Chapter 4
FACILITY REQUIREMENTS

This chapter summarizes the facilities and land areas required to accommodate the forecast aviation demand at George Bush Intercontinental Airport/Houston (hereinafter referred to as the Airport, or IAH), presented in Chapter 3. Facility requirements were developed for the airfield, passenger terminal complex, ground transportation and parking, general aviation, air cargo, airline support, and airport support facilities based on assessments of existing capacity and future demand for major aviation-related facilities.

4.1 INTRODUCTION

This section provides a summary of the aviation demand that was used to evaluate future requirements for various Airport facilities and a summary of the resulting requirements for each major facet of the Airport.

4.1.1 Planning Activity Levels

Recognizing the uncertainties associated with long-range aviation demand forecasting, planning activity levels (PALs) were identified to represent future levels of activity at which major airside and landside improvements would be necessary. Because actual activity could grow faster or slower than the baseline forecast for a number of reasons, the use of PAL "triggers" allows Airport management to adjust the timeframe for recommended projects according to actual realized activity, rather than arbitrary years. The aviation demand associated with each PAL is summarized in Table 4-1. Each of the PALs is named for the number of enplaned passengers expected during that timeframe; however, the PALs do have other operational demand activity associated with them, including aircraft operations.

Table 4-1
FORECASTS AND PLANNING ACTIVITY LEVELS

	Planning Activity Levels			
	BASE	PAL25	PAL33	PAL40
Timeframe *(a)*	2012 *(b)*	2019-2023	2028-2037	2034-2048
Enplaned Passengers (m)				
Domestic	15.5	19.0	23.0	27.0
International	4.4	6.0	10.0	13.0
Total	19.9	25.0	33.0	40.0
Aircraft Operations				
Commercial *(c)*	497,833	619,128	737,210	811,281
Other	12,409	13,530	14,769	15,659
Total	510,242	632,658	751,979	826,940

(a) Timeframe corresponds to the Baseline and Low-Growth scenarios from the *Aviation Demand Forecast*, LeighFisher, dated June 20, 2012.
(b) December 2012 traffic report, Houston Airport System.
(c) Includes all passenger and cargo operations.

4.1.2 Future Flight Schedules

Aircraft flight schedules for the baseline (2012), PAL25, PAL33 and PAL40 demand levels were developed based upon the aviation demand forecast. The flight schedules used for facility planning represent an average day in the peak month (ADPM), which is a flight schedule with a daily number of operations representing the total number of operations in July divided by 31. More details on the forecast and flight schedule development can be found in the document entitled, *Aviation Demand Forecast,* prepared by LeighFisher, dated June 20, 2012.

Table 4-2 summarizes the ADPM demand levels that were simulated to estimate future requirements. Commercial passenger and air cargo arrivals in the flight schedules were “linked” to subsequent departing flights to provide a matched flight schedule to facilitate the modeling of terminal gate occupancy and pushback operations.

Table 4-2
AVERAGE-DAY-PEAK-MONTH (ADPM) ACTIVITY LEVELS

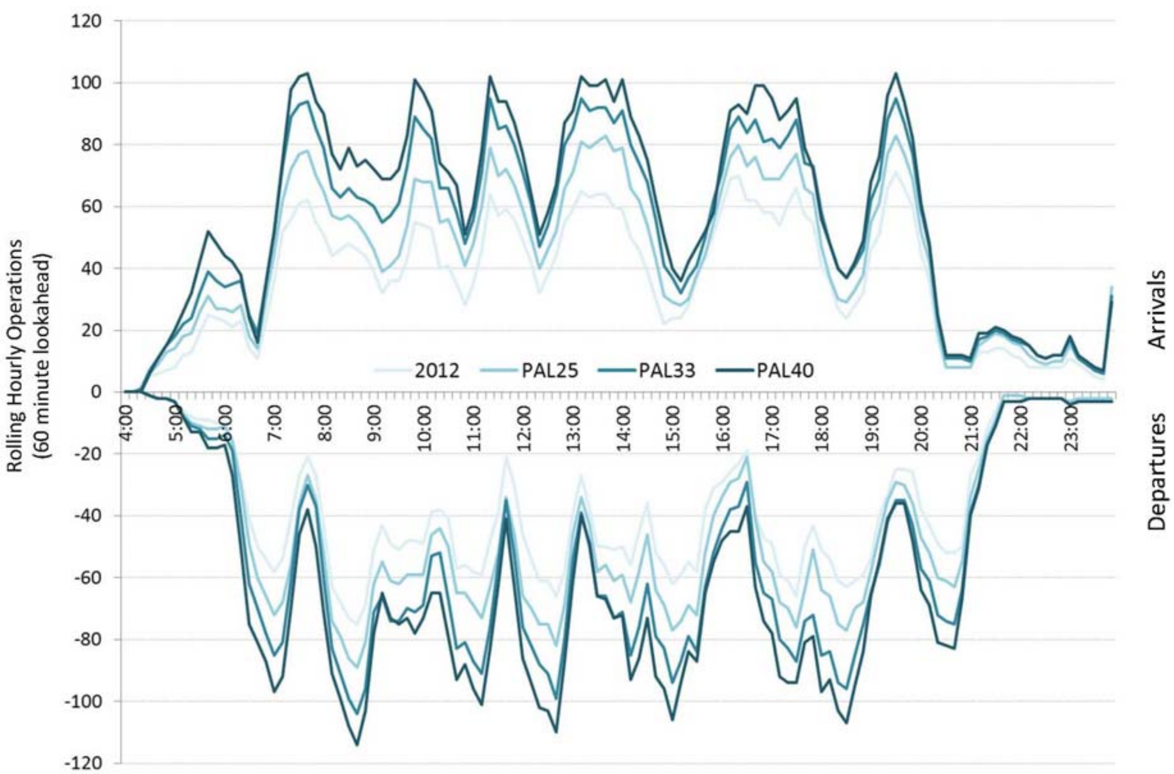
Airport Operations	2012	PAL25	PAL33	PAL40
Annual	524,552	632,658	751,980	826,940
Average Day Peak Month (passenger only)	1,449	1,765	2,101	2,315
Peak Hour (passenger only)				
Overall Peak Hour				
Arrivals	66	77	88	95
Departures	66	76	87	94
Total	**132**	**153**	**175**	**189**
Peak Departure Hour				
Arrivals	46	55	63	73
Departures	**75**	**89**	**104**	**114**
Total	121	144	167	187
Peak Arrival Hour				
Arrivals	**71**	**83**	**95**	**103**
Departures	25	56	76	38
Total	96	139	171	141

Source: LeighFisher, February 2013.

Figure 4-1 shows the temporal distribution of the Baseline, PAL25, PAL33 and PAL40 passenger flight schedules. This figure shows the number of passenger operations scheduled in 10-minute rolling hourly average. Arrivals are shown plotted upward on the positive vertical or y-axis, and departures are shown plotted downward on the negative y-axis.

The historical peaking characteristics at the Airport indicates approximately 9 percent of the daily arrivals occur in the peak hour, and approximately 10 percent of the daily departures in the peak hour. In determining the forecast levels of peak hour operations it was assumed that the timing of the peak hour should not change and the total peak hour operations would not increase at the same rate as the growth in total operations for the future activity demand levels, i.e., the schedule was subject to peak spreading. Part of the increase in peak hour operations is spread over other arrival and departure banks, as much of the future growth is expected to be in market frequency. The percentage of operations from the peak hour that are spread-over to the other arrival and departure banks were developed based on the mid-range elasticity assumptions from FAA and United Kingdom's Civil Aviation Authority forecast methodologies.

Figure 4-1
TEMPORAL DISTRIBUTION, PASSENGER AIRCRAFT OPERATIONS



Source: LeighFisher, February 2013.

4.1.3 Summary of Requirements

The Airport facility requirements are summarized in Table 4-3.

Table 4-3
SUMMARY OF FACILITY REQUIREMENTS

		Estimated Requirement			
	Existing	Baseline (2012)	PAL25	PAL33	PAL40
Airfield					
Design aircraft					
Wingspan	A380-800	A380-800	A380-800	A380-800	A380-800
Length	B-747-8	B-747-8	B-747-8	B-747-8	B-747-8
Wheelbase	B-777-300ER	B-777-300ER	B-777-300ER	B-777-300ER	B-777-300ER
Gross weight	A380-800	A380-800	A380-800	A380-800	A380-800
Runway length (feet)	12,001	12,001	12,001	12,001	12,001
Instrument approach capability	CAT IIIc	CAT IIIc	CAT IIIc	CAT IIIc	CAT IIIc
Passenger Terminal					
Gates/aircraft parking	154	111	147	186	202
Domestic	119	79	105	132	133
International	35	32	42	54	69
Ticketing and check-in					
Curbside (positions)	21	8	10	11	13
Agent counters (positions)	272	126	154	209	262
Self-service kiosks (units)	73	28	36	43	50
Passenger security screening					
Checkpoints (lanes)	30	23	29	36	45
Baggage handling					
Baggage security screening (EDS units)	26	22	26	30	36
Outbound baggage make-up (cart positions)	409	329	397	494	568
Baggage claim device frontage (LF)	2,910	1,306	1,508	2,002	2,224
FIS/International arrivals facility					
Processing booths (piggy-back positions)	40	27	42	45	61
Queuing area (SF)	42,900	23,288	36,225	38,813	52,613
Baggage claim frontage (LF)	3,060	2,491	3,410	3,575	4,972
Passenger security screening (lanes)	6	6	9	12	15
Recheck positions	34	32	50	68	87
Auto Parking *(a)*					
Terminal area (stalls)	13,190	11,490	16,890	25,500	32,680
Remote (stalls)	8,550	3,250	4,770	7,200	9,230
Non- United Employee (stalls)	2,100	1,850	2,280	2,860	3,300
United Employee (stalls)	3,500	3,080	3,800	4,760	5,480

Table 4-3 *(page 2 of 2)*
SUMMARY OF FACILITY REQUIREMENTS

		Estimated Requirement			
	Existing	Baseline (2012)	PAL25	PAL33	PAL40
Ground Transportation					
Terminal A curbsides *(b)*					
North (private arrivals)		E/F	E/F	E/F	E/F
East (departures)		C or better	C or better	D	E/F
South (commercial arrivals)		C or better	C or better	C or better	C or better
West (commercial arrivals)		D	D	E/F	E/F
Terminal B curbsides *(b)*					
North (private arrivals)		D	D	E/F	E/F
East (departures)		C or better	C or better	D	E/F
South (commercial arrivals)		C or better	C or better	D	D
North loop (shuttles)		D	D	E/F	E/F
South loop (limousines)		C or better	C or better	C or better	D
Terminal C curbsides *(b)*					
North (private arrivals)		E/F	E/F	E/F	E/F
East (departures)		D	D	E/F	E/F
South (commercial arrivals)		D	D	E/F	E/F
West (commercial arrivals)		C or better	C or better	C or better	C or better
Terminal D curbside *(b)*					
Inner (private departures)		D	D	D	E/F
Outer (commercial departures)		D	D	D	E/F
Terminal E curbsides *(b)*					
Lower (arrivals)		E/F	E/F	E/F	E/F
Upper (departures)		C or better	C or better	D	E/F
Rental cars					
Ready/return (SF)	1,224,000	916,000	1,090,000	1,440,000	1,790,000
Customer service suites (SF)	31,480	27,060	30,000	34,600	40,000
Service sites and QTA (acres)	54.9	42.4	49.5	66.7	83.0
General Aviation					
Apron area (acres)	9.2	9.2	10.0	11.0	11.7
Hangar space (acres)	10.5	5.0	5.5	6.1	6.4
Air Cargo					
East cargo site (acres)	49.0	38.2	44.0	55.9	66.5
Central cargo site (acres)	67.0	67.0	67.0	67.5	69.0
All cargo apron area (acres)	57.0	44.1	55.1	64.3	73.2
Airport and Airline Support					
Aircraft rescue and firefighting (index)	E	E	E	E	E
Airport maintenance complex (acres)	17.9	17.9	18.2	25.5	25.5
Airport administration offices (SF)	84,250		*Future*	*132,650*	
Fuel storage					
8-day supply gross storage (gal)	12,078,000	15,593,027	19,933,049	24,722,601	28,319,869
Land area (acres)	22	28	36	45	52

(a) Assumes off-airport parking supply remains constant and all additional requirements are accommodated on-Airport.
(b) Assessed using level of service (LOS) rather than curbside length as curbside requirements at the Airport are a function of the unique curbside operations and layouts at the 15 separate curbside areas and the interactions between the curbsides and the adjacent roadway operations.

Source: LeighFisher, July 2013.

A summary of the requirements for each major component of the Airport over the course of the planning period follows.

4.1.3.1 Airfield and Airspace

The existing runway system provides sufficient capacity to accommodate forecast demand until PAL33, albeit marginally under poor weather conditions. Particularly, additional departure capacity should be provided in west flow and additional arrival capacity in east flow. Runway length of 12,000 feet is adequate to accommodate long-haul departures from the Airport, however another 12,000-foot runway should be provided in the east-west direction.

In the near-term, projects should be undertaken to improve taxiway flows and surface movements. Providing redundant crossfield taxiway capability to Taxiway SF is required in the near-term as this represents a single point of failure for aircraft ground movements. Additional taxiway infrastructure to expedite runway crossings and improve departure queuing and staging at the ends of Runways 15L, 15R, and 9 should be provided by PAL33. Taxiways NA and NB should be widened to accommodate Taxiway Design Group (TDG) 7 aircraft and all other taxiway shoulders should be widened to accommodate TDG 6 aircraft.

