading to the runway ends can reduce the possibility of natural growth or man-made obstructions. Planning of runways should include an evaluation of aircraft types expected to use the airport, or a particular runway now and in the future. Future plans should be realistic and supported by the FAA approved forecasts and should be based on the critical design aircraft (or family of aircraft).

The first step in evaluating runway length is to determine general runway length requirements for the majority of aircraft operating at the airport. The majority of operations at Livermore Municipal Airport are conducted using smaller single and multi-engine piston powered aircraft weighing less than 12,500 pounds. Following guidance from AC 150/5325-4B, to accommodate 95 percent of small aircraft with less than 10 passenger seats, a runway length of 3,200 feet is recommended. To accommodate 100 percent of these small aircraft, a runway length of 3,800 feet is recommended. Small aircraft with 10 or more passenger seats require a runway length of 4,200 feet.

Runway length requirements for business jets weighing less than 60,000 pounds have also been calculated. These calculations take into consideration the runway gradient and landing length requirements for contaminated runways (wet). Business jets tend to need greater runway length when landing on a wet surface because of their increased approach speeds. AC 150/5325-4B stipulates that runway length determination for business jets consider a grouping of airplanes with similar operating characteristics. The AC provides two separate "family groupings of airplanes" each based upon their representative percentage of aircraft in the national fleet. The first grouping is those business jets that make up 75 percent of the national fleet, and the second group is those making up 100 percent of the national fleet. **Table 2F** presents a partial list of common aircraft in each aircraft grouping. A third group considers business jets weighing more than 60,000 pounds. Runway length determination for these aircraft must be based on the performance characteristics of the individual aircraft.

TABLE 2F
Business Jet Categories for Runway Length Determination

75 percent of the national fleet	MTOW	75-100 percent of the national fleet	MTOW	Greater than 60,000 pounds	MTOW
Lear 35	20,350	Lear 55	21,500	Gulfstream II	65,500
Lear 45	20,500	Lear 60	23,500	Gulfstream IV	73,200
Cessna 550	14,100	Hawker 800XP	28,000	Gulfstream V	90,500
Cessna 560XL	20,000	Hawker 1000	31,000	Global Express	98,000
Cessna 650 (VII)	22,000	Cessna 650 (III/IV)	22,000		
IAI Westwind	23,500	Cessna 750 (X)	36,100		
Beechjet 400	15,800	Challenger 604	47,600		
Falcon 50	18,500	IAI Astra	23,500		

MTOW: Maximum Take Off Weight
Source: FAA AC 150/5325-4B, Runway Length Requirements for Airport Design

Table 2G presents the results of the runway length analysis for business jets developed following the guidance provided in AC 150/5325-4B. To accommodate 75 percent of the business jet fleet at 60 percent useful load, a runway length of 5,500 feet is recommended. This length is derived from a raw length of 4,707 feet that is adjusted, as recommended, for runway gradient and consideration of landing length needs on a contaminated runway (wet and slippery). Dry runways would require approximately 5,000 feet, while 5,400 feet is needed to accommodate business jets landing in wet conditions. To accommodate 100 percent of the business jet fleet at 60 percent useful load, a runway length of 5,700 feet is recommended.

TABLE 2G
Runway Length Requirements
Livermore Municipal Airport

Airport Elevation	400 feet above mean sea level
Average High Monthly Temp.	89.1 degrees (July)
Runway Gradient (0.5%)	27' Runway 7L-25R

Fleet Mix Category	Raw Runway Length from FAA AC	Runway Length With Gradient Adjustment (+50')	Wet Surface Landing Length for Jets (+15%)*	Recommended Runway Length
75% of fleet at 60% useful load	4,707'	4,977'	5,413'	5,400'
100% of fleet at 60% useful load	5,456'	5,726'	5,500'	5,700'
75% of fleet at 90% useful load	6,644'	6,914'	7,000'	7,000'
100% of fleet at 90% useful load	8,378'	8,648'	7,000'	8,700'

*Max 5,500' for 60% useful load and max 7,000' for 90% useful load in wet conditions
Source: FAA AC 150/5325-4B, Runway Length Requirements for Airport Design.

Utilization of the 90 percent category for runway length determination is generally not considered by the FAA unless there is a demonstrated need at the airport. This could be documented activity by a cargo carrier or by a business jet operator that flies out frequently with heavy loads. To accommodate 75 percent of the business jet fleet at 90 percent useful load, a runway length of 7,000 feet is recommended. To accommodate 100 percent of business jets at 90 percent useful load, a runway length of 8,700 feet is recommended.

Runway 7L-25R Length

Runway 7L-25R is the primary runway and it is 5,253 feet long. To fully accommodate at least 75 percent of the business jet fleet at 60 percent useful load, a runway length of 5,400 should be provided. To accommodate the next category of business jets, 75 percent at 90 percent useful load, a runway length of 5,700 feet would be recommended.

The current length of the primary runway can and does accommodate all general aviation aircraft, including the largest business jets in the national fleet. At times, particularly on very hot days, some of the larger aircraft may be impacted by the current runway length. The impact to operators will typically include taking on a lighter load (less fuel, passengers or cargo), or making an intermediate stop for additional fuel. While it is recognized that the current runway length is somewhat less than optimal, the close proximity of Isabel Avenue to the east and the golf course to the west make additional runway length highly impractical.

Runway 7R-25L Length

Runway 7R-25L is the parallel training runway and is 2,699 feet long. The runway is intended to accommodate small aircraft exclusively. The current pavement strength is 12,500 pounds for single wheel landing gear struts. To accommodate all small aircraft including those with 10 or more passenger seats, a runway length of 4,200 feet is recommended. To accommodate all small aircraft with nine or fewer passenger seats, a runway length of 3,800 feet is recommended. The design aircraft on the current ALP (and the planned future design aircraft) is the Beech C99 Airliner, which is a small twin engine aircraft with greater than 10 passenger seats.

To fully meet the FAA recommended runway length for the parallel Runway 7R-25L, a length of 4,200 feet would be recommended. Various extension options have been considered. The first considered adding the extension on the west end of the runway. The new landing threshold would be located 248 feet to the west of the landing threshold to primary Runway 7L. To access the new threshold, a short, 248-foot parallel taxiway would have to be located between the runways. Such a partial parallel taxiway would not meet runway/taxiway separation requirements. A parallel taxiway should be at least 300 feet from the primary runway and 240 feet from the parallel runway. In addition, this layout would create a potentially confusing jog in the taxiway.

Another option considered splits the extension between both ends. In this option, 1,253 feet would be added to the west end of the runway and 248 feet would be added to the east. The extension to the east may be problematic, however. The RPZ would shift to the east, which would place Taxiway B within the RPZ. Design standards for the RPZ may not permit the introduction of new incompatibilities (subject to FAA review). However, on the west end of the runway, both runway thresholds would be parallel, which would permit a threshold taxiway that connects between the Runway 7L and Runway 7R threshold. This is a much more familiar layout for pilots.

For purposes of this planning effort, no extension will be considered on the Runway 25L end. An extension of 1,253 feet will be considered on the Runway7R end, which will line up the runway thresholds. A total runway length of 3,952 feet is recommended for parallel Runway 7R-25L.

There are numerous potential benefits for the airport and community to planning for a runway length of 3,952 feet for Runway 7R-25L. The primary community benefit is economic. By having a parallel runway length that meets the FAA recommendation for most small aircraft, the runway can serve a greater variety of aircraft. This becomes particularly important for those times when the main runway may be closed, typically for maintenance or a disabled aircraft. At 3,952 feet in length, most turboprop aircraft such as the Beech King Air or Pilatus, as well as a portion of the small business jet fleet, could also use the runway. These types of aircraft are highly utilized for business activity. By making the parallel runway available for a greater variety of aircraft, business activity can continue uninterrupted to the benefit of the community.