4.1.3.2 Passenger Terminal Complex

Shortfalls are projected in the number of total gates beginning at PAL25, but will increase through PAL33 and PAL40. The Airport's existing 154 gates will need to increase to 202 gates by PAL40 to keep pace with demand. Most of the projected shortfall is in international gates, beginning in PAL25 with a requirement for 7 additional gates increasing to 34 additional gates needed by PAL40.

In addition to gates, detailed terminal facility requirements were assessed for each of the Airport's existing unit terminals, including check-in, passenger security screening checkpoints, checked baggage screening, outbound baggage handling, and baggage claim. The requirements for the terminals and the FIS are summarized below.

- Terminal A: additional passenger security screening checkpoint capacity is required at PAL25, and additional checked baggage screening capacity at PAL40.
- Terminal B: modest increases in check-in facilities and checked baggage screening facilities at PAL25 are required, and expansion of outbound baggage handling area at PAL25 is required.
- Terminal C/E: additional checked bag screening capability is required at PAL25. Check-in functions will remain adequate in Terminal C but will require expansion in Terminal E by PAL33. In addition, passenger security screening checkpoints, and outbound baggage handling will need expansion at PAL33.
- Terminal D: Additional passenger security screening checkpoint capacity is needed beginning at PAL25. Expanded check-in capacity will be needed at PAL40. In addition, the building does have mechanical and building systems issues that will need to be addressed regardless of future activity levels.
- FIS: Deficiencies are expected in all functional areas, including number of booths, baggage claim, and recheck by PAL25, and queue area by PAL40.

4.1.3.3 Ground Transportation and Parking

The existing terminal area roadways and parking facilities do not provide sufficient capacity to accommodate PAL40, and many elements will require additional capacity by PAL33. The terminal area roadways, particularly the private vehicle arrivals curbsides at Terminals A, C, and E represent a weak point in the ground transportation network. As passenger activity increases, the congestion occurring at these locations is expected to worsen and interfere with traffic operations on the entire terminal roadway system. In addition, roadway segments serving large volumes of weaving traffic are expected to fail including (1) the segment of North Terminal Road between Taxiway SF and the Terminal C arrivals curbside, (2) the segment of South Terminal Road between the Terminal A departures curbside exit and the Terminal B south curbside exit, (3) the diverge on South Terminal Road approaching the Will Clayton Parkway/John F. Kennedy Boulevard split, (4) the return-to-terminal road east of Terminal B, and (5) the signalized return-to-terminal/U-turn ramp at Colonel Fisher Road. The poor quality of roadway operations in the terminal area are due to a lack of lane capacity coupled with unexpected lane drops, lack of lane balance at diverge points, insufficient weaving area capacity, short decision making distances, “wrong” side merges and exits, and inefficient curbside roadway layouts and operations. Because of this poor quality of roadway operations, the peak period travel times experienced by motorists are expected to increase by as much as 20 percent between now and PAL25.

The demand for public parking in the terminal area is expected to exceed the number of available spaces before PAL25. Demand for economy parking or EcoPark spaces is expected to exceed the number of available spaces sometime after PAL33. Additional employee parking spaces are expected to be required before PAL25. The rental car facilities generally provide sufficient capacity through PAL25, with expansion of all rental car facilities needed by PAL33.

4.1.3.4 Airport and Airline Support

Corporate and general aviation requirements are adequate for the planning period with the exception of aircraft parking apron, which is projected to require apron expansion by PAL40. Air cargo, which is a robust and unique operation at IAH, currently has adequate facilities. However, the East Cargo Area will need to be expanded by 20 acres to accommodate projected demand through PAL40, and the Central Cargo Area will require expansion by two acres in that same timeframe. Air cargo ground support equipment storage will require dedicated space by PAL33, and bonded storage facilities (about one acre) should be developed in the near term to more fully support the air cargo business at IAH. In terms of the two integrated air cargo carriers, FedEx and UPS, each are likely to need expansion by about one acre, primarily to support additional aircraft parking.

There are several Airport support facilities that will require attention during the planning period, including the aircraft rescue and firefighting (ARFF) facilities. Currently, ARFF facilities are adequate for the long-term; however, if the Master Plan proposes changes to the airfield (including possibly a new runway) response times will have to be calculated to ensure the current ARFF locations are adequate. Airport maintenance operations occur at several places throughout the Airport. Consolidating some of those operations into a centralized facility would be advantageous for organizational efficiency. Further, the Airport’s administration offices may need expansion on the order of one acre of additional building space and 3.6 acres of additional auto parking.

The fuel farm will require expansion at various points through PAL40, totaling an additional 14 million gallons. Reserving space for about 15 acres to support United Airlines maintenance, and smaller expansion areas should be planned to support the needs of the airline flight kitchens and mail sort facilities. Expansion of the flight simulator complex is expected; however, the current site appears to be capable of accommodating the expansion currently envisioned by United Airlines.

4.2 AIRFIELD AND AIRSPACE REQUIREMENTS

The assessment of airfield and airspace facility requirements consisted of the following six tasks:

- Evaluate the recommendations from the previous master plan and determine which should be considered for further study in the alternatives section.
- Recommend the appropriate Runway Design Code and Taxiway Design Group based upon the forecast demand and airport role.
- Assess the need for new or modified airfield facilities to meet airport design standards or eliminate existing modifications to design standards.
- Evaluate the potential impacts of technology, airline fleet mix changes (e.g., the expanding use of larger gage regional jets and low-fare carriers) and other industry trends on the need for new or modified airfield facilities.
- Assess the potential effects of anticipated NextGen-enabled technologies and procedures on the need for and timing of additional capacity improvements, including the Houston Optimization of Airspace and Procedures in the Metroplex (OAPM) Study.
- Compare demand and capacity to determine if aviation activity levels forecast for the planning horizon would exceed the capacity of the airfield system. This included using an analytical model to assess runway capacity and fast-time simulation of the existing airspace and airfield system that serves the Airport, to study taxiway and operational issues.

The last of these subtasks was the primary focus of the work effort. In this subtask, the Total Airspace and Airport Modeller (TAAM)—a fast-time airfield and airspace simulation model—was used to assess the performance of the existing airfield and airspace system at the Airport. The results of the simulation analyses, coupled with other analytical tools, were used to establish the activity levels at which existing airfield and airspace systems would be expected to reach capacity. This simulation modeling effort was undertaken in coordination with Houston Airport System (HAS) personnel, FAA (i.e., IAH Tower and Texas Airports Development Office), and United Airlines.

4.2.1 Recommendations for Further Study from Previous Master Plan

The key recommendations from the previous master plan include those listed below. The need for these improvements was re-evaluated as part of this master planning effort.

- Two additional runways, Runway 8C-26C and Runway 9R-26L
- A perimeter taxiway system supporting the runway system
- Additional taxiway improvements to enhance operational efficiency
  - Crossfield taxiway east of Taxiway SF
  - Reconfigured taxiways to support departure queuing to Runways 15L and 15R

- Widen Taxiway NR west of Terminal A
- Expanded hold pads for Runway 9-27

These recommendations will be considered as part of the airfield requirements and alternatives process.

4.2.2 FAA Standards and Requirements

The FAA publishes its airport design standards and requirements in its Advisory Circular, 150/5300-13A, *Airport Design*. The major design standards evaluated in the context of a master plan include: design aircraft, Runway Design Code, Taxiway Design Group, runway safety areas, runway protection zones, and modifications of standards as described in the following sections.

4.2.2.1 Design Aircraft, Runway Design Code, and Taxiway Design Group

The design aircraft is intended to represent the most demanding aircraft types expected to be accommodated at the Airport. The two main components which determine the design aircraft are Runway Design Code (RDC) and Taxiway Design Group, explored in the following paragraphs.

The FAA uses three key characteristics to designate the design criteria that apply to runways, termed the RDC. The first component of the RDC—indicated with a letter ranging from A to E—is the aircraft approach category (AAC) and indicates the maximum approach speed of the aircraft that the runway can accommodate. The second part of an RDC—indicated with a Roman numeral ranging from I to VI—is termed the Airplane Design Group (ADG) and indicates the maximum aircraft wingspan a runway can accommodate. The third component of the RDC—expressed by runway visual range (RVR) values in feet—relates to the approach visibility minimums of a runway.

For the geometric design of the airfield, the aircraft type with the most demanding RDC expected to use the Airport on a regular basis was selected as the design aircraft. FAA Advisory Circular 150/5300-13A, *Airport Design,* does not specify a minimum threshold level of operations required for an aircraft type to be the design aircraft. Instead the determination of the design aircraft is subject to the airport management's discretion, provided the airport design is not based on an aircraft expected to use an airport infrequently. Based on the aviation demand forecasts, the future fleet mix was analyzed to identify the design aircraft and corresponding RDC at each Planning Activity Level. Aircraft characteristics were evaluated on the basis of wingspan, length, wheelbase, and gross weight. The recommended design aircraft and RDC at each PAL is the Airbus A380-800, which has an RDC of D-VI and a TDG of 7, as summarized in Table 4-4.

Table 4-4
DESIGN AIRCRAFT

	Planning Activity Level			
	2012	PAL25	PAL33	PAL40
Design aircraft	A380-800	A380-800	A380-800	A380-800
Runway Design Code (RDC)	D-VI-1200	D-VI-1200	D-VI-1200	D-VI-1200
Taxiway Design Group (TDG)	7	7	7	7

Source: LeighFisher, July 2013.

The A380-800 is the largest aircraft currently using the Airport on a regular basis, and is expected to remain the largest aircraft throughout the planning period. The A380-800 and B747-800 are both classified by the FAA as RDC D-VI aircraft, and have (1) approach speeds of at least 141 knots, but less than 166 knots, and (2) wingspans of at least 214 feet, but less than 262 feet. RDC D-VI aircraft are expected to account for approximately 0.3 percent (approximately 2,242 annual operations) of passenger aircraft operations at the Airport by PAL40. Consequently, airfield facilities should meet design standards associated with D-VI aircraft.

FAA criteria for taxiway width and taxiway shoulder width are defined in terms of the TDG, which is based on the dimensions of the undercarriage of the aircraft. The aircraft with the most demanding TDG expected to use the Airport regularly is the A380-800, classified as a TDG 7 aircraft. To meet TDG 7 standards it is required that taxiways are designed to be at least 82 feet wide, and taxiway shoulders are at least 40 feet wide. B747-800 is classified as a TDG 6 aircraft, which require taxiways to be at least 75 feet wide, and taxiway shoulders to be at least 35 feet wide.

4.2.2.2 Runway Safety Areas

Runway safety areas (RSAs) are rectangular areas that encompass runways and the land areas immediately around them. RSAs are required to be cleared, graded, and capable of supporting aircraft without causing damage to them in the case of an aircraft undershooting the runway on arrival or overshooting the runway on departure or arrival. RSAs are intended to minimize damage to aircraft and injury to passengers and flight crew in the event of an aircraft excursion from the runway.

For runways serving ADG VI aircraft, like those at the Airport, standard RSAs are 500 feet wide, centered on the runway, and extend 1,000 feet beyond each of the runway's physical ends. Objects taller than three inches above grade are not permitted within RSAs unless they are (1) fixed by function and (2) mounted on frangible couplings that are no higher than three inches above grade. At the Airport, all RSAs are clear and meet FAA requirements.

4.2.2.3 Runway Protection Zones

Runway protection zones (RPZs) are trapezoidal areas beyond the ends of runways, centered on the extended runway centerline, intended to protect people and property on the ground in the event of an aircraft accident. The departure RPZ begins at 200 feet beyond the runway end or 200 feet beyond the far end of the takeoff run available (TORA). The approach RPZ begins 200 feet beyond the arrival threshold of the respective runway.

For runways with visibility minima lower than 3/4 mile (including Runways 8L, 26R, 8R, 26L, 9, 27, 15R, and 33R), RPZs are 2,500 feet long, 1,000 feet wide at the inner edge (i.e., closest to the runway), and 1,750 feet wide at the outer edge. For visual runways (including Runways 33L and 15L), RPZs are 1,700 feet long, 500 feet wide at the inner edge, and 1,010 feet wide at the outer edge.

As stated in paragraph 310e of AC 150/5300-13A, "[t]he FAA Office of Airports must evaluate and approve any proposed land use within the limits of land controlled by the airport owner of an existing or future RPZ." There are incompatible uses within the limits of the existing RPZs, albeit beyond the Airport's property line, including:

- Runway 8L: Richey Road, Farrell Road, Birnamwood Boulevard
- Runway 26R: Farm to Market 1960
- Runway 9: John F. Kennedy Boulevard
- Runway 33R: Hardy Toll Road, Greens Road

It is recommended that these incompatible land uses be reviewed based on the guidance currently under development by FAA, titled *Evaluation and Approval of RPZ Land Use Guidelines*.

4.2.2.4 Modification of Standards

This section summarizes the requirements for new or modified airfield facilities to eliminate existing modifications to design standards. Non-conforming airfield conditions are summarized in Working Paper 1, *Assessment of Existing Conditions*. As discussed earlier, any new airfield facilities should be designed to meet design requirements for ADG VI and TDG 7.

The Airport currently has modifications of standards in place to allow interim operation of ADG VI aircraft on runways and taxiways not currently meeting ADG VI pavement sections and/or lateral separation. These modifications of standards are assumed to remain in place throughout the planning period; however, the HAS intends to address these issues as pavement rehabilitation is required.

Interim operation of ADG VI aircraft is allowed on runways and taxiways not currently meeting ADG VI pavement sections and/or lateral separations, including:

- ADG VI can operate on Runways 8L-26R and 8R-26L, despite the substandard shoulder width of 35 feet;
- ADG VI aircraft are not authorized to land or depart on Runway 9-27;
- Hold pad closures occur at the ends of Runways 15L and 15R when an ADG VI aircraft is present;
- Taxiway restrictions due to lateral clearance: Taxiway SB with Runway 9-27, Taxiway NB between Taxiways SF and NJ; Taxiway NB west of Taxiway NE (i.e., Taxiway NA closed when ADG VI present); Taxiway WB between Taxiways WD and WH; and Taxiway SF between Taxiway NB and Gate D12.

These conditions should be resolved through upgrades to airfield facilities.

All taxiways at the Airport are at least 75 feet wide, which is the standard for TDG 6 aircraft. The standard for TDG 7 taxiways is 82 feet. Taxiway shoulders are substandard per FAA criteria and should be widened to meet the standard for TDG 6 aircraft at a minimum, namely 35 feet. Taxiways which are expected to be used frequently by TDG 7 aircraft should be 82 feet wide and have shoulders of 40 feet. This includes the primary taxiway route to Runway 15L for departures, namely Taxiway NB, and a route from Runway 8L-26R, the primary arrival runway for aircraft destined for Terminal D, namely Taxiway NA. Taxiways to any future runways designed for TDG7 aircraft operations also should be 82 feet wide with 40-foot shoulders.

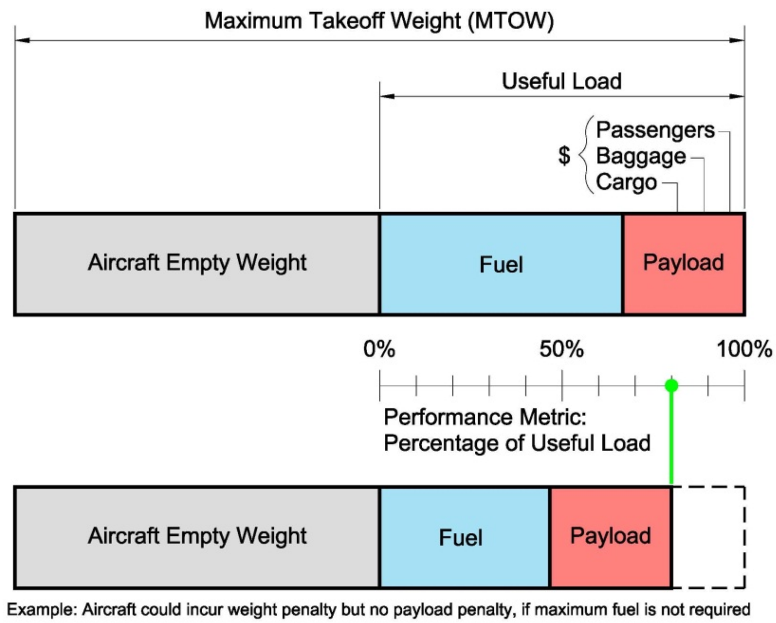
4.2.3 Runway Length Requirements

Runway length requirements for the Airport is evaluated by assessing the takeoff and landing length requirements for the critical aircraft – A380-800 and B747-800 – based on the aircraft manufacturers' published planning criteria. The analysis of takeoff and landing runway length requirements incorporated the following assumptions:

- Ambient temperature of 35 degrees Celsius, reflecting the mean daily maximum temperature historically experienced at the Airport during the hottest month. This is determined based on historical weather data at the Airport between 2005 and 2011 provided by the National Climate Data and Information Archive.

- Use of the most common engine types for the critical aircraft under consideration.
- Zero runway gradient and zero wind.
- Airport elevation of 97 feet.
- Useful load of the critical aircraft are considered. Useful load is defined as the aircraft's maximum takeoff weight minus the aircraft empty weight. An aircraft's useful load can be used to transport either fuel or payload (i.e., passengers, baggage, and cargo) and, within certain limits, can be allocated between fuel and passengers. See Figure 4-2.

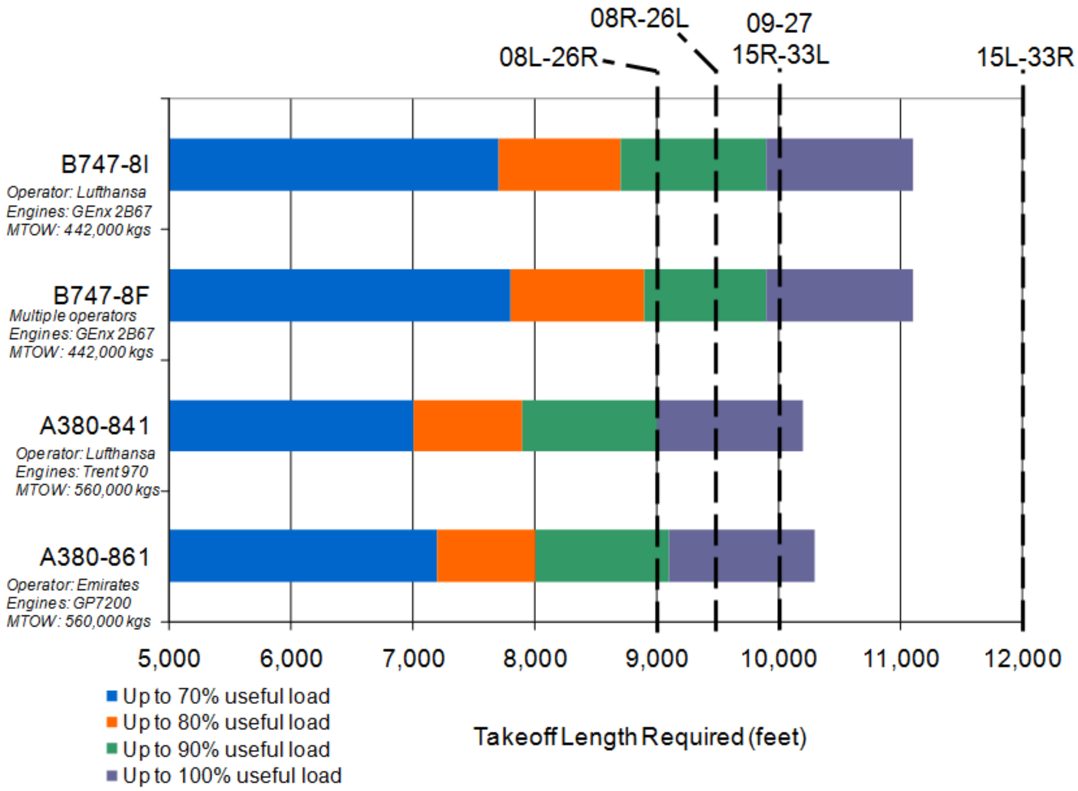
Figure 4-2
AIRCRAFT USEFUL LOAD



Source: LeighFisher, July 2013.

Figure 4-3 illustrates the takeoff length requirements for the A380-800 and B747-800 series at varying useful loads. The length of the primary departure runway, Runway 15L-33R, is sufficient to accommodate departures of both aircraft at maximum takeoff weight. Runways 9-27 and 15R-33L can each accommodate departures with up to 90 percent useful load. Runways 8L-26R and 8R-26L can accommodate departures with up to 80 percent useful load. Currently, the length of Runway 15L-33R is adequate to serve departures to long haul destinations. Consideration should be given to extending another runway to increase flexibility for accommodating departures of heavy aircraft to long haul destinations and to provide redundancy in the event that Runway 15L-33R is unavailable (e.g., for maintenance or rehabilitation).

Figure 4-3
TAKEOFF RUNWAY LENGTH REQUIREMENTS

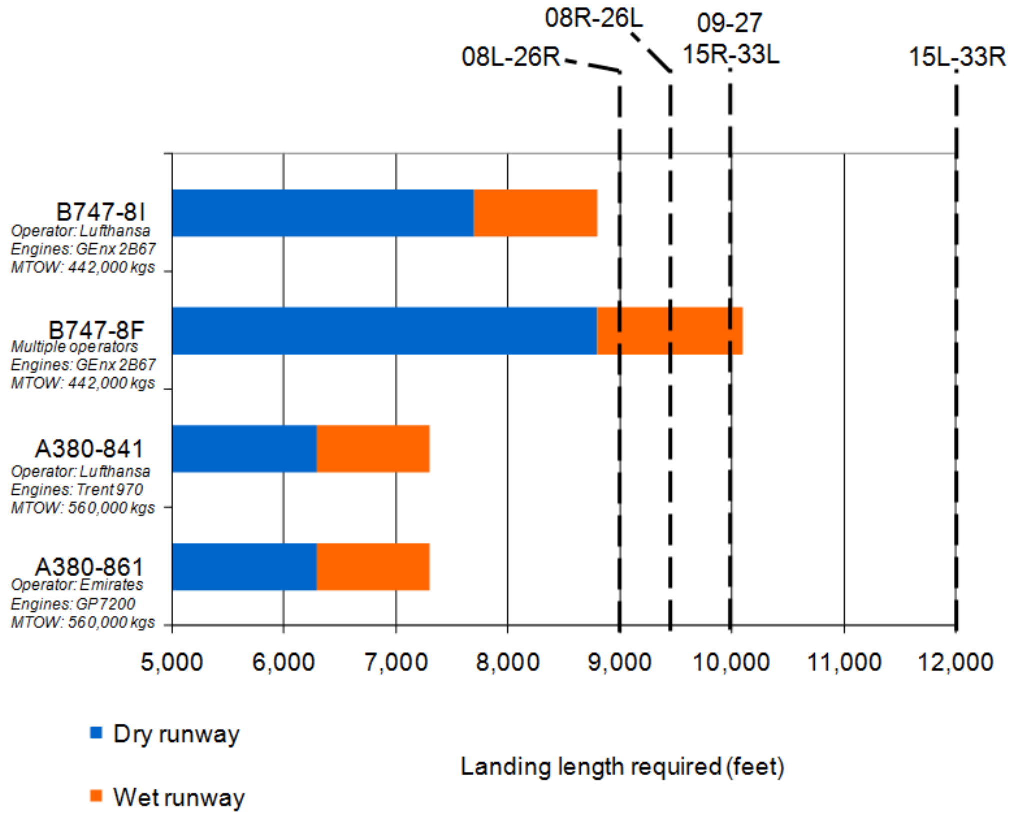


Notes: Obstacles which may limit payload are not considered within these results.

Sources: Aircraft Characteristics for Airport Planning, published by Boeing and Airbus, JP Airline-Fleets International, 2007/2008, and FAA Advisory Circular 150/5325-4B, *Runway Length Requirements for Airport Design.*

Landing length requirements are determined based on the maximum landing weight and are shown on Figure 4-4. Landings of the A380-800 and B747-8I could be accommodated on any of the runways under dry conditions. Under wet runway conditions, the B747-8F would likely require Runway 9-27, 15R-33L or Runway 15L-33R.

Figure 4-4
LANDING RUNWAY LENGTH REQUIREMENTS



Note: For the A380, wet runway requirements are assumed to be 15 percent higher than dry runway length requirements.

Sources: Aircraft Characteristics for Airport Planning, published by Boeing and Airbus, engine types from JP Airline-Fleets International, 2007/2008.

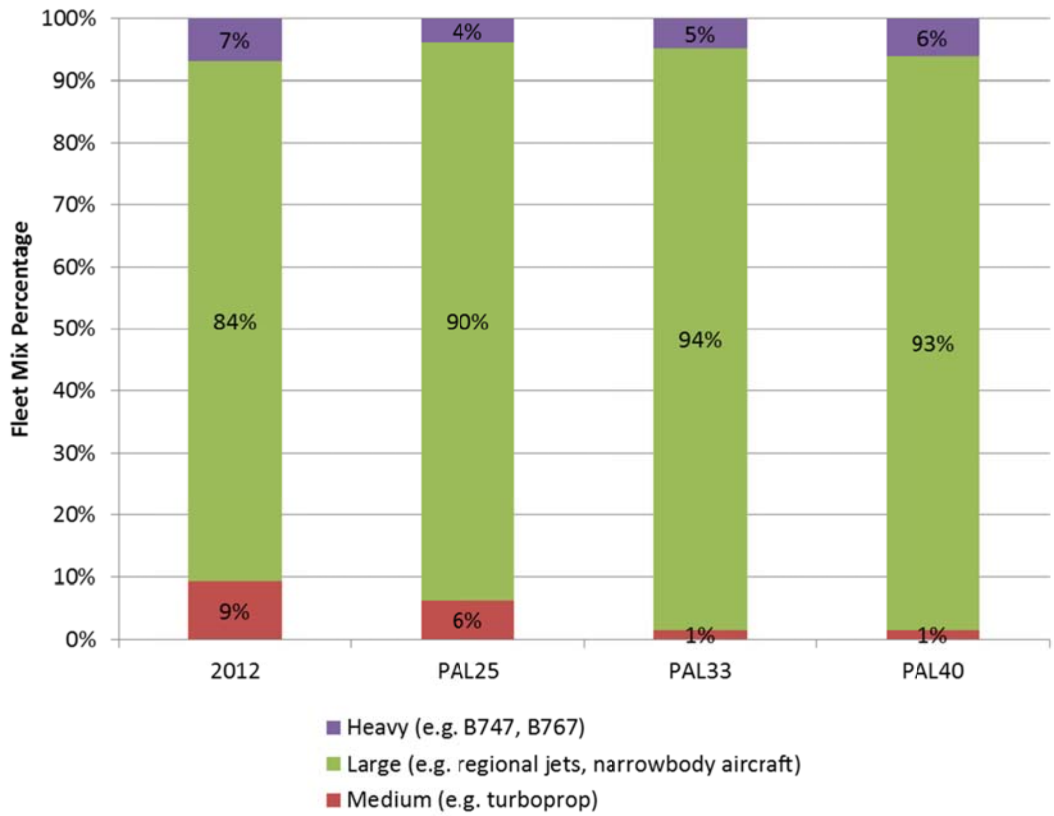
4.2.4 Potential impacts of Technology and Industry Trends

Over the planning period considered in this study, there are a variety of technological advancements and industry changes that could have an impact on airfield facility requirements at the Airport. Key among these are changes in airline fleet mix and technological improvements to the air traffic control system that are part of FAA's Next Generation Air Transportation System (NextGen).