Planning the parallel runway to the recommended length for the current design aircraft would provide a back-up capability that would benefit the community beyond economic growth. Many air ambulance operators could then utilize the parallel runway. Fixed wing law enforcement operations could continue. The list of benefits includes just about all the benefits that aviation brings. The only group of aviation activity that could not operate to a parallel runway that is 3,952 feet long would be medium and large business jets.

There is a safety benefit that can be achieved if the parallel runway were a more optimal length. Most of the aviation-related businesses are located on the south side of the airfield closest to the parallel runway. Those aircraft that are currently unable to use the parallel runway due to length limitations must utilize the primary runway. From the primary runway, they have a long taxi using the end-around taxiways or they must cross the parallel runway. The FAA's Runway Safety Area Program indicates that movements across an active runway should be reduced or eliminated through design when possible. Since additional length of the parallel runway would permit a wider variety of aircraft to use it, the need for runway crossings to access south side businesses and hangars would be reduced. The same would hold true for aircraft based on the south side that must currently use the primary runway.

The efficiency of aircraft ground and air movements would also be greatly enhanced. Tower personnel indicated that a longer parallel runway would provide them with more options for routing aircraft, particularly for arrival or departure.

As a busy general aviation facility, capacity of the airfield may be a concern. The forecasts of aviation demand indicate that by 2030, the airport could experience up to 220,000 annual operations. A longer parallel runway would have the added benefit of enhancing airfield capacity by increasing the efficiency of aircraft movements, both on the ground and in the air. For ground movements, aircraft can be instructed to land or takeoff on the closest runway, thus reducing the time on the ground. In the air, aircraft may not have to hold in the traffic pattern as long while waiting for the main runway to clear. Currently, the tower may have to extend the traffic pattern in order to properly sequence arriving aircraft. This leads to more overflights of the community and additional emissions released into the air. Instead, aircraft can potentially land sooner, to the parallel runway, thus reducing time in the air.

A reduction in taxi times would present additional benefits. Shorter taxi times result in a reduction of emissions by aircraft engine, which means cleaner air for the community. Shorter taxi times would also benefit aircraft operators in that they would not burn as much fuel while on the ground. Less fuel burn means lower operational costs and greater range.

Naturally, local citizens may have concerns about the impact that additional runway length may present to them. Typically the impact of an airport on people is related to noise. A longer parallel runway is only intended to more efficiently accommodate existing users of the airport. It would not, in and of itself, attract additional operations. As a result, the current noise contours for the airport are not likely to change to any significant degree. In fact, significant advancements have been made by aircraft and engine manufacturers to reduce noise generated by aircraft. As a result, many airports are seeing their noise contours shrink even while total operations are increasing.

It should be noted that the Livermore City Council passed Resolution No. 2010-058 on March 23, 2010. The resolution established various operational and development policies. Item number four states, "The City does not intend to extend the existing runways." Should the City Council, in the future, choose to pursue the recommendation to extend parallel Runway 7R-25L to a length of 3,952 feet, they will need to address the status of resolution No. 2010-058. **Appendix B** is a copy of the resolution.

In conclusion, it is recommended that the ALP show a future condition where Runway 7R-25L is planned to 3,952 feet in length. The additional length will be planned for the west end because the design standards, including RPZ land use compatibility, can be met on the west end only. At 3,952 feet in length, the runway would fully accommodate all small aircraft with nine or fewer passenger seats. A portion of those small aircraft with 10 or more passenger seats may be slightly weight restricted. There are so few of these types of aircraft in the national fleet, the operational impact of not fully achieving 4,200 feet is likely to be minimal.

The recommended extension to the west will increase safety and efficiency by reducing runway crossings and taxi times. It will provide a backup capability for those times when the primary runway is closed (e.g., maintenance, accident). While not all aircraft that utilize the primary runway will be capable of using the parallel, a meaningful portion will, including turboprops and some small business jets. The overall utility of the airfield will be improved with an extension of the parallel runway.

Runway Width

The runway width standard is a function of the runway design code (RDC). The current and future RDC for Runway 7L-25R is B-II-2400. The current runway width of 100 feet meets the design standard and should be maintained.

Runway 7R-25L is 75 feet wide and has a current and future RDC of B-I-1 (small aircraft). The minimum runway width design standard is 60 feet. The existing width provides an added safety margin for this busy airport and should be maintained.

Runway Strength

An important feature of airfield pavement is its ability to withstand repeated use by aircraft. The FAA Airport/Facility Directory places the pavement strength for Runway 7L-25R at 45,000 pounds single wheel loading (S) and 60,000 pounds dual wheel loading (D). This pavement strength is adequate for the type of aircraft frequently operating at the airport and should be maintained.
The strength rating for Runway 7R-25L is 12,500 pounds (S). This runway is planned to accommodate small aircraft now and into the future; therefore, this strength rating should be maintained. The strength ratings of a runway do not preclude operations by aircraft that weigh more; however, frequent activity by heavier aircraft can shorten the useful life of that pavement.

TAXIWAYS

The design standards associated with taxiways are determined by the taxiway design group (TDG) or the airplane design group (ADG) of the critical design aircraft. As determined previously, ADG-I applies to parallel Runway 7R-25L and ADG-II applies to Runway 7L-25R. **Table 2H** presents the various taxiway design standards for the airport.

TABLE 2H
Taxiway Dimensions and Standards
Livermore Municipal Airport

STANDARDS BASED ON WINGSPAN	ADG I		ADG II
Taxiway Protection			
Taxiway Safety Area (TSA) width	49'		79'
Taxiway Object Free Area (TOFA) width	89'		131'
Taxilane Object Free Area width	79'		115'
Taxiway Separation			
Taxiway Centerline to:			
Fixed or Movable Object	44.5'		65.5'
Parallel Taxiway/Taxilane	69'		105'
Taxilane Centerline to:			
Fixed or Movable Object	39.5'		57.5'
Parallel Taxilane	64'		97'
Taxiway Centerline to*:			
Runway 7L-25R Centerline	NA		300'
Runway 7R-25L Centerline	150'		NA
Wingtip Clearance			
Taxiway Wingtip Clearance	20'		26'
Taxilane Wingtip Clearance	15'		18'
STANDARDS BASED ON TDG	**TDG 1**	**TDG 2**	**TDG 3**
Taxiway Width Standard	25'	35'	50'
Taxiway Edge Safety Margin	5'	7.5'	10'
Taxiway Shoulder Width	10'	10'	20'

*Based on RDC for each runway
ADG: Airplane Design Group
TDG: Taxiway Design Group
Source: FAA AC 150/5300-13A, Airport Design

The table also shows those taxiway design standards related to TDG. The TDG standards are based on the Main Gear Width (MGW) and the Cockpit to Main

Gear (CMG) distance of the critical design aircraft expected to use those taxiways. Different taxiways/taxilane pavements can and should be designed to the most appropriate TDG design standards.

The TDG for Runway 7L-25R is 3, which means that the taxiways associated exclusively with this runway should be 50 feet wide. The taxiway standards for Runway 7R-25L is 1, which means taxiways exclusively associated with this runway should be at least 25 feet wide.

Table 2J presents the existing taxiway dimensions and separation distances at the airport. The current taxiway widths generally accommodate those aircraft types likely to use them. Taxiway L, which is parallel to Runway 7R-25L, is 35 feet wide, which exceeds the design standard of 25 feet. Since this taxiway may on occasion be utilized by larger aircraft to access the Runway 7L threshold, it should be maintained at its current width to provide an additional safety margin. Taxiway B north of the Runway 25L threshold is 57 feet wide. This should be reduced to 50 feet at the time of next reconstruction.