4.2.5 Changes in Airline Fleet Mix

Hourly runway capacity is defined as the maximum number of aircraft operations that can take place on a runway in an hour. Aircraft fleet mix (see Figure 4-5) is one of the factors in determining the runway capacity, since the minimum allowable time separations between aircraft are governed by different combinations of aircraft types using the runways, based on the aircraft's operating characteristics and wake turbulence effects. Over the planning period, it is expected that there will be increased use of larger regional jets (e.g., CRJ-700, CRJ-900) in place of turboprop aircraft and smaller regional jet aircraft (e.g., ERJ-145, Q-400, and Saab 340), and increased use of narrow-body aircraft (e.g., B737-800). The Boeing 757 is expected to be phased out of airline fleets through the planning period and replaced by B737 and A320 aircraft. It is expected that the trend toward a more homogeneous aircraft fleet mix will cause a slight increase in airfield capacity.

Figure 4-5
COMMERCIAL FLEET MIX BY WAKE TURBULENCE CATEGORY



Source: LeighFisher, July 2013.

4.2.6 NextGen Technology

NextGen consists of a set of evolving air traffic control and aircraft navigation technologies designed to transform the U.S. Air Traffic Control system from a ground-based system to a satellite-based system. NextGen is expected to enable increases in airfield capacity through a variety of operational improvements.

One of the core technologies of NextGen is the Global Positioning System (GPS) based Automatic Dependent Surveillance-Broadcast (ADS-B) system. The system will display aircraft position more accurately than legacy radar systems, enabling reductions in achievable average separations between aircraft. Separation buffers built into today's operations will be reduced so that aircraft can achieve average separations closer to published minimum standards. Therefore, arriving aircraft will be more reliably delivered to the runway with the desired separation from the preceding aircraft, potentially increasing arrival capacity. Required Navigational Performance (RNP) will enable aircraft to fly more direct and narrowly defined routes, even during inclement weather conditions. RNP is expected to reduce the required centerline separation for conducting simultaneous arrivals, especially in poor weather conditions. As the Airport has the required runway centerline separation to conduct independent approaches in poor weather conditions, there would not be a benefit from this use of RNP. However, the Airport could benefit by defining more direct aircraft routes for noise abatement or obstacle avoidance purposes.

Surface management, enabled by ASDE-X currently in use at the Airport, is a key NextGen initiative. It is aimed at reducing time spent in the departure queue and reducing taxiway congestion by holding departing aircraft at the gate based on their estimated departure time slot, instead of waiting on the taxiway with engines running. Additionally, surface management can be used for the sequencing and metering of departure aircraft to optimize departure queues based on wake turbulence characteristics or first fix. The implementation of surface management would require improved data quality and integration of operations among the airlines and FAA. The major benefits to be expected are reduction in fuel burn, carbon emissions, ground congestion.

Ground Based Augmentation System (GBAS) augments the GPS signals and provides instrument approach capability. The GBAS landing system, GLS (GNSS Landing System), was first commissioned to be in use at Newark International Airport as a CAT-I system, which was largely driven by United Airlines. In 2013, IAH commissioned its own GBAS landing system. The expected benefits from GBAS are: (1) lower maintenance costs since a single GLS can support multiple runways, (2) reduced ground infrastructure footprint by eliminating standard ILS critical areas, and (3) possible increase in arrival capacity from reduced wake avoidance separation with variable glideslopes and touchdown points.

4.2.7 Optimization of Airspace and Procedures in the Metroplex (OAPM)

The Houston OAPM program identifies the key factors for efficiency and complexities in the Houston Metroplex (which includes George Bush Intercontinental and William P. Hobby airports), and provides recommendations to the existing airspace and flight procedures at the airports. The Environmental Assessment for the OAPM was published in January 2013, and its recommendations are expected to be in place by 2014. The OAPM conceptual proposals include the following changes at the Airport:

- Implement RNAV Standard Terminal Arrival Routes (STARs) with Optimized Profile Descents (OPDs) to minimize radar vectoring and horizontal segment (i.e., “level-offs”) during approach to increase flight efficiency.
- Dual STARs from the northeast and northwest will be used on a consistent basis; dual STARS from the southeast and southwest are also possible as demand dictates.
- Implement RNAV SIDS (area navigation standard instrument departures) procedures such that they are procedurally de-conflicted from arrivals, minimizing intervention by controllers to ensure adequate aircraft separation.
- Implement RNAV/RNP approaches such that shorter routes will be flown, reducing unnecessary delays and taking advantage of aircraft performance capabilities.

It is expected that 89 percent of the Airport's operations are RNAV-capable.* The benefits from the implementation of the above changes are likely to be reductions in aircraft travel times, fuel burn, carbon emissions, noise exposure, and controller workload, rather than increases in runway throughput.

4.2.8 Demand-Capacity Comparison

Demand and capacity were compared to determine if aviation activity levels forecast within the planning horizon would exceed the capacity of the airfield system. An analytical model was used for a preliminary assessment of runway capacity. TAAM was used to assess the existing airspace and airfield system that serves the Airport to study taxiway and operational issues. The following sections summarize the requirements developed through these analyses.

4.2.8.1 Runway Capacity

The planning team used a cumulative-curve queuing model to assess capacity of the existing runway system against forecast demand for aircraft operations. The model estimates average aircraft arrival delays associated with future flight schedules. The future flight schedules were used as the primary input to the model, which include total aircraft operations by passenger, cargo, GA, and military flights, for 2012, PAL25, PAL33, and PAL40. These are the same future flight schedules that were used for the airfield and airspace simulation analysis using TAAM. This section describes the cumulative-curve queuing model for estimating average aircraft arrival delays associated with those flight schedules, as well as the resulting requirement for runway capacity.

Objectives

This aircraft-delay analysis was conducted to answer the question:

> ***At what level of operations (i.e., at what PAL) will additional arrival capacity be needed to accommodate forecast arrival demand at reasonable levels of delay?***

More specifically, the objectives of this analysis are to (1) provide high-level estimates of aircraft delays associated with future flight schedules for various runway uses and weather conditions, and (2) identify the approximate timing of the need for additional airfield capacity to accommodate future demand.

A deterministic queuing model was used for this analysis. It is based on cumulative demand and capacity curves and is well suited for estimating aircraft arrival delays under saturated conditions where demand exceeds capacity for significant periods of time.

Assumed Hourly Arrival Capacities

Aircraft arrival capacities used in this analysis are summarized in Table 4-5. These capacities are the current Airport Arrival Rates (AARs) obtained from the controllers in the IAH airport traffic control tower.

*Environmental Assessment for Houston Optimization of Airspace and Procedures in the Metroplex, FAA, January 2013.

Table 4-5
ASSUMED AIRFIELD ARRIVAL CAPACITIES

Runway-Use Configuration	Hourly Arrival Capacities (AARs)	Percent Occurrence
West-VMC	108	58.4%
West-IMC	80	11.7%
East-VMC	84	21.7%
East-IMC	72	8.2%

VMC = visual meteorological conditions
IMC = instrument meteorological conditions

Source: Airport Arrival Rates (AARs) from IAH Airport Traffic Control Tower.

These AARs are particularly well suited for this analysis because they:

- Are estimated by FAA to represent maximum sustainable hourly arrival rates.
- Represent the adverse impact of the interactions between arrivals on Runway 9-27 and departures on Runways 15L-33R and 15R-33L

Although this method only considers arrival capacities, arrival capacities are a direct consequence of the interactions between departures and arrivals at the Airport.

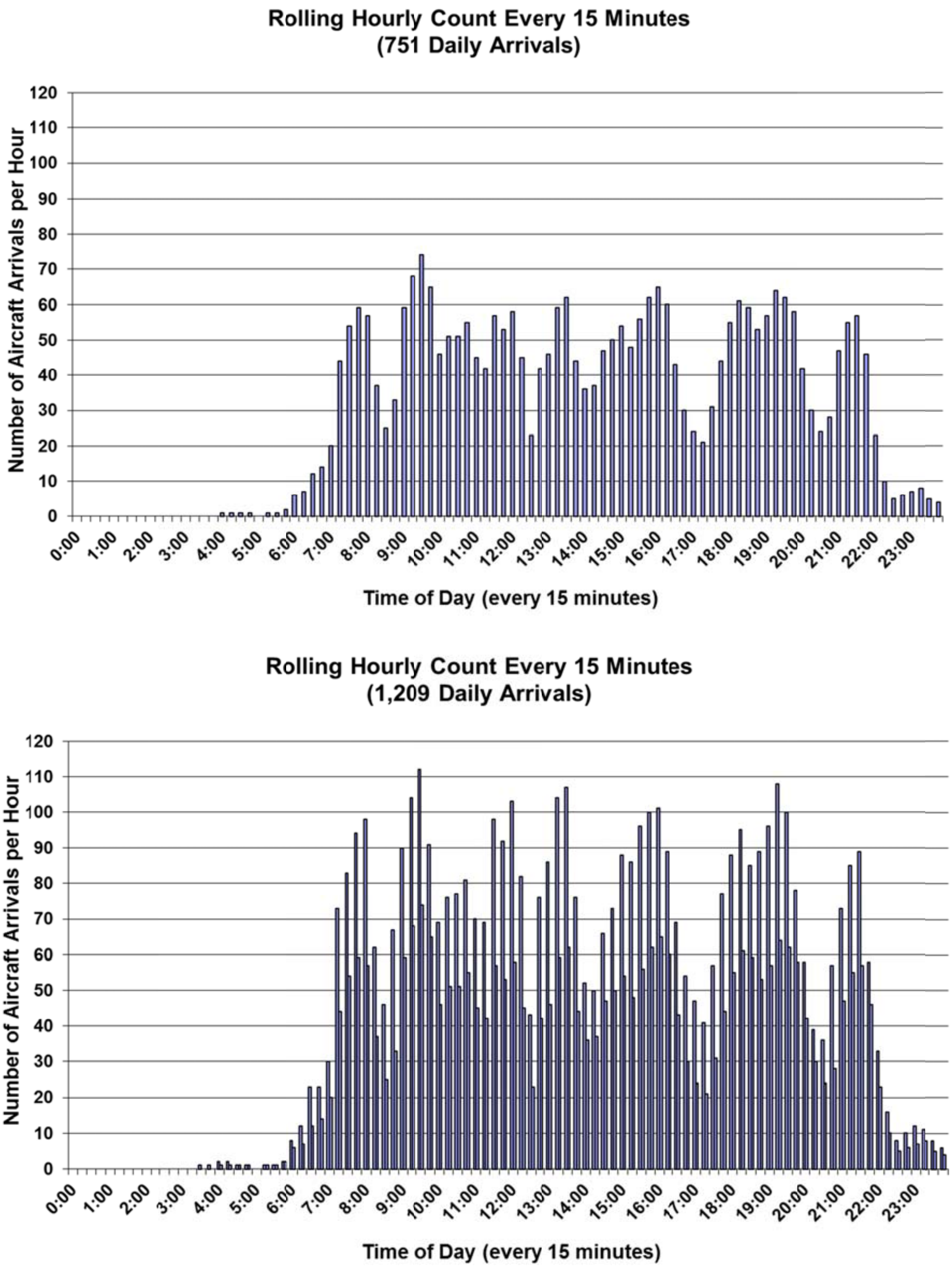
Theoretically, triple approaches could be conducted in both east and west flow at IAH under both visual meteorological conditions (VMC) and instrument meteorological conditions (IMC). If there were no interactions between arrivals on the east-west parallel runways and departures on the diagonal runways, then the AARs in VMC for both east and west flow would be on the order of 108 arrivals per hour, and the AARs in IMC for both east and west flow would be on the order of 96 arrivals per hour. The differences between these values of 108 and 96 and the values shown in Table 4-5 are due to the impacts of the potential airspace interactions between arrivals on Runway 9-27 and departures on Runways 15L-33R and 15R-33L. These dependencies are mitigated procedurally by adding additional spacing between arrivals on Runway 27 in IMC and on Runway 9 in both VMC and IMC.

Rolling 60-Minute Counts of Arrivals

Aircraft delays at the Airport are due in large part to the peaking pattern of demand over the hours of the day. The peaking patterns for arrivals in 2012 and at the PAL40 level of demand are shown in Figure 4-6 as rolling hourly counts of arrivals every 15 minutes. These rolling counts were prepared from the future flight schedules for 2012 and PAL40 and indicate that the current peaking pattern is expected to continue in the future.

Figure 4-6

EXISTING AND FUTURE ARRIVAL PEAKING PATTERNS AT IAH IN 2012 AND PAL40



Source: LeighFisher, July 2013.

Cumulative-Curve Analyses for the PAL40 Level of Demand

Figures 4-7 through 4-10 illustrate the cumulative arrival demand and capacity curves for PAL40. The cumulative arrival curve is prepared by taking the scheduled arrival times in the PAL40 flight schedule and subtracting a taxi-in time of five minutes to represent the approximate time at which the arrival would be expected to appear at the landing threshold. The hourly airfield capacity curve is a straight line plotted at a slope equal to the hourly arrival capacity – the hourly arrival capacity line is only visible when the slope of the cumulative arrival curve exceeds the hourly arrival capacity, which indicates a backup of arrivals waiting to land.

The top graph in each of the Figures 4-7 through 4-10 show the cumulative arrival demand and capacity curves. The horizontal differences between the two curves represent aircraft delays to individual arrivals. The vertical differences between the two curves represent the queue length that each arrival encounters. As noted above, when the slope of the arrival curve is less than the capacity curve, the aircraft delays and queue lengths are zero, and the two curves coincide.

The bottom graph in each of the Figures 4-7 through 4-10 show the aircraft delay experienced by each arrival in the flight schedule. The magnitude of these arrival delays is equal to the horizontal difference between the cumulative arrival curve and the hourly arrival capacity curve.

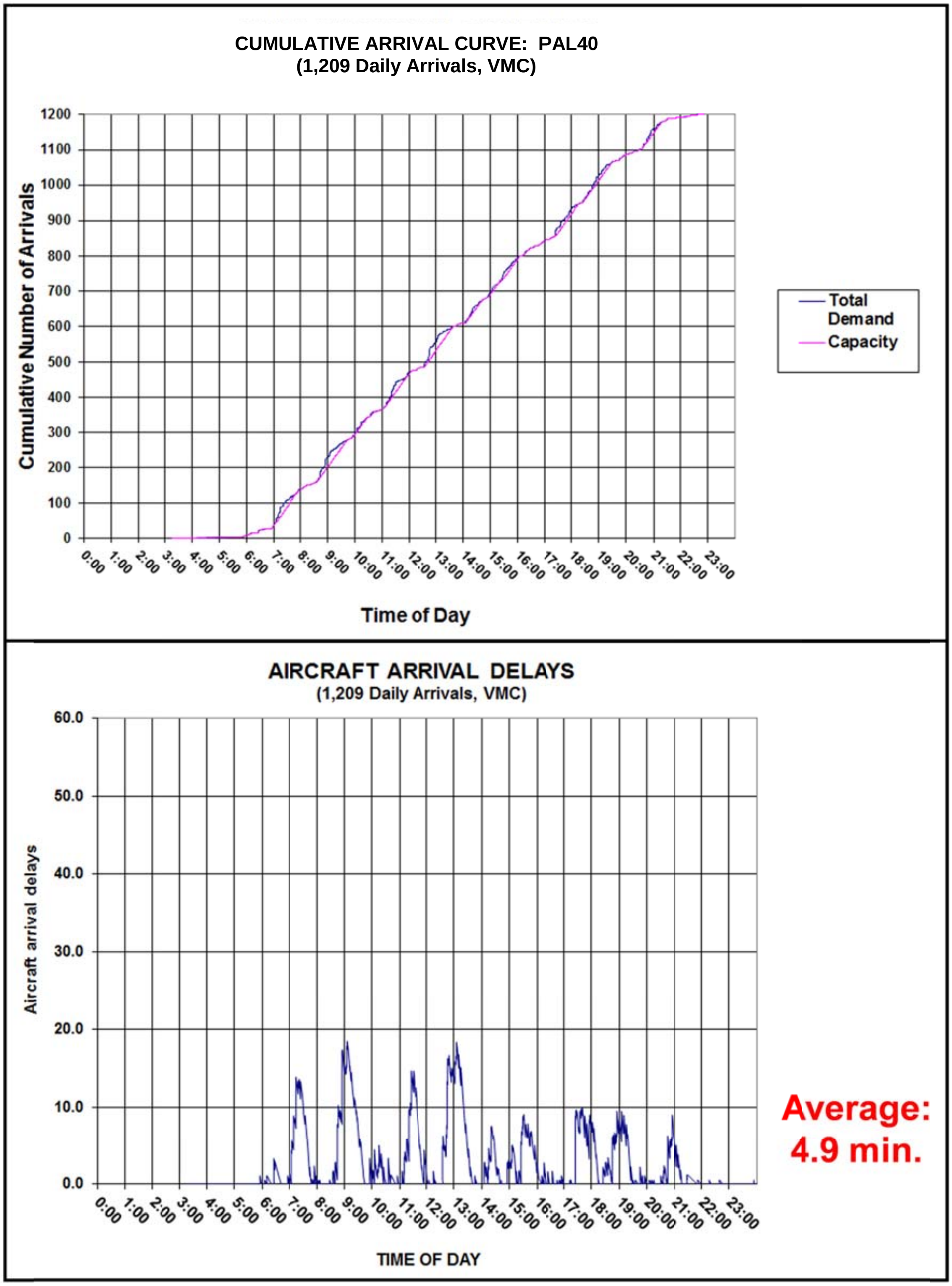
In Figure 4-7, which represents west flow in VMC, the horizontal differences between the two curves are relatively small and appear only in the peaks represented by the steep portions of the cumulative arrival curve. As shown, with the west-flow VMC capacity of 108 arrivals per hour, delays are relatively small with the PAL40 demand level with maximum delays of about 18 minutes per arrival. The average delay under these conditions is estimated to be 4.9 minutes per arrival.

In Figure 4-8, which represents west flow in IMC, the differences between the two curves are more visible indicating significantly higher arrival delays. As shown, with the west-flow IMC capacity of 80 arrivals per hour, delays are greater at the PAL40 demand level with maximum delays of about 40 minutes per arrival. The average delay under these conditions is estimated to be 20.1 minutes per arrival.

In Figure 4-9, which represents east flow in VMC, the differences between the two curves are much greater than for west flow VMC. As shown, with the east-flow VMC capacity of 84 arrivals per hour, delays are very significant with the PAL40 demand level with maximum delays of about 30 minutes per arrival. The average delay under these conditions is estimated to be 13.9 minutes per arrival.

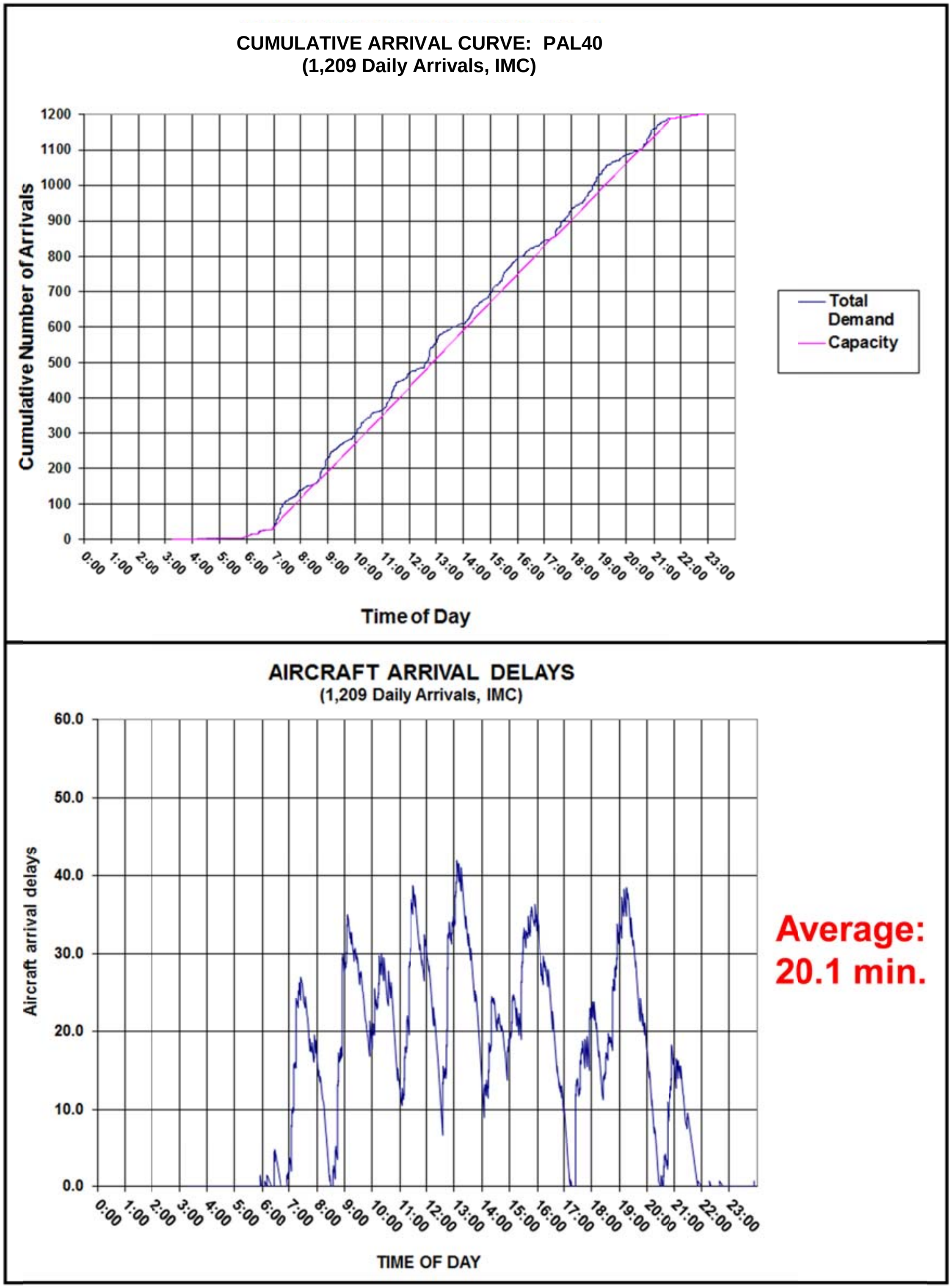
In Figure 4-10, which represents East flow in IMC-C, the differences between the two curves are easily seen, which would indicates excessive arrival delays. With the east flow IMC capacity of 72 arrivals per hour, maximum arrival delays are estimated to exceed 90 minutes per arrival. The average delay under these conditions is estimated to be 61.8 minutes per arrival.

Figure 4-7
CUMULATIVE ARRIVAL CURVE ANALYSIS FOR PAL40 IN WEST FLOW, VMC



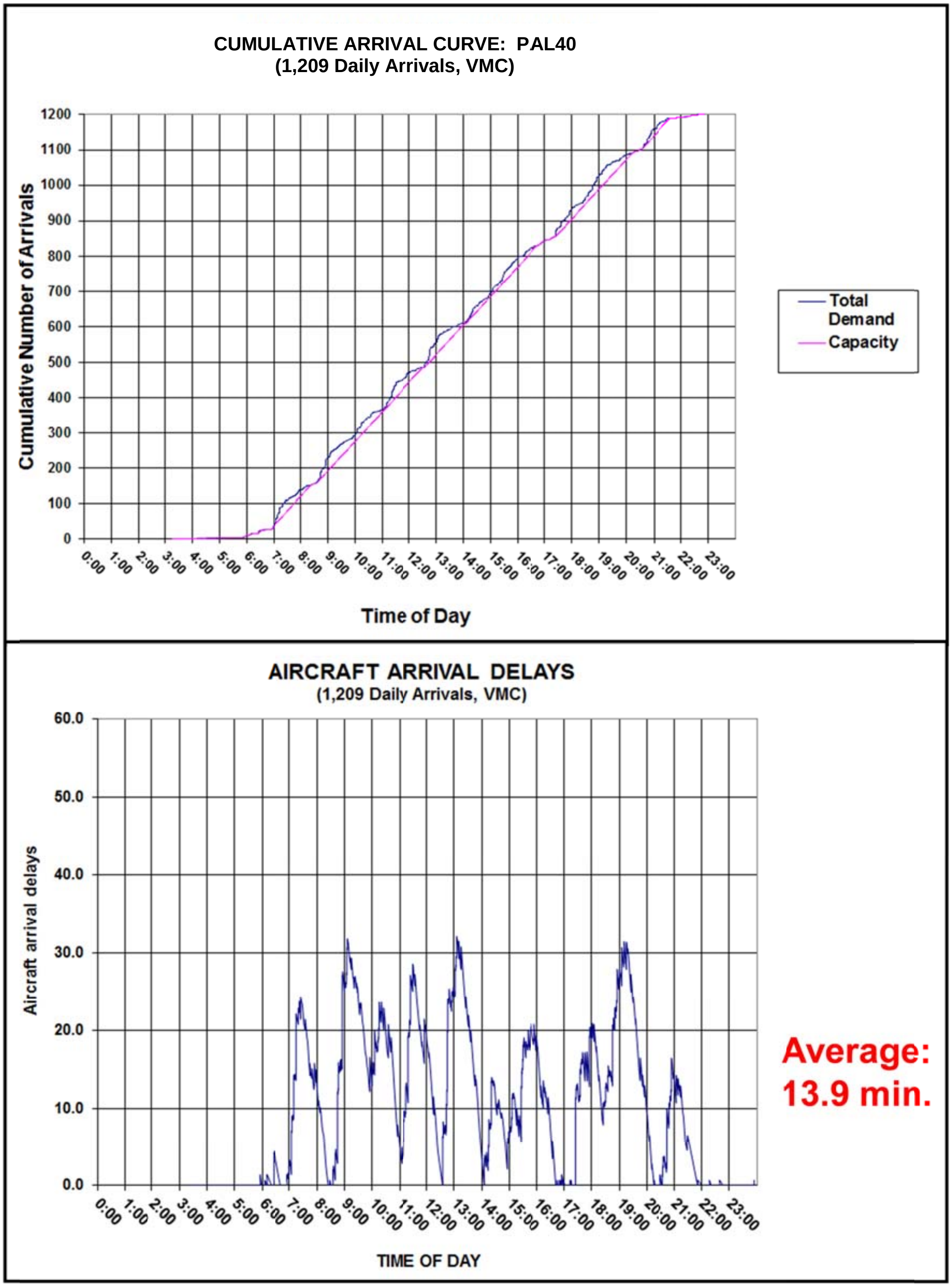
Source: LeighFisher, July 2013.