TABLE 2J
Existing Taxiway Condition
Livermore Municipal Airport

Taxiway	Width
Taxiways A, C, D, E, F, J, K	50'
Taxiway B (north of Rwy 25R)	57'
Taxiway B (south of Rwy 25R)	50'
Taxiway G (north of Rwy 7L-25R)	50'
Taxiway G (south of Rwy 7L-25R)	35'
Taxiway H (north of Rwy 7L)	50'
Taxiway H (south of Rwy 7L)	35'
Taxiway L	35'
Existing Taxiway Separations	
Taxiway A to Runway 7L-25R	250'
Taxiway L to Runway 7R-25L	240'

Source: FAA AC 150/5300-13A, Airport Design

As discussed previously, Taxiway A is 250 feet from the runway, centerline to centerline. The design standard is 300 feet. Due to the impracticality of relocating the taxiway, it is planned to remain in its current location. A modification to standard may need to be issued and documented on the ALP.

Taxiway Design Considerations

FAA AC 150/5300-13A, *Airport Design*, provides guidance on recommended taxiway and taxilane layouts to enhance safety by avoiding runway incursions. A runway incursion is defined as "any occurrence at an airport involving the incorrect presence of an aircraft, vehicle, or person on the protected area of a surface designated for the landing and takeoff of aircraft." The taxiway system at Livermore Municipal Airport generally provides for the efficient movement of aircraft. The following is a list of the taxiway design guidelines and the basic rationale behind each recommendation:

1. **Taxi Method**: Taxiways are designed for "cockpit over centerline" taxiing with pavement being sufficiently wide to allow a certain amount of wander. On turns, sufficient pavement should be provided to maintain the edge safety margin from the landing gear. When constructing new taxiways, upgrading existing intersections should be undertaken to eliminate the need for pilot "judgmental over-steering," which is when the pilot must intentionally steer the cockpit outside the marked centerline in order to assure the aircraft remains on the taxiway pavement.
2. **Steering Angle**: Taxiways should be designed such that the nose gear steering angle is no more than 50 degrees, the generally accepted value to prevent excessive tire scrubbing.

3. **Three-Node Concept**: To maintain pilot situational awareness, taxiway intersections should provide a pilot a maximum of three choices of travel. Ideally, these are right and left angle turns and a continuation straight ahead.
4. **Intersection Angles**: Design turns to be 90 degrees wherever possible. For acute angle intersections, standard angles of 30, 45, 60, 120, 135, and 150 degrees are preferred.
5. **Runway Incursions**: Design taxiways to reduce the probability of runway incursions.
   - *Increase Pilot Situational Awareness*: A pilot who knows where he/she is on the airport is less likely to enter a runway improperly. Complexity leads to confusion. Keep taxiways systems simple using the "three node" concept.
   - *Avoid Wide Expanses of Pavement*: Wide pavements require placement of signs far from a pilot's eye. This is especially critical at runway entrance points. Where a wide expanse of pavement is necessary, avoid direct access to a runway.
   - *Limit Runway Crossings*: The taxiway layout can reduce the opportunity for human error. The benefits are twofold – through simple reduction in the number of occurrences, and through a reduction in air traffic controller workload.
   - *Avoid "High Energy" Intersections*: These are intersections in the middle third of runways. By limiting runway crossings to the first and last thirds of the runway, the portion of the runway where a pilot can least maneuver to avoid a collision is kept clear.
   - *Increase Visibility*: Right angle intersections, both between taxiways and runways, provide the best visibility. Acute angle runway exits provide for greater efficiency in runway usage, but should not be used as runway entrance or crossing points. A right angle turn at the end of a parallel taxiway is a clear indication of approaching a runway.
   - *Avoid "Dual Purpose" Pavements*: Runways used as taxiways and taxiways used as runways can lead to confusion. A runway should always be clearly identified as a runway and only a runway.
   - *Indirect Access*: Do not design taxiways to lead directly from an apron to a runway. Such configurations can lead to confusion when a pilot typically expects to encounter a parallel taxiway.
   - *Hot Spots*: Confusing intersections near runways are more likely to contribute to runway incursions. These intersections must be redesigned when the associated runway is subject to reconstruction or rehabilitation. Other hot spots should be corrected as soon as practicable.
6. **Runway/Taxiway Intersections**:
   - *Right Angle*: Right-angle intersections are the standard for all runway/taxiway intersections, except where there is a need for a high-speed exit. Right-angle taxiways provide the best visual perspective to a pilot approaching an intersection with the runway to observe aircraft in both the left and right directions. They also provide optimal orientation of the runway holding position signs so they are visible to pilots.
   - *Acute Angle*: Acute angles should not be larger than 45 degrees from the runway centerline. A 30-degree taxiway layout should be reserved for high speed exits. The use of multiple intersecting taxi-

ways with acute angles creates pilot confusion and improper positioning of taxiway signage.
- *Large Expanses of Pavement*: Taxiways must never coincide with the intersection of two runways. Taxiway configurations with multiple taxiway and runway intersections in a single area create large expanses of pavement, making it difficult to provide proper signage, marking, and lighting.

7. **Taxiway/Runway/Apron Incursion Prevention**: Apron locations that allow direct access into a runway should be avoided. Increase pilot situational awareness by designing taxiways in such a manner that forces pilots to consciously make turns. Taxiways originating from aprons and forming a straight line across runways at mid-span should be avoided.
   - *Wide Throat Taxiways*: Wide throat taxiway entrances should be avoided. Such large expanses of pavement may cause pilot confusion and makes lighting and marking more difficult.
   - *Direct Access from Apron to a Runway*: Avoid taxiway connectors that cross over a parallel taxiway and directly onto a runway. Consider a staggered taxiway layout that forces pilots to make a conscious decision to turn.
   - *Apron to Parallel Taxiway End*: Avoid direct connection from an apron to a parallel taxiway at the end of a runway.

FAA AC 150/5300-13A, Airport Design, states that "existing taxiway geometry should be improved whenever feasible, with emphasis on designated "hot spots." To the extent practicable, the removal of existing pavement may be necessary to correct confusing layouts.

The first areas to consider are FAA-identified hot spots, of which there are six at the airport. These were previously identified on Exhibit 1B. Hot Spots are usually identified because of previous runway incursions. The first solution to consider for mitigating a hot spot is the geometric design of the location. If the location already meets geometric design standard, then additional safety measures can be considered such as pavement marking, lighting or signage.

There is a wide variety of pavement markings that can be used to enhance pilot awareness when on the airfield. Potential markings may include surface painted holding position markings or runway hold position markings on taxiways. At Livermore Municipal Airport, all taxiways that connect to the runways have runway hold position markings on the taxiways. The addition of surface painted holding position markings may enhance pilot situational awareness.

Airfield signs can assist pilots as they travel on runway and taxiway pavements. These signs will typically include runway hold position signs, taxiway location signs, runway boundary signs, directional signs, and destination signs.

There are several airfield lighting solutions that can enhance pilot situational awareness while on the airfield. These include taxiway centerline lights, clearance bar lights, stop bar lights, and runway guard lights (commonly referred to as wig-wags).

Consideration should be given to a combination of markings and lighting to enhance pilot situational awareness, particularly at the hot spot locations. Marking of the runway designation on the taxiway pavement immediately before the hold bar and installation of runway guard lights (wig-wags) should be considered if the problem of runway incursion is acute.

Taxiway Geometric Solutions

There are several pavement geometries at the airport that are of concern. The following is a discussion of those areas and potential solutions.