Figure 4-8
CUMULATIVE ARRIVAL CURVE ANALYSIS FOR PAL40 IN WEST FLOW, IMC



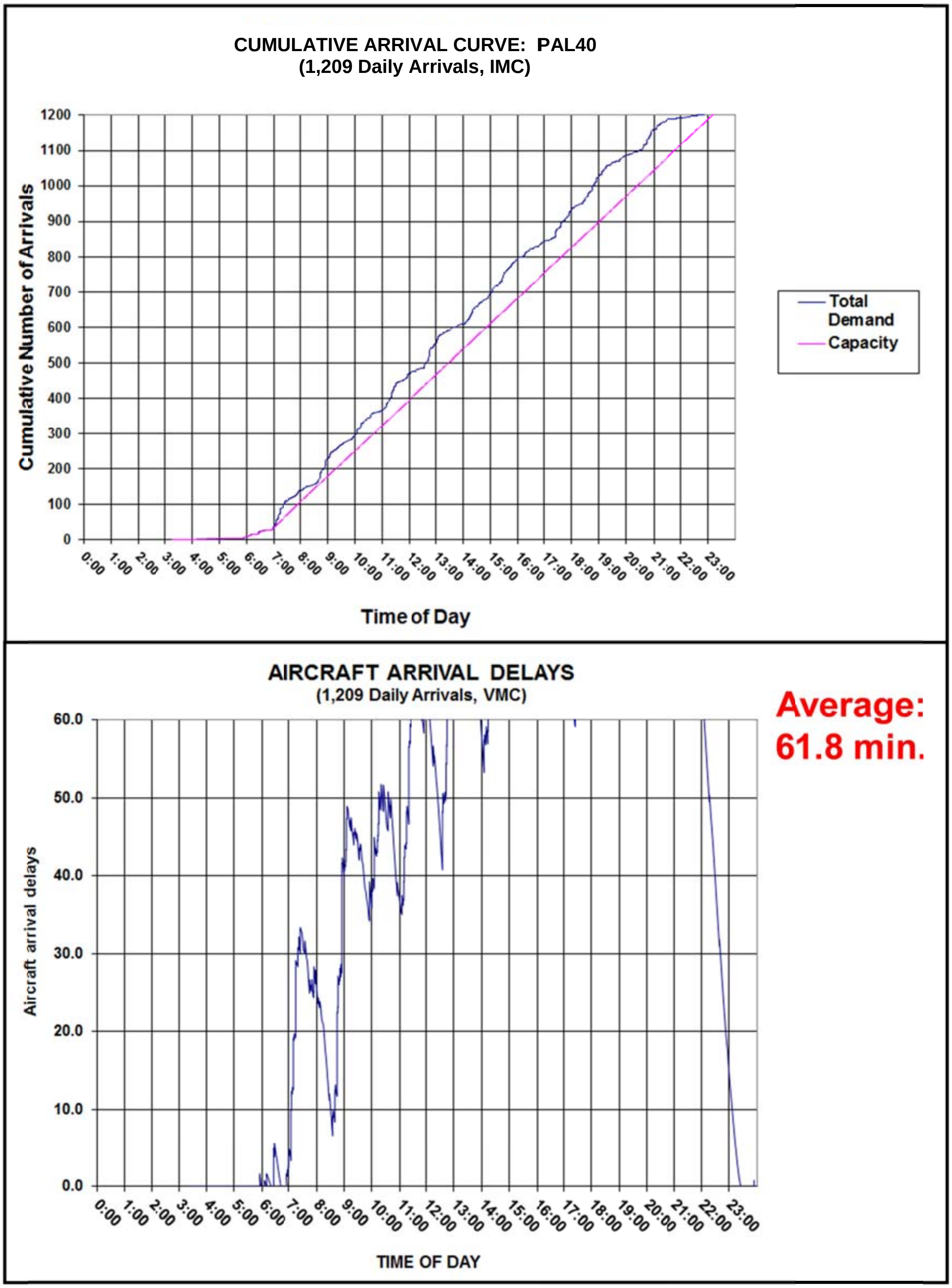
Source: LeighFisher, July 2013.

Figure 4-9
CUMULATIVE ARRIVAL CURVE ANALYSIS FOR PAL40 IN EAST FLOW, VMC



Source: LeighFisher, July 2013.

Figure 4-10
CUMULATIVE ARRIVAL CURVE ANALYSIS FOR PAL40 IN EAST FLOW, IMC



Source: LeighFisher, July 2013.

Summary of Aircraft Arrival Delay Estimates

The results of the deterministic cumulative-curve queuing modeling are presented in Table 4-6 for each of the four major runway use/weather condition combinations: west flow VMC, west flow IMC, east flow VMC, and east flow IMC.

Also shown in Table 4-6 is an estimate of the average annual arrival delay for each of the demand levels. These average annual arrival delays were computed as the weighted average of the arrival delays for the various runway-use and weather conditions using the occurrence percentages shown in the right-hand column of Table 4-6. These average arrival delays are represented by the delay curves (dashed line) in Figure 4-11.

Figure 4-12 shows the same arrival delay curves and also indicates ranges of acceptable and unacceptable average annual arrival delays. For example, the area of Figure 4-12 shaded in green represents average annual arrival delays that would normally be considered as acceptable. The area of Figure 4-12 shaded in blue represents a range of maximum tolerable average annual arrival delays. The area of Figure 4-12 shaded in red represent the range of unacceptable average annual arrival delays.

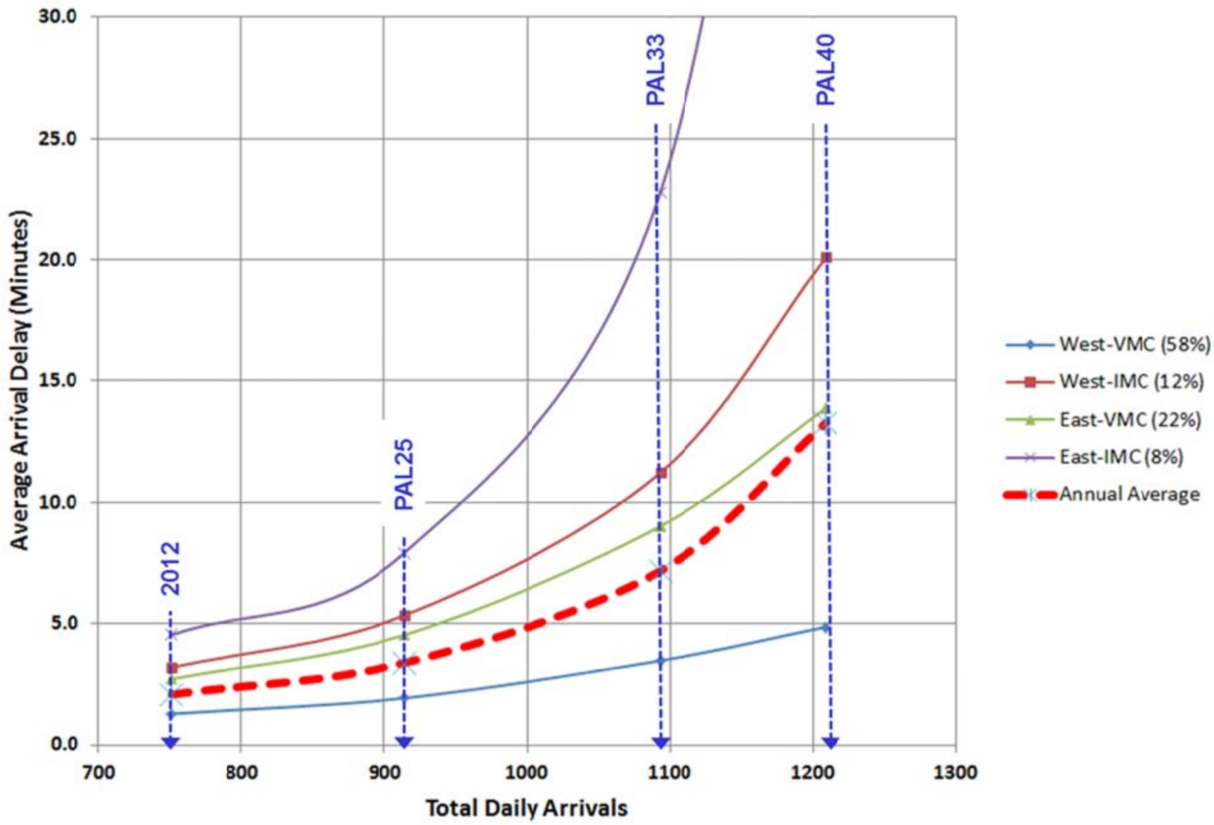
Table 4-6
ASSUMED AIRFIELD ARRIVAL CAPACITIES AND ESTIMATED AVERAGE AIRCRAFT ARRIVAL DELAYS

Runway-Use Configuration	Hourly Arrival Capacity (AARs)	Average Arrival Delay (minutes/arrival)				% Occurrence
		2012	PAL25	PAL33	PAL40	
West-VMC	108	1.3	1.9	3.5	4.9	58.4%
West-IMC	80	3.2	5.3	11.2	20.1	11.7%
East-VMC	84	2.7	4.5	9.0	13.9	21.7%
East-IMC	72	4.5	7.9	22.8	61.8	8.2%
Average Annual Arrival Delay:		2.1	3.4	7.2	13.3	100.0%

Sources: Airport Arrival Rates (AARs) from IAH Airport Traffic Control Tower. Average arrival delay calculations LeighFisher, July 2013.

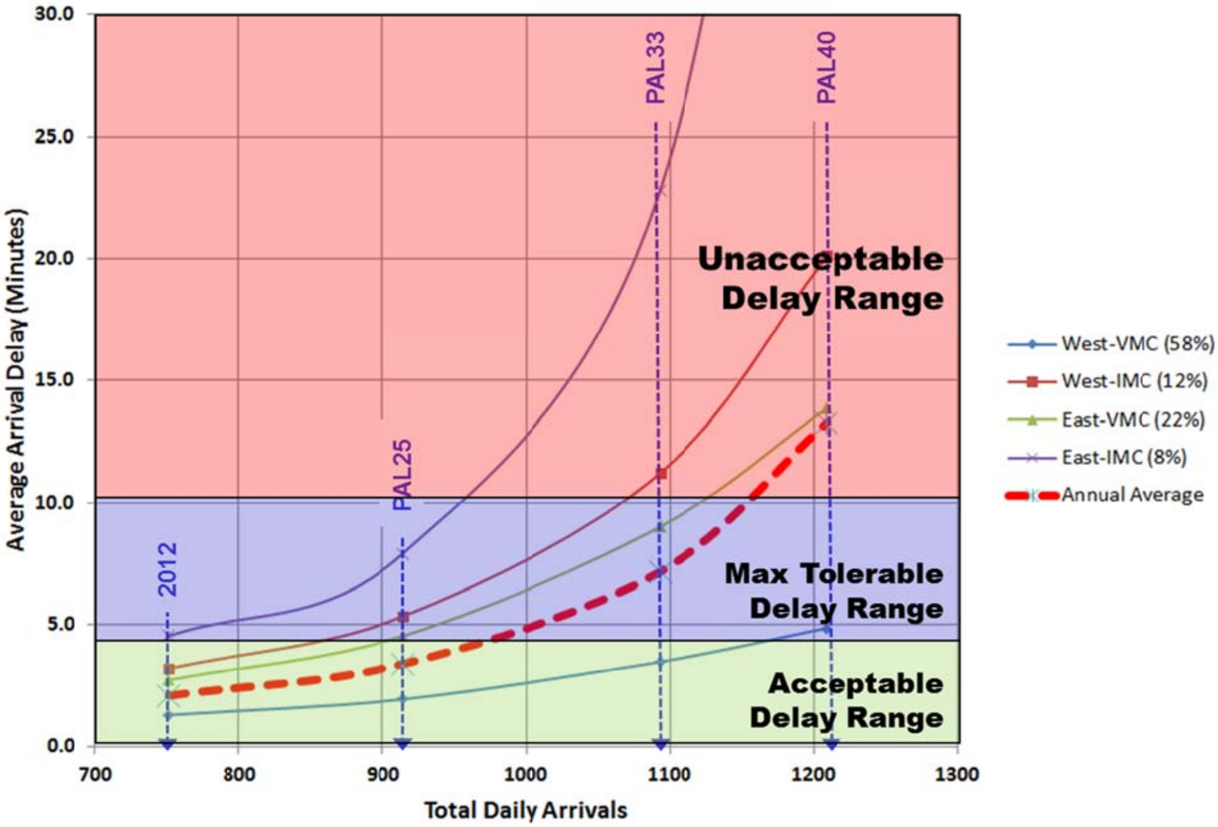
Figure 4-11

AVERAGE AIRCRAFT ARRIVAL DELAY CURVES SHOWING AVERAGE ARRIVAL DELAYS FOR EACH RUNWAY USE/WEATHER CONDITION AND AVERAGE ANNUAL DELAY



Source: LeighFisher, July 2013.