1. A portion of Taxiway B north of the runway threshold is 57 feet wide and should be reduced to 50 feet with a fillet entrance to accommodate TDG 3.
2. The intersection of Taxiways A, B, and J constitute a wide expanse of pavement. In addition, there is an aircraft hold apron that extends into the POFZ, to the east of the lateral edge of the runway threshold. The extra taxiway pavement should be removed and the hold apron should be relocated. An alternative to relocating the hold apron is to have established Standard Operating Procedures (SOP) with the tower so that no aircraft are on the hold apron as an aircraft is approaching Runway 25R in instrument conditions.

3. Taxiway C, north of Runway 7L-25R extends from the north apron, across Taxiways J and A to the runway. Direct access from an apron to the runway should be avoided. The portion of Taxiway C between the apron and Taxiway A should be relocated to force pilots to make a turn before entering the runway environment.

4. Taxiway C south of Runway 25L presents a potentially confusing taxiway layout. This portion of Taxiway C provides direct access to the Runway 25L threshold from the last row of T-hangars. Currently, there is a hold line marked on the pavement to make pilots aware that they are approaching a taxiway. This may be adequate since it is locally based pilots who would presumably be aware of the approaching Taxiway L. The hold apron at the intersection contributes to a wide expanse of pavement; however, it is marked with a taxiway hold position marking which may be acceptable. If the location of this hold apron is not acceptable, then it would need to be marked, lighted, or painted as unusable or removed.

5. The hold apron on Taxiway B south of the Runway 25R threshold is situated in the POFZ. To maintain this apron, an SOP should be established with the tower in which they do not allow aircraft to use the hold apron if an aircraft is on final approach to Runway 25R in instrument conditions. Without the SOP, the hold apron should be marked as unusable.

6. Taxiway D and E provide direct access from the north terminal apron to Runway 7L-25R; however, the taxiway centerline as marked does not indicate direct access. This solution may be acceptable to the FAA. If simple centerline marking is not acceptable to prevent direct access from an apron to a runway, then two other solutions are available. The first is to relocate those portions of Taxiways D and E connecting from the apron to Taxiway A, thus forcing pilots to turn before entering the runway environment. The second is to construct islands of unusable pavement at the terminal apron which forces pilots to turn onto the taxiways from the apron rather than having direct access to the runway.

7. Taxiway J at the west end of the airfield has a 200-foot wide throat where

it intersects with Taxiway A. This should be reduced to 50 feet in width.

Taxiway geometry is receiving higher priority from the FAA. The FAA's goal is to reduce or prevent runway incursions. Technically, the above mentioned taxiways do not meet the current design standards; however, the most appropriate solution will need to be determined on a case-by-case basis. For example, taxiway centerline markings may be acceptable to preventing direct access from an apron to the runway. In other cases, the FAA may recommend construction of an island of unusable pavement or relocation of the taxiway.

Taxilane Design Considerations

Taxilanes are distinguished from taxiways in that they do not provide access to or from the runway system directly. Taxilanes typically provide access to hangar areas. As a result, taxilanes can be designed to varying design standards depending up on the type of aircraft utilizing the taxilane. For example, a taxilane leading to a T-hangar area only needs to be designed to accommodate those aircraft typically accessing a T-hangar. The taxilanes at Livermore Municipal Airport are appropriate for the type of aircraft to be served.

INSTRUMENT NAVIGATIONAL AIDS

The airport has a sophisticated ILS (CAT-I) instrument approach to Runway 25R. This approach provides for visibility minimums as low as ½-mile and cloud ceilings down to 200 feet. An LPV (Localizer Performance with Vertical Guidance) instrument approach is also available to Runway 25R with a visibility minimum of ¾-mile and cloud ceiling of 320 feet. This approach utilizes the constellation of GPS satellites to provide both vertical and horizontal guidance for approaching aircraft without the need for extensive ground based equipment. None of the other runway ends have instrument approaches and are to be utilized in visual conditions exclusively.

Recent advancements in the accuracy of GPS instrument approaches has led to the possibility of new or improved approach visibility minimums across the country at little or no expense to the airport. Any new instrument approaches considered for the airport should be GPS based. Currently, the FAA is considering an RNAV (GPS) instrument approach to Runway 7L. Future planning will consider this instrument approach to Runway 7L with visibility minimums not lower than ¾-mile.

Runway 7R-25L does not have an instrument approach. It is recommended that future planning consider 1-mile visibility non-precision instrument approaches to both ends of the runway. The RPZs for the runway would remain the same size and no new incompatibilities would be introduced.

VISUAL NAVIGATION AIDS

The airport beacon is located in the terminal area vehicle parking lot. When replacement of the beacon is considered, it should be relocated to the airside of the airport. A location adjacent to the administration building is considered.

As discussed in Chapter One – Inventory, Runway 25R has a four-box VASI on the left side of the runway. Many airports are upgrading their older VASIs with PAPIs. If the VASI serving Runway 25R needs replacement, then PAPIs should be installed. Runway 7L has a four-box PAPI on the right side of the runway. This unit should be maintained.

A basic approach glide path lighting system should be made available on both ends of parallel Runway 7R-25L once the runway is outfitted with runway edge lights. A basic system might be a PAPI-2L which provides the same indication of the appropriate glide path as the PAPI-4. If non-precision instrument approaches are made available to this runway, then the PAPIs become more important.

Runway end identification lights (REIL) are strobe lights set to either side of the runway. These lights are directed in the air and provide rapid identification of the runway threshold. REILs should be installed at runway ends not currently providing an approach lighting system but supporting instrument operations. A REIL system should be considered for the approach to Runway 7L.

The FAA recommends an approach lighting system for instrument approaches not lower that ¾-mile and requires one for lower visibility minimums. Runway 25R has a medium intensity approach lighting system with runway alignment indicator lights (MALSR). This system is required as part of the ILS approach and allows for the visibility minimums to be ½-mile. This system should be maintained.

WEATHER AND COMMMUNICATION AIDS

A lighted windsock is situated within a segmented circle in between the two runways. These should be maintained. A supplemental unlit windsock is located between Taxiways A and J at the west end of the airfield. This windsock is outside of the RSA but within the ROFZ. If required by the FAA, the windsock should be relocated outside of the ROFZ.

Livermore Municipal Airport is equipped with an Automated Surface Observing System (ASOS). This is an important system that automatically records weather conditions such as wind speed, wind gust, wind direction, temperature, dew point, altimeter setting, visibility, fog/haze condition, precipitation, and cloud height. This system should be maintained through the planning period.

The airport has an airport traffic control tower (ATCT) that is operated by the FAA. The tower should be maintained.

LANDSIDE REQUIREMENTS

Landside facilities are those necessary for the handling of aircraft and passengers while on the ground. These facilities provide the essential interface between the air and ground transportation modes. The capacity of the various components of each element was examined in relation to projected demand to identify future landside facility needs. This includes components for general aviation needs such as:

- Aircraft Hangars
- Aircraft Parking Aprons
- Administration building Services
- Auto Parking and Access
- Airport Support Facilities

HANGARS

Utilization of hangar space varies as a function of local climate, security, and owner preferences. The trend in general aviation, whether single or multi-engine aircraft, is toward more sophisticated aircraft (and consequently, more expensive aircraft); therefore, many aircraft owners prefer enclosed hangar space to outside tie-downs.

The demand for aircraft storage hangars is dependent upon the number and type of aircraft expected to be based at the airport in the future. However, hangar construction should be based upon actual demand trends and financial investment /conditions.

While a majority of aircraft owners prefer enclosed aircraft storage, a number of based aircraft owners may still tie-down outside (due to the lack of hangar availability, hangar rental rates, and/or operational needs). Therefore, enclosed hangar facilities do not necessarily need to be planned for each based aircraft. At Livermore Municipal Airport, it is estimated that 84 of the 495 based aircraft utilize tie-down space. In the long term, based aircraft are forecast to grow to 720, of which 122 may utilize tie-down space. Therefore, hangar storage space should be made available for 598 aircraft by the long term.