Figure 4-12
AIRCRAFT ARRIVAL DELAY CURVES SHOWING RANGE OF ACCEPTABLE, MARGINAL, AND UNACCEPTABLE AVERAGE ANNUAL ARRIVAL DELAYS



Source: LeighFisher, July 2013.

Conclusions and Recommendations

The deterministic queuing analysis of aircraft arrival delays was prepared for purposes of providing an estimate of when additional airfield capacity will be needed at the Airport. The estimate of the timing for a new runway informed the design of subsequent experiments using TAAM which further specifies the requirement for additional airfield capacity.

The conclusion of this queuing analysis is that additional runway capacity will be needed by the PAL33 demand level, given the following findings:

- Arrival delays with 2012 demand level (751 daily arrivals) are within the acceptable range for all but one runway use and weather condition; notably, east-flow, IMC is approaching an arrival delay estimate that would be considered unacceptable.
- Between PAL25 and PAL33, all average arrival delays are expected to grow to the maximum tolerable delay range (except for west-flow, VMC). Average annual arrival delay is expected to be 7.2 minutes which exceeds acceptable delay range.

- Additional airfield capacity appears to be needed by the PAL33 demand level (1,093 daily arrivals), at which point average arrival delays reach:

  - West-flow VMC: 3.5 minutes
  - West-flow IMC: 11.2 minutes
  - East-flow VMC: 9.0 minutes
  - East-flow IMC: 22.8 minutes
  - Average annual: 7.2 minutes

The ranges of acceptable, maximum, and unacceptable arrival delays will be used for primary screening purposes in the subsequent evaluation of alternatives. Although the assessment of runway requirements is based on average aircraft arrival delay, the need for additional runway capacity should consider variations between different flow directions and weather conditions. In particular, runway dependencies between departures from Runways 15L and 15R and arrivals to the three east-west runways (Runways 8L-26R, 8R-26L, and 9-27) cause an imbalance in arrival and departure capacity between the two primary flow directions. The runway requirements include providing adequate arrival and departure capacity in both flow directions, mitigating the following constraints.

- In west flow, the airfield is constrained by *departure capacity* since only two runways (Runways 15L and 15R) are typically available for departures. During IMC, departure capacity is reduced because Runways 15L and 15R are closely spaced, thus fully dependent. The departure capacity is further reduced because Runway 15L and 15R departures cannot be released with an arrival to Runway 27 within 2 nautical miles of the threshold to protect for a missed approach.

- In east flow, the airfield is constrained by *arrival capacity* since the use of Runways 15L and 15R for departures limits the use of Runway 9 for arrivals. An in-trail separation of 10 nautical miles is required between arrivals to Runway 9, to allow sufficient gap for departures from Runways 15L and 15R. The additional spacing required for arrivals to Runway 9, and interaction with departures from Runways 15L and 15R also reduces arrival capacity as compared to west flow.

- The issues with the current airfield operating scheme will be considered as part of the analysis of runway alternatives to meet projected airfield facility requirements.

4.2.8.2 Taxiway Capacity and Operational Efficiency

To ensure the efficient movement of aircraft and optimal operation of the runway system, adequate taxiway capacity must be provided. Taxiway requirements were developed through observation of the simulation model, TAAM. TAAM is a fast-time airfield and airspace simulation model provided by Jeppesen Optimization Solutions used to simulate the existing airfield and airfield development alternatives. A fast-time model signifies that the time required to run the simulation model is less than real-time (i.e., one minute of simulation covers more than one minute of real-time). TAAM Version 2012.4.0, Release 17, was used for this particular simulation for the following reasons:

1. TAAM provides a superior visual modeling environment that is easily understood by key stakeholders.

2. The model enables the user to program in flexible taxiway, runway, and gate usage rules, which permit realistic modeling of aircraft ground movements. It models the airspace to/from the outer fixes reflecting runway assignment versus a more random flight-to-runway assignment.

3. TAAM has been used previously to evaluate the Airport.

4. TAAM produces performance metrics that are well suited to the assessment of runway, taxiway, and gate operations, including the following:

   – Arrival and departure delays, which represent excess travel times associated with sequencing arrivals and departures with other aircraft.

   – Taxiing delays, which would include any delays incurred while taxiing and in the lineup queue (i.e., waiting in line for departure).

   – Unimpeded aircraft taxiing times, measured as unimpeded OUT-to-OFF times (out of the gate to off the ground) for departures and unimpeded ON-to-IN times (on the ground to in the gate) for arrivals.

Model inputs and assumptions can be found in Appendix B, *Airfield and Airspace Simulation Assumptions,* which discusses the following topics:

- Flight schedule development
- Wind and weather analysis
- Runway use configurations
- Airspace structure and flight procedures
- Runway assignment
- Airfield layout/taxiing patterns
- Terminal layout/gate assignments
- Model calibration

The baseline models developed were used to identify the areas on the airfield which limit the capacity and contribute to airfield congestion and delay to identify taxiway requirements. These models will be used in the subsequent analysis of alternatives to evaluate and compare performance of various alternatives developed to meet demand.

Several opportunities were observed for needed taxiway and operational improvements during the TAAM simulation effort. These requirements are summarized in the following sections.

Redundant Crossfield Taxiway Capability

Currently, Taxiway SF, on the east side of the passenger terminal complex, is the single crossfield taxiway serving the Airport. It is primarily used by arriving aircraft, either (1) arrivals to Runway 9-27 destined for the north passenger apron, or (2) arrivals to Runways 8L-26R or 8R-26L destined for the south passenger apron. Taxiway NR, on the west side of the passenger terminal complex, is a partial crossfield taxiway since it “dead-ends” into Taxiway WB and does not provide a direct connection to the south passenger apron. Additionally, Taxiway NR is limited to aircraft with wingspans of 125 feet or less.

Observation of the TAAM simulation revealed that there is significant taxiway congestion experienced on Taxiway SF. “Head-to-head” traffic flow on Taxiway SF is common, especially in peak arrival periods, contributing to taxiway delays. Discussion with FAA, Airport staff, and airline representatives has confirmed this observation.

Additionally, Taxiway SF represents a single-point of failure; it is critical to the circulation of aircraft, yet there is no other taxiway that provides the same function. If Taxiway SF were to be inoperable (i.e., routine maintenance, aircraft incident, unexpected pavement failure), ground movements at the Airport would be severely challenged and operations would likely reach a near standstill.

Redundant crossfield taxiway capability is required to ensure the reliability of airfield operations. Dual crossfield taxiways are needed to provide bi-directional flow. The crossfield taxiways should be designed to accommodate ADG VI aircraft.

Runway Crossing Capability

Aircraft arriving on Runway 8L-26R bound for the passenger terminal complex must cross Runway 8R-26L either at Taxiway NP or Taxiway NE. The runway crossings increase aircraft taxiing time for arrivals to Runway 8L-26R and reduce arrival throughput on Runway 8R-26L. As observed in the TAAM simulation, aircraft arriving on Runway 8L-26R form a long queue on Taxiway NP waiting to cross the runway. The impacts of runway crossings are somewhat mitigated with the use of the land-and-hold-short procedure in east flow. Additionally, in poor weather, aircraft might taxi via Taxiways EE, EA or EB, and NB, which provides independent end-around taxiway capability, albeit with additional taxiing distance.

Additional taxiway infrastructure which would expedite runway crossings is required to reduce aircraft taxiing times and ensure that runway throughput is not impacted.

Departure Queuing and Sequencing

Area for queuing and sequencing is limited near the ends of the primary departure runways, Runway 15L, 15R, and 9. For departures on Runways 15L and 15R, queues which build up on Taxiways NA and NB impact taxiway circulation. Additionally, minimal queuing area is provided near the end of Runway 9 before impacting Taxiways RA and RB, which are critical to circulation. Additional departure queuing capacity near the runway ends of the primary departure runways is required to sequence aircraft and reduce taxiway congestion.

4.2.9 Airfield and Airspace Conclusions

The results of the requirements analysis indicate that there will be sufficient runway capacity to accommodate forecast demand through PAL33, albeit marginally during east flow and under poor weather conditions. Average aircraft delays at the Airport are expected to remain at an acceptable level through PAL25, and begin to reach unacceptable thresholds nearing PAL33. In the near-term, projects should be undertaken to improve taxiway flows and surface movements, namely to provide redundant crossfield taxiway capability, expedite runway crossings, and improve departure queuing and staging. More significant airfield improvements, including additional runway capacity, will be required to meet PAL40 demand levels. Various options to meet these requirements will be explored in the alternatives analysis.

4.3 PASSENGER TERMINAL COMPLEX REQUIREMENTS

This section presents an assessment of passenger terminal complex requirements which covers both aircraft gates and key passenger and baggage processing facilities.

4.3.1 Aircraft Gate Requirements

The assessment of overall gate requirements for the airport focused on (1) evaluating the capacity of the Airport's existing gate inventory to accommodate forecast demand, and (2) identifying any additional gate capacity that would be needed at future demand levels.

4.3.1.1 Existing Gate Supply

Table 4-7 summarizes the existing gate supply at IAH by type of gate and location. Also indicated are the airline groups that currently use gates at each location. For Terminals C, D and E, the number of gates presented in Table 4-7 is a range. This range is provided because these locations include a number of dependent gate positions (i.e., positions that can accommodate either two small aircraft or one large aircraft). The low end of the range represents the total if only large aircraft are accommodated and the high end of the range represents the total if only smaller aircraft are accommodated.

Table 4-7
SUMMARY OF EXISTING GATES

Type of Gate Location	Gates	Used by airline group(s)
Domestic		
A North	17	Non-United domestic airlines + United
A South	10	Non-United domestic airlines
B ICE	17	United regional
B North	16	United regional
B South	30	United regional
C North	12 to 13	United mainline
C South	15 to 16	United mainline
Total Domestic	117 to 119	
International		
D	11 to 12	Foreign flag airlines + United
E	16 to 23	United mainline
Total International	27 to 35	
Total Domestic + International	144 to 154	

Source: LeighFisher, January 2013.

As shown in Table 4-7, gate use by non-United domestic airlines is limited to Terminals A and D, and gate use by foreign flag airlines is limited to Terminal D, while United uses gates at all of the Airport's terminals. Most of United's activity is accommodated at Terminals B, C and E. With the exception of international arrivals by United's regional affiliates, all of which are accommodated at Terminal D, United typically only uses gates at Terminals A and D when Terminal B, C, and E gates are not available.

Gates in Table 4-7 are designated as international gates if they have a loading bridge that connects to sterile passenger circulation providing access to the Federal Inspection Station (FIS). Currently international gates at Terminal D are typically only used for international flights. United's international gates at Terminal E are operated as "swing" gates, with their use prioritized for international flights, however these gates do frequently accommodate domestic flights when they are not needed for international activity.

4.3.1.2 Gate Requirements Methodology

Gate requirements were assessed using LeighFisher's proprietary Gate Model. The Gate Model is a planning tool that assigns flights to gates. In performing these assignments the Gate Model considers physical, policy, and operational constraints that include:

1. The maximum size aircraft that can be accommodated on the gate.
2. Any physical dependencies that exist between adjacent gate positions that would restrict operations.

3. Rules that stipulate which flights are permitted to use which gates and in what priority, as well as the actions that the model is allowed to perform when attempting to gate a flight. For example, if an aircraft is on the ground for a sufficiently long time it may be handled as separate arrival and departure gate operations and involve towing to and from a remote position in the interim.

4. Operational parameters that specify detailed assumptions such as the minimum amount of gate occupancy time typically required for a full turnaround operation, an arrival operation, or a departure operation, for example. These also include assumptions for buffer times, i.e., the minimum amount of "down" time typically reserved between successive operations on a gate.

Estimating gate requirements with the Gate Model involved the following procedure. Flights in an ADPM flight schedule were assigned to gates sequentially one flight at a time. The sequence of gate assignment is determined by the model rules. These rules were set up to reflect gate management and policies and procedures that typify current operations at the Airport. The model first attempts to gate a flight on an existing gate. If no suitable and permitted existing gate is available then the model generates a new gate and assigns the flight to the new gate. These steps are repeated until all flights are gated. The number of gates required to accommodate the planning day flight schedule is equal to the number of existing gates that were assigned one or more flights plus the number of new gates generated by the model.

4.3.1.3 Estimated Gate Requirements

Table 4-8 presents the estimated number of gates required by type and size of gate for the baseline 2012 demand level and three planning activity levels. For purposes of this analysis, 'gate type' is either domestic or international, and gate sizes are classified using the FAA's Airplane Design Group standards. Table 4-8 presents absolute gate counts estimated for each aircraft size category. A "narrowbody equivalent" (NBEQ) gate count, which adjusts for aircraft size by indexing all gates to a standard size, is also presented in the last row of Table 4-8. The standard aircraft used in this analysis was a Boeing 737-900 winglet aircraft with a wingspan of 117.4 feet. A gate's NBEQ value is equal to the wingspan of the largest aircraft that the gate can accommodate divided by 117.4.

As shown in Table 4-8, shortfalls are projected in the number of total gates at PAL33 and PAL40. The estimated shortfall of 32 gates projected at PAL33 increases to a shortfall of 48 gates at PAL40. Also shown in Table 4-8, most of the projected shortfall is in international gates. The shortfall in international gates is also projected to occur earlier, starting with a shortfall of 7 gates at PAL25 and increasing to 34 gates by PAL40. Within the international category, estimated gate shortfalls are projected in all aircraft size categories except Group IV, which is comprised largely of the Boeing 757 which is projected to be retired from the fleet mix over time and replaced with various Group III aircraft. Within the domestic category, nearly the entire projected gate shortfall is in the Group III size category.