There are three general types of aircraft storage hangars: T-hangars, box hangars, and conventional hangars. T-hangars are similar in size and will typically house a single engine piston powered aircraft. Some multi-engine aircraft owners may elect to utilize these facilities as well. There are typically many T-hangar units "nested" within a single structure. There are 355 T-hangar units at the airport encompassing an estimated 339,200 square feet of floor space. For determining future aircraft storage needs, a planning standard of 1,200 square feet per based aircraft is utilized for T-hangars.

Box hangars are open-space facilities with no interfering supporting structure. Box hangars can vary in size and can either be attached to others or be standalone hangars. Typically, box hangars will house larger multi-engine, turboprop, or jet aircraft. At Livermore Municipal Airport, there are 36 box hangar spaces encompassing approximately 125,200 square feet of floor space. For future planning, a standard of 2,500 square feet per aircraft is utilized for box hangars.

Conventional hangars are the familiar large hangars with open floor plans that can store several aircraft. At Livermore Municipal Airport, conventional hangars are estimated to encompass 18,200 square feet of floor space and provide 9 aircraft storage positions. For future planning needs, 2,500 square feet per aircraft is utilized for conventional hangars.

Table 2K presents aircraft storage needs based on the long term demand forecasts. Assumptions have been made on owner preferences for a hangar type based on trends at general aviation airports. All turboprops, business jets, and helicopters are assumed to be stored in box or conventional hangars. T-hangars are assumed to house single engine piston aircraft and a small portion of multi-engine piston aircraft.

A portion of executive box and conventional hangars often are utilized primarily for maintenance activities or for office space. A planning standard of 15% of the structure footprint is considered for these purposes in addition to the aircraft storage needs. Nested T-hangar facilities typically have small storage units on the end as well.

It is estimated that there is 482,600 square feet of hangar storage space available currently. This includes 339,200 square feet for T-hangars, 125,200 square feet for box hangars, and 18,200 square feet from conventional hangars. Hangar calculations indicate that there is an immediate need for all hangar storage types. By the long term planning period, an additional 176,800 square feet of T-hangar space is forecast, 169,800 square feet for box hangars, and 107,800 square feet for conventional hangars. In total, it is forecast that the airport needs an additional 454,400 square feet of hangar space and an additional 36,600 feet dedicated for maintenance and office activities.

TABLE 2K
Hangar Needs
Livermore Municipal Airport

	Currently Supply	Long Term	Total Need Less Current Supply
Based Aircraft	495	720	
Aircraft to be Hangared	411	598	187
T-Hangar Positions	355	430	75
Box Hangar Positions	36	118	82
Conventional Hangar Positions	9	50	41
Hangar Area Requirements			
T-Hangar Area	339,200	516,000	176,800
Box Hangar Area	125,200	295,000	169,800
Conventional Hangar Area	18,200	126,000	107,800
Total Storage Area (s.f.)	482,600	937,000	454,400
Maintenance Area	26,600	63,200	36,600

Source: Coffman Associates analysis.

Hangar requirements are general in nature and are based on standard hangar size estimates. If a private developer desires to construct or lease a large hangar to house one plane, any extra space in that hangar may not be available for other aircraft. The actual hangar area needs will be dependent on the usage within each hangar.

It should be reiterated that the airport has a significant current demand for hangar storage space as evidenced by a wait list of over 150 aircraft owners.

AIRCRAFT PARKING APRON

The aircraft parking apron is an expanse of paved area intended for aircraft parking and circulation. Typically, a main apron is centrally located near the airside entry point, such as the administration building or FBO facility. Ideally, the main apron is large enough to accommodate transient airport users as well as a portion of locally based aircraft. Often, smaller aprons are available adjacent to FBO hangars and at other locations around the airport. The apron layout at Livermore Municipal Airport follows this typical pattern.

It is estimated that there are 71,500 square yards of apron utilized for local aircraft tie-down activity. These apron areas provide for approximately 250 aircraft tie-down positions. There is an additional 20,000 square yards of pavement utilized for transient activity. There are 37 transient positions for small aircraft and nine positions for larger business jets.

FAA Advisory Circular 150/5300-13A, *Airport Design*, suggests a methodology by which transient apron requirements can be determined from knowledge of busy-day operations. At Livermore Municipal

Airport, the number of itinerant spaces required is estimated at 13 percent of the busy-day itinerant operations (181 x 0.13 = 24). This results in a current need for 24 itinerant aircraft parking spaces. Of these, 19 (approximately 80 percent) should be for small aircraft and five should be for turboprops and business jets. By the long term planning period, 39 spaces are estimated to be needed, with 31 identified for small aircraft and eight for larger planes.

A planning criterion of 800 square yards per aircraft was applied to determine future transient apron area requirements for single and multi-engine aircraft. For turboprops and business jets (which can be much larger), a planning criterion of 1,600 square yards per aircraft position was used. The current need for transient apron area is 22,600 square yards. By the long term planning period, approximately 37,500 square yards is estimated.

An aircraft parking apron should provide space for the number of locally based aircraft that are not stored in hangars, transient aircraft, and for maintenance activity. For local tie-down needs, an additional ten spaces are identified for maintenance activity. Maintenance activity would include the movement of aircraft into and out of hangar facilities and temporary storage of aircraft on the ramp. Calculations indicated that local aircraft tie-down positions are adequate through the long term planning period. Total apron parking requirements are presented in **Table 2L**.

TABLE 2L
Aircraft Apron Requirements
Livermore Municipal Airport

	Currently Available (2012)	Calculated Need (2012)	Long Term Forecast
Local Apron Positions	250	115	132
Local Apron Area (s.y.)	71,500	40,400	46,300
Transient Apron Positions	46	24	39
Piston Transient Positions	37	19	31
Turbine Transient Positions	9	5	8
Transient Apron Area (s.y.)	20,000	22,600	37,500
Total Apron Area (s.y)	91,500	63,000	83,800

Source: Coffman Associates analysis

The current transient apron area is estimated to provide an adequate number of spaces, but is slightly undersized. If feasible, a larger transient apron should be made available and parking space separation increased. The apron area dedicated for local tie-downs is larger than recommended. As demand dictates, portions of the local apron can be converted to transient needs.

AIRPORT ADMINISTRATION BUILDING

General aviation administration facilities have several functions. Space is necessary for a pilots' lounge, flight planning, concessions, management, and storage. More advanced airports will have leasable space in the administration building for such features as a restaurant, FBO line services, and other needs. This space is not necessarily limited to a single, separate administration building, but can include space offered by FBOs in their hangars/offices for these functions and services.

The methodology used in estimating general aviation administration facility needs is based on the number of airport users expected to utilize general aviation facilities during the design hour. General aviation space requirements were then calculated based upon providing 120 square feet per design hour itinerant passenger. Design hour itinerant passengers are determined by multiplying design hour itinerant operations by the estimated number of passengers on the aircraft (multiplier). An increasing passenger count (from 1.9 to 2.3) is used to account for the likely increase in the number of passengers utilizing general aviation services. **Table 2M** outlines the general aviation administration facility space requirements for Livermore Municipal Airport.

TABLE 2M
Administration Building Facilities
Livermore Municipal Airport

	Existing	Long Term
Design Hour Operations	66	110
Design Hour Itinerant Operations	27	45
Multiplier	2	2
Total Design Hour Itinerant Passengers	51	104
Administration Building Space (s.f.)	2,600	12,500

Note: Additional space may be needed for amenities such as restaurant, conference room, and leasable space.
Source: Coffman Associates analysis

The existing administration building at Livermore Municipal Airport encompasses approximately 2,600 square feet of floor space. It is estimated that a building of approximately 6,200 square feet would more adequately meet the current needs of the airport. By the long term, an administration building of 12,500 square feet is recommended.

The airport administration building is the entrance to the community for most air passengers utilizing the airport. It should be assumed that these passengers include decision-makers who may be considering investment in the community. Therefore, it is recommended that the airport sponsor be cognizant of the appearance of the airport and the administration building in particular. Some communities will provide a separate general aviation administration building which may include additional amenities such as a restaurant or community conference room.

The City of Livermore is in the process of planning for a new administration building to be located to the immediate east of the existing facility. The planned facility would meet the needs of the airport now and into the future.

SUPPORT REQUIREMENTS

Various facilities that do not logically fall within classifications of airside or landside facilities have also been identified. These other areas provide certain functions related to the overall operation of the airport.

AUTOMOBILE PARKING

Planning for adequate automobile parking is a necessary element for any airport. Parking needs can effectively be segmented between transient airport users, locally based users, and airport business needs. Transient users include those employed at the airport and visitors, while local users are those with an aircraft based at the airport. A planning standard of 1.9 times the design hour passenger count provides the minimum number of vehicle spaces needed for transient users. Locally based parking spaces are calculated as one-half the number of based aircraft.

A planning standard of 315 square feet per space is utilized to determine total vehicle parking area necessary, which includes area needed for circulation and handicap clearances. Parking requirements for the airport are summarized in **Table 2N**.

TABLE 2N
GA Vehicle Parking Requirements
Livermore Municipal Airport

	Existing (Estimate)	Long Term
Design Hour Itinerant Passengers	51	104
VEHICLE PARKING SPACES		
GA Itinerant Spaces	200	197
GA Based Spaces	44	360
Total Parking Spaces	244	557
VEHICLE PARKING AREA		
GA Itinerant Parking Area (s.f.)	64,000	62,000
GA Based Parking Area (s.f.)	45,000	113,000
Total Parking Area (s.f.)	109,000	175,000

Source: Coffman Associates analysis

There appears to be enough designated vehicle parking through the long term planning period for itinerant airport users. Parking should be made available in close proximity to the administration building and airport businesses. Adequate parking should be planned to accommodate the new administration building and to account for the spaces lost due to the installation of the solar array in the current administration building parking lot.

Currently, most aircraft owners will drive to their hangar and park their cars in the hangar when utilizing their aircraft. In an effort to limit the level of vehicle traffic on the aircraft movement areas, many general aviation airports are providing separate parking in support of facilities with multiple aircraft parking positions, such as T-hangars. Planning for future hangars should consider segregating vehicle parking from the aircraft movement surfaces.

AIRPORT ACCESS ROADS

The Livermore Municipal Airport has excellent access to Interstate 580 from Airway Boulevard. Terminal Circle and Clubhouse Drive provide a loop road system to the administration building. Terminal Circle may need to be extended to accommodate future development to the east of the existing administration building.

Access to the south side of the airport is available via West Jack London Blvd., which was recently extended on the south side of the airport to the west and connects with El Charro Road. This road provides a means to traverse on all sides of the airport.

AIRCRAFT RESCUE AND FIRE FIGHTING (ARFF) FACILITIES

Livermore Municipal Airport is not a Part 139 (under Title 14 Code of Federal Regulations), airport and, therefore, is not required to have on-site firefighting capabilities. Livermore-Pleasanton Fire Department temporary station No. 10 is located on the north side of the airfield. This is a great benefit to the airport as quick response times are possible.

FUEL STORAGE

The airport maintains an underground fuel farm on the north edge of the main apron. There are three tanks, each with a 15,000 gallon capacity. Two of the tanks are reserved for 100LL (AvGas) and one is for Jet A fuel. The airport leases four fuel delivery trucks. Two of the trucks are for AvGas and have capacities of 2,000 gallons and 1,200 gallons. Two of the trucks are for Jet A fuel and have capacities of 3,000 gallons each. The airport maintains a self-serve fuel island immediately in front of the administration building. There are two fuel pumps for AvGAS.

Additional fuel storage capacity should be planned when the airport is unable to maintain an adequate supply and reserve. While each airport (or FBO) determines their own desired reserve, a 14-day reserve is common for general aviation airports. When additional capacity is needed, it should be planned in 10,000 to 12,000 gallon increments to accommodate fuel tanker trucks which commonly have an 8,000-gallon capacity.

Underground fuel farms are more difficult to monitor for leaks or other deterioration. Where feasible, older underground fuel storage should be replaced with above-ground facilities which are easier to monitor.

A summary of airside and landside needs is presented on **Exhibit 2D**.

RECOMMENDED CONCEPT

The recommended airport layout plan concept preserves the current nature of the airport by maintaining the focus on supporting small single and multi-engine piston-powered aircraft. The airport will continue to experience activity by business jets as well. The recommended airport layout plan concept, as shown on **Exhibit 2E**, presents the ultimate configuration for the airport that preserves the role of the airport while meeting FAA design standards to the greatest degree feasible. A phased program to implement the recommended development concept will be presented in Chapter Three - Capital Improvement Program. The following will describe the recommended concept and the rationale behind it.

AIRSIDE CONCEPT

The airside plan generally considers those improvements related to the runway and taxiway system. Primary Runway 7L-25R is planned to stay the same. The length is recommended to remain at 5,253 feet and

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AIRSIDE REQUIREMENTS

	CURRENT	FUTURE
RUNWAYS		
	Primary Runway 7L-25R	**Primary Runway 7L-25R**
Design Aircraft	B-II-3	Same
Runway Design Code	B-II-2400	Same
Runway Reference Code	B-II-4000/B-I-2400	Same
Dimensions	5,253' x 100'	Same
Pavemente Strength	45,000 (S), 60,000 (D)	Same
Runway Safety Area (RSA)	Localizer in RSA	FAA to relocate/remove localizer
Runway Object Free Area (ROFA)	Numerous penetrations	Modification to Standard or maintain non-standard condition
Runway Obstacle Free Zone (ROFZ)	Holdline in OFZ	Relocate hold lines or maintain non-standard condition
Runway Precision Obstacle Free Zone (POFZ)	Hold apron, taxiway, and service road penetrate	Clear POFZ or institute SOP with ATCT
Runway Protection Zone (RPZ)	Numerous incompatibilities	Clear if feasible
Runway Markings	Precision	Same
Runway Lighting	MIRL	Same
Hold Lines	175' from centerline	Move to 200' (outside OFZ) if feasible
	Parallel Runway 7R-25L	**Parallel Runway 7R-25L**
Design Aircraft	B-I-1 (small)	Same
Runway Design Code	B-I-VIS (small)	B-I-5000
Runway Reference Code	B-II-4000	Same
Dimensions	2,699' x 75'	3,952' x 75'
Pavement Strength	12,500 (S)	Same
Runway Safety Area (RSA)	Meets standard	Same
Runway Object Free Area (ROFA)	Meets Standard	Same
Runway Obstacle Free Zone (ROFZ)	Meets standard	Same
Runway Protection Zone (RPZ)	Numerous incompatibilities	Clear if feasible
Runway Markings	Basic	Non-precision
Runway Lighting	NA	MIRL
Runway Separation	Runway are 500' apart	Same (No duel approaches)
TAXIWAYS		
Taxiway Design Group	3/2 (Twy L)	Same
Marking	Centerlines	Same
Width	Narrow Twy B to 50'. Maintain all others.	Same
Lighting	MITL	Same
Hot Spot and layout deficiencies	Correct Hot Spots and redesign layout where feasible	Same
Separation Standard	Taxiway A is 250' from Rwy centerline	Maintain non-standard condition
NAVIGATIONAL AND WEATHER AIDS		
	ASOS, Two windsocks, beacon, ATCT, ATIS	Same
	Primary Runway 7L-25R	**Primary Runway 7L-25R**
Instrument Approach	CAT-I ILS and ¾-Mile LPV (25R)	Same (25R)/ ¾-Mile (7L)
Approach Lighting System	MALSR (25R)	Same
Approach Slope Lighting	VASI-4L (25R)	Upgrade to PAPI 4L (25R)
	PAPI-4R (7L)	Same
Runway End Identification Lighting	None	Consider REIL (7L)
	Parallel Runway 7R-25L	**Parallel Runway 7R-25L**
Instrument Approach	Visual	1-Mile
Approach Slope Lighting	None	Consider PAPI-2L

LANDSIDE REQUIREMENTS

	BASE YEAR (2012)	SHORT TERM	INTERMEDIATE TERM	LONG TERM
Based Aircraft	495	620	650	720
AIRCRAFT TO BE HANGARED				
Single Engine	375	459	469	498
Multi-Engine	30	43	53	73
Jet	4	9	13	20
Helicopter	2	4	5	7
Total to be Hangared	411	515	540	598
HANGAR POSITIONS				
T-Hangars Positions	355	394	404	430
Box Hangar Positions	36	85	96	118
Conventional Hangar Positions	9	35	40	50
HANGAR AREA				
T-Hangars (s.f.)	339,200	473,000	484,000	516,000
Executive Box Hangar (s.f.)	125,200	213,000	240,000	295,000
Conventional Hangar (s.f.)	18,200	88,000	100,000	126,000
Maintenance Area (s.f.)	32,200	45,200	51,000	63,200
AIRCRAFT PARKING				
Local Apron Positions	250	115	121	132
Local Apron Area (s.y.)	71,500	40,400	42,200	46,300
Transient Apron Positions	46	33	35	39
Piston Transient Positions	37	27	28	31
Turbine Transient Positions	9	7	7	8
Transient Apron Area (s.y.)	20,000	32,100	33,800	37,500
Total Apron Area (s.y)	91,500	72,500	76,000	83,800
AUTO PARKING				
Total Spaces	244	457	487	557
Total Area (s.f.)	109,000	144,000	153,000	175,000
ADMINISTRATION BUILDING				
Area (s.f.)	2,600	9,300	10,200	12,500

ABBREVIATION KEY

SOP - Standard Operating Procedures

NP1 - Non-precision instrument approach with 1 to 3-mile visibility minimums

PAPI - Precision Approach Path Indicator

LPV - GPS with Localizer Performance and Vertical Guidance

MIRL - Medium Intensity Runway Lighting

MITL - Medium Intensity Taxiway Lighting

ASOS - Automated Surface Observation System

MALSR - Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights

##-S/D/DT - Runway Strength Rating in Thousands of Pounds for Single (S), Dual (D) Wheel Struts

ATCT - Air Traffic control Tower

ATIS - Automatic Traffic Information Service

Exhibit 2D
AIRPORT REQUIREMENTS

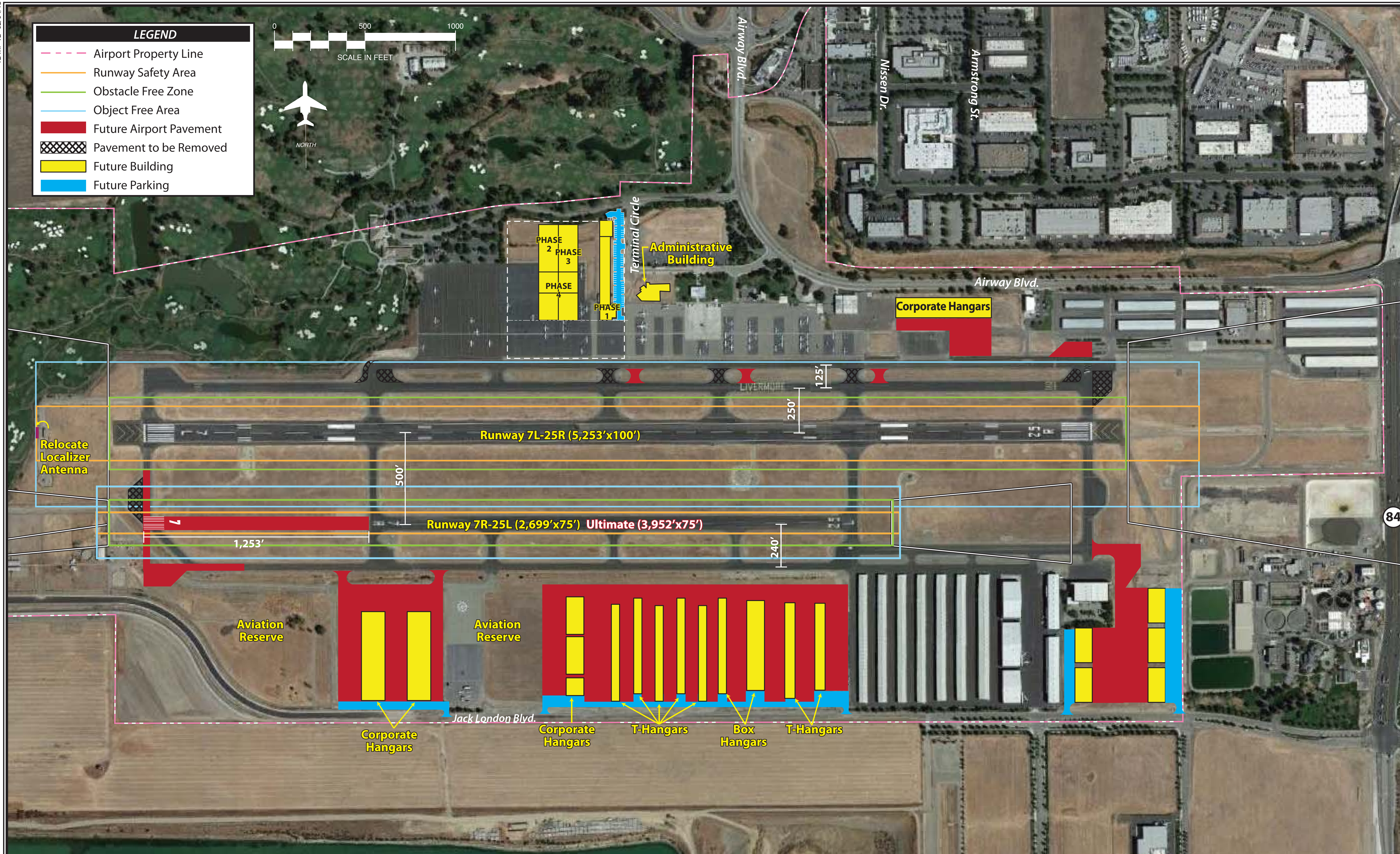

Exhibit 2E
RECOMMENDED CONCEPT

the width at 100 feet. The design aircraft is planned to remain B-II-3, which is represented by a combination of the Falcon 900B and Cessna Citation X (750) business jets. The runway design code (RDC) will remain B-II-2400 and the runway reference code (RRC) will remain at B-I-2400/B-II-4000. Under ideal conditions, the RDC and the RRC would be the same; however, the existing runway system predates the FAA design standards.

Analysis was presented that indicated that the airport exceeds the 500 annual operations threshold for a design aircraft in C-II-3, which would be represented by medium and large business jets. It is impracticable to fully meet design standards associated with C-II-3. Parallel Taxiway A would need to be relocated to a distance of 400 feet from the runway and the RSAs would change from 600 feet beyond the runway ends to 1,000. Adjacent properties, including the golf course, would be negatively impacted.

As a result, Livermore Municipal Airport is one of many general aviation airports that cannot reasonably be designed to fully accommodate a change to a more restrictive design aircraft (B-II-3 to C-II-3). As a result, planning for Runway 7L-25R is intended to meet design standards for a B-II-3 design aircraft to the greatest extent practicable.

Parallel Runway 7R-25L is recommended to remain the same as well in all aspects except runway length and the availability of instrument approaches. The current design aircraft for the runway is B-I-1 (small) which is represented by the Beech C99 Airliner. The RDC and RRC are currently B-I-VIS. In the future, this runway is planned to have edge lighting installed, making the runway available for nighttime operations. The approach slope and RPZ are the design standards typically impacted by the availability of instrument approaches. For this runway, these elements are the same for non-precision instrument approaches of not less than 1-mile and for visual conditions. As a result, the parallel runway is planned to have non-precision instrument approaches to both runway ends (provided there are no hazardous obstacles).

At 2,699 feet in length, the parallel runway does not meet the recommended length for the current design aircraft. The runway is recommended to be extended to the west, bringing the total runway length to 3,952 feet. At this length, the runway will increase the safety and efficiency of aircraft currently operating at the airport.

The taxiway system is recommended to be improved in order to provide greater efficiency of ground movement and improve safety by increasing pilot situational awareness through design. The taxiway improvements include removal of excess pavement, removing direct access from aprons to active runways, and instituting Standard Operating Procedures with the tower to increase safety.

LANDSIDE CONCEPT

Generally, landside issues relate to those airport facilities necessary, or desired, for the safe and efficient parking and storage of aircraft, movement of passengers and pilots to and from aircraft, airport land use, and overall revenue support functions. In addition, elements such as fueling capability, availability of services, and emergency response are also considered in the landside functions.

Landside planning focuses on facility locating strategies following a philosophy of separating activity levels. To maximize airport efficiency, it is important to locate facilities intended to serve similar functions. For example, it makes sense to plan T-hangar structures in a designated area rather than haphazardly building them as needed on the next available spot at the airport. It is also important to plan for facilities that users of the airport desire and to group those facilities together, whether they are T-hangars, box hangars, and larger conventional hangars.

The orderly development of the airport terminal area (those areas parallel to the runway and along the flightline) can be the most critical, and probably the most difficult development to control on the airport. A development approach of "taking the path of least resistance" can have a significant effect on the long term viability of an airport. Allowing development without regard to a functional plan can result in a haphazard array of buildings and small ramp areas, which will eventually preclude the most efficient use of valuable space along the flightline.

Activity in the terminal area should be divided into three categories at an airport. The high-activity area should be planned and developed as the area providing aviation services on the airport. An example of a high-activity area is the aircraft parking apron, which provides outside storage and circulation of aircraft. In addition, large conventional hangars housing fixed base operators (FBOs), other airport businesses, or used for bulk aircraft storage would be considered high-activity uses. A conventional hangar structure in the high-activity area should be a minimum of 6,400 square feet (80 feet by 80 feet). If space is available, it is more common to plan these hangars for up to 200 feet by 200 feet. The best location for high-activity areas is along the flightline near midfield, for ease of access to all areas of the airfield.

The medium-activity category defines the next level of airport use and primarily includes corporate aircraft operators that may desire their own box or conventional hangar storage on the airport. A hangar in the medium-activity use area should be at least 50 feet by 50 feet, or a minimum of 2,500 square feet. The best location for medium-activity use is off the immediate flightline, but still with ready access to the runway/taxiway system. Typically, these areas will be adjacent to the high-activity areas. Parking and utilities such as water and sewer should also be provided in this area.

The low-activity use category defines the area for storage of smaller single and twin-engine aircraft. Low-activity users are personal or small business aircraft owners who prefer individual space in T-hangars or small box hangars. Low-activity areas should be located in less conspicuous areas or to the ends of the flightline. This use category will require electricity, but may not require water or sewer utilities.

In addition to the functional compatibility of the terminal area, the proposed development concept should provide a first-class appearance for Livermore Municipal Airport. Consideration to aesthetics should be given high priority in all public areas, as the airport can many times serve as the first impression a visitor may have of the community.

Livermore Municipal Airport has approximately 495 based aircraft which is forecast to grow to 720 provided adequate hangar space is available. There are over 150 aircraft owners on the wait list for hangar space. The landside concept primarily addresses the location and type of hangar space planned for the airport in the future.

Not all aircraft owners will necessarily want an enclosed aircraft hangar space; therefore, hangar planning is not necessary to house all based aircraft. At Livermore, it is estimated that approximately 17 percent of aircraft owners will elect to utilize outside aircraft tie-down space. In the future, it is estimated there is a need for 75 T-hangar spaces, 82 box hangar spaces, and 41 conventional hangar spaces. A total of 454,400 square feet of additional hangar space is estimated to be needed through 2030.

The recommended future layout of hangars has been established through previous planning efforts as detailed in the *Livermore Municipal Airport General Plan Amendment and Rezoning EIR* (2009). The future layout has been analyzed in terms of efficiency and capacity. The future layout does generally follow the strategy of separating activity levels at the airport. For example, new FBO facilities are planned on the north side of the airport in high activity areas along the flight-line. Future box hangars, corporate hangars, and T-hangars are grouped together.

The future hangar layout plan provides for approximately 594,000 square feet of new aircraft storage space, which would meet the long term need as calculated previously. The plan provides approximately 193,000 square feet of new T-hangars, 175,000 square feet for new box/corporate hangars, and 226,000 square feet for larger conventional hangars.

SUMMARY

The intent of this chapter has been to outline the facilities required to meet potential aviation demand projected for Livermore Municipal Airport based on the current FAA approved forecasts which extend to 2030. In an effort to provide a more flexible plan, the yearly forecasts have been converted to planning horizon levels. The short term roughly corresponds to a five-year timeframe, the intermediate term is approximately 10 years, and the long term is 20 years. By utilizing planning horizons, airport management can focus on demand indicators for initiating projects and grant requests rather than on specific dates in the future.

The Livermore Municipal Airport has evolved over the years from a more rural general aviation facility accommodating small single and multi-engine piston powered aircraft to one that experiences frequent business jet activity. Frequent activity is defined as 500 or more annual operations. As such, the airport sponsor must consider meeting design standards associated with the aircraft type operating frequently.

The Runway Design Code (RDC) for primary Runway 7L-25R is B-II-2400. This runway is planned to remain in its current capacity. Parallel Runway 7R-25L is classified as RDC B-I-VIS (small aircraft). If 1-mile visibility non-precision instrument approaches are introduced to this runway then the future RDC falls in B-I-5000.

The most significant change considered for the runway system is the recommendation to extend the parallel runway from 2,699 feet in length to 3,952 feet in length. This extension is intended to accommodate aircraft currently operating at the airport and is not intended to attract any new aircraft larger than what is currently operating at the airport. The planned length of 3,952 feet does not fully meet the FAA recommended length of 4,200 feet. This is due to a desire to line-up the thresholds of the two runways in order to avoid creating potentially confusing access taxiways.

The purpose of the recommended extension of the parallel runway is to increase the safety and efficiency of the airfield. Currently, due to inadequate runway length, many aircraft must wait longer on the ground or in the air to utilize the primary runway. This increases operator costs and fuel burn. It also means operators must cross active runways to get to their destination on the airfield. This is particularly true at Livermore Municipal Airport because most of the airport businesses are located on the south side of the airport.

On the landside, planning calculations show a need for additional hangars of all varieties. The availability of additional hangar space is a significant factor as to whether the airport will experience and can accommodate the forecast growth in based aircraft. The airport has a wait list of over 150 aircraft owners desiring an enclosed hangar space as of January 2013. The hangar layout plan includes the addition of 454,400 square feet of aircraft storage space. This would accommodate forecast needs at the airport.