Table 4-8
GATE REQUIREMENTS

Type of Gate Airplane Design Group *(a)*	Existing Number Provided *(b)*	Estimated Requirement By Activity Level				Surplus (Deficiency) By Activity Level			
		BASE	PAL25	PAL33	PAL40	BASE	PAL25	PAL33	PAL40
Domestic									
Group II	66	39	43	47	39	27	23	19	27
Group III	36	27	56	83	89	9	(20)	(47)	(53)
Group IV	17	13	6	2	1	4	11	15	16
Group V	--	--	--	--	4	--	--	--	(4)
Group VI	--	--	--	--	--	--	--	--	--
Total Domestic	119	79	105	132	133	40	14	(13)	(14)
International *(c)*									
Group II	--	4	9	8	4	(4)	(9)	(8)	(4)
Group III	18	15	18	30	47	3	--	(12)	(29)
Group IV	8	5	3	1	1	3	5	7	7
Group V	9	8	10	11	11	1	(1)	(2)	(2)
Group VI	--	--	2	4	6	--	(2)	(4)	(6)
Total International *(c)*	35	32	42	54	69	3	(7)	(19)	(34)
Domestic + International									
Group II	66	43	52	55	43	23	14	11	23
Group III	54	42	74	113	136	12	(20)	(59)	(82)
Group IV	25	18	9	3	2	7	16	22	23
Group V	9	8	10	11	15	1	(1)	(2)	(6)
Group VI	--	--	2	4	6	--	(2)	(4)	(6)
Total Domestic + International	154	111	147	186	202	43	7	(32)	(48)
Narrowbody Equivalent Gate		125	139	178	204	29	15	(24)	(50)

(a) Size classification based on FAA Airplane Design Group wingspan dimensions: Group II = 49 to 79 feet; Group III = 79 to 118 feet; Group IV = 118 to 171 feet; Group V = 171 to 214 feet; Group VI = 214 to 262 feet.
(b) Number of gates provided in the existing terminal platform upon completion of the Terminal B South renovations. These counts assume that dependent positions at Terminals C, E and D are occupied by smaller aircraft. Hardstand positions are not included.
(c) Gates providing sterile access to FIS facilities for arriving international passengers may also be used by domestic flights.

Source: LeighFisher, June 2013.

4.3.2 Passenger and Baggage Processing Facility Requirements

In addition to gates, detailed terminal facility requirements were assessed for each of the Airport's existing unit terminals. For purposes of this assessment the assumed distribution of activity among the terminals was based on how passengers are currently directed to their respective terminals by roadway signage when entering the terminal complex, as depicted in Table 4-9. It is expected that this assumed distribution may change as alternatives for terminal development are evaluated with HAS and airline representatives.

Table 4-9
ALLOCATION OF ACTIVITY BY TERMINAL

	Activity accommodated	
Existing terminal	Airline group(s)	Passenger/baggage flow(s)
A	Non-United domestic airlines	Departing domestic Arriving domestic
B	United regional	Departing domestic Arriving domestic
C	United mainline	Departing domestic Arriving domestic
E	United mainline United regional	Departing international
Terminal D	Foreign flag airlines	Departing international
FIS	Foreign flag airlines United mainline—international United regional—International	Arriving international

Source: LeighFisher, July 2013.

4.3.2.1 Passenger and Baggage Processing Methodology

The following sections describe the facilities assessment process by functional element. All analysis was based on the ADPM passenger airline flight schedules.

Ticketing and check-in

The assessment of check-in facility requirements focused on estimating the number of processing facilities required to accommodate the peak period volume of originating passengers who are checking baggage or printing boarding passes at the Airport. These facilities were assumed to include three types of processors in the terminal check-in lobbies as well as skycap positions at the terminal curbsides. The terminal check-in lobby facilities include airline agent positions, kiosk positions that accept passengers with checked baggage, and kiosk positions for passengers with carry-on baggage only.

The estimated peak period demand for check-in facilities was developed using LeighFisher's Flow Model. Specific originating passenger flows were developed for each terminal check-in location shown in Tables 4-10 through 4-14 based on the activity allocation described in Table 4-9. This involved calculating each departing flight's originating passenger total and applying earliness distributions to estimate passengers' arrival process at the Airport. Factors were then applied to the originating passenger flows to estimate the passenger flows that would use airport check-in facilities, and the distribution to the four types of check-in facilities (i.e., skycap, agent, kiosk, bag drop). These factors were derived from information provided in documentation for the *Peak Week Survey* conducted in the summer of 2010.

The peak 15-minute demand was determined and used as the basis for calculating the number of processors required. A surge factor was applied to the peak 15-minute demand to account for random variation in the flow rate and ensure that a maximum 15-minute service time standard could be met with a reasonable level of confidence. The number of processors required is based on the surged 15-minute demand divided by the 15-minute throughput capacity per server.

Passenger Security Screening Checkpoints

The assessment of passenger security screening checkpoints (SSCPs) focused on estimating the number of checkpoint lanes required to accommodate the peak period volume of originating passengers. Also included were SSCPs for transferring international passengers that are processed at the FIS.

The estimated peak period demand for passenger security screening checkpoints was developed using LeighFisher's Flow Model. This involved calculating each departing flight's originating passenger total and applying earliness distributions to estimate passengers' arrival process at the airport. Specific originating passenger flows were developed for each checkpoint location shown in Tables 4-10 through 4-14 based on the activity allocation describes in Table 4-9. The Flow Model was also used to estimate arriving international transfer passengers at SSCP checkpoints at the FIS.

The peak 10-minute demand was determined and used as the basis for calculating the number of SSCP lanes required. Based on TSA's published goal to keep wait times below 10 minutes, a surge factor was applied to the peak 10-minute demand to account for random variation in the flow rate and ensure that the 10-minute service standard could be met with a reasonable level of confidence. The number of SSCP lanes required is determined based on the surged 10-minute demand divided by the 10-minute throughput capacity per lane.

Checked Baggage Screening

The assessment of checked baggage screening facilities focused on estimating the number of explosives detection system (EDS) machines required to accommodate the peak period volume of originating checked baggage. Transfer bags from international arrivals must also be screened and the estimated of the flow of arriving international transfer at international recheck facilities bags were included in the assessment of Terminals C and E.

The estimated peak period demand for checked baggage screening was developed using LeighFisher's Flow Model. This involved calculating each departing flight's originating baggage total and applying earliness distributions to estimate the baggage arrival process at the airport. Specific originating baggage flows were developed for each baggage screening location shown in Tables 4-10 through 4-8 based on the activity allocations described in Table 4-9. In assessing Terminal C/E, arriving international l transfer baggage flows were developed with the flow model in a similar process. Instead of the earliness distribution used for originating flows, a lag distribution was applied to approximate the metering effect of FIS processes that arriving international transfer passengers and baggage must undergo before rechecking.

The peak 10-minute demand was determined and used as the basis for calculating the number of EDS machines required. Based on TSA's published 10-minute service standard, a surge factor was applied to the peak 10-minute demand to account for random variation in the flow rate and ensure that the service standard could be met with a reasonable level of confidence. The number of EDS machines required is based on the surged 10-minute demand divided by the 10-minute throughput capacity per EDS.

Outbound Baggage Handling

The assessment of outbound baggage handling facilities focused on estimating the peak number of baggage carts or containers that would need to be staged in the baggage makeup areas at any time during the analysis day.

The peak number of cart staging positions required was developed using a queuing analysis described as follows. The departing flight schedules were first analyzed to determine each individual flight's cart staging requirement. A flight's staging requirement is defined by the number of carts required to accommodate its total baggage load and by the block of time that must be allotted to stage these carts. The staging time required for a flight is based on its scheduled departure time and by assumed offsets from this time that mark the beginning and end of staging. Once each flight's staging requirement is determined, the peak accumulation of carts can be found by stepping through the analysis day in 10-minute steps and finding the cumulative number of carts staged at each step. The cumulative number staged at each step is equal to the cumulative number of carts that have begun staging minus the cumulative number that have ended staging.

FIS Primary Inspection

The assessment of facilities for FIS primary inspection focused on estimating the number of agent booths and the amount of queue area required to accommodate the peak hour volume of arriving international passengers.

The estimated peak period flow of arriving international passengers was developed using LeighFisher's Flow Model. This involved calculating each arriving international flight's passenger load and finding the peak 60-minute period. Planning standards based on peak hour flows are published by the U.S Customs and Border Protection in *Airport Technical Design Standards for Passenger Processing Facilities* (August 2006 edition). The estimated requirements for booths and queue area were derived from this reference.

Baggage Claim (Domestic and International)

The assessment of baggage claim facilities focused on estimating the amount of baggage claim device frontage required to accommodate the number of passengers who would be simultaneously present in the baggage claim during the peak period of the day.

Peak baggage claim frontage requirements were developed using a queuing analysis described as follows. The arriving flight schedule was first analyzed to determine each individual flight's baggage claim frontage requirement. A flight's baggage claim frontage requirement is defined by the number of passengers claiming bags, the amount of frontage required per passenger, and by the block of time that frontage must be allocated to process the flight. The time allocated to a flight is based on its scheduled arrival time, an assumed offset from the scheduled arrival time that marks the beginning of the time allocation and by an assumed amount of time typically required to clear a flight of that size. Once each flight's frontage requirement is determined, the peak frontage required is found by stepping through the analysis day in 10-minute steps and finding the cumulative frontage required at each time step. The cumulative frontage required at each step is equal to the cumulative frontage for flights that have begun allocation minus the cumulative frontage for flights that have cleared.

International Recheck

The assessment of international recheck facilities focused on estimating the number of recheck agent positions that would be required to process the peak period volume of international transfer passengers as they exit the FIS.

The estimated peak period flow of international transfer passengers was developed using LeighFisher's Flow Model. This involved calculating each arriving international flight's load of transfer passengers and applying a lag distribution to approximate the metering effect of FIS processing that passengers experience prior to their arrival at the recheck facilities. The peak 10-minute demand was determined and used as the basis for calculating the number of recheck positions required. A surge factor was applied to the peak 10-minute demand to account for random variation in the flow rate and ensure that a 10-minute service standard could be met with a reasonable level of confidence. The number of recheck positions required is based on the surged 10-minute demand divided by the 10-minute throughput capacity per recheck agent position.

4.3.2.2 Requirements by Terminal

Tables 4-10 through 4-8 present estimated facility requirements by terminal for key passenger and baggage processing functions based on the activity allocation described above. The following paragraphs provide a summary discussion by terminal.

Terminal A. Table 4-10 presents requirements for the non-United domestic carriers (including Air Canada) that are currently accommodated at existing Terminal A. As shown in Table 4-10, Terminal A's existing passenger and baggage processing facilities are estimated to provide more than adequate capacity for these carriers through the forecast period. Additional capacity needs are projected for passenger security screening checkpoints, with one new lane required at PAL25 and five new lanes by PAL40. The need for additional checked baggage screening capacity is also projected, but not until PAL40.

Terminal B. Table 4-11 presents requirements to serve domestic activity by United's regional affiliates at existing Terminal B. As shown in Table 4-11, while baggage claim facilities are projected to be adequate through the forecast period, modest additions are projected to be needed for check-in facilities and checked baggage screening facilities. An area of potential concern is outbound baggage handling which appears to be somewhat undersized. However, based on observations of the operation, United's baggage handling operation likely allows for more efficient space utilization than was assumed in this this conservative analysis.

Terminals C and E. Table 4-12 presents requirements to serve United's mainline domestic activity and departing international activity at Terminals C and E. As shown in Table 4-12, existing Terminal C check-in facilities are projected to be adequate to serve United's domestic mainline passenger demand through the forecast period. Existing Terminal E check-in facilities to serve United's international passengers are projected to need very modest additions at PAL33, and more significant additions at PAL40. Passenger security screening checkpoints in both Terminals C and E are projected to be adequate through PAL25, needing modest increased capacity by PAL33, and more significant capacity by PAL40. A modest increase in checked baggage screening capacity is projected to be needed at PAL25 with more significant increases projected for PAL33 and PAL40. Significant increases in checked baggage screening capacity and outbound baggage handling capacity are projected to be needed beginning at PAL33 and approaching PAL40. Existing domestic baggage claim facilities in the Terminal C baggage claim lobby are projected to be adequate through the forecast period.

Terminal D. Table 4-13 presents estimated requirements to serve international departure activity by foreign flag carriers at existing Terminal D. As shown in Table 4-13, check-in capacity is projected to be generally adequate until PAL40 when 10 additional check-in positions would be needed. The need for additional passenger security screening lanes is projected with one new lane required at PAL25, two new lanes at PAL33, and three new lanes at PAL40. Checked baggage screening capacity is projected to be adequate through the forecast period as is outbound baggage handling capacity.

Central FIS. Table 4-14 presents estimated requirements to serve international arrivals activity by United Airlines and the foreign flag airlines at the Central FIS. As shown in Table 4-14, deficiencies are projected by PAL25 in all functional areas that were assessed. The number of double-agent booths for primary inspection is projected to be only slightly deficient at PAL25 but by PAL40 approximately 21 new booths are projected to be required. The amount of queue area currently provided for primary inspection exceeds Customs and Border Protection published standards in terms of area per booth so it is not projected to be deficient until PAL40. However, if needed increases in the number of booth are not provided, then queuing requirements will increase beyond that shown in Table 4-14, in which case queue area deficiencies would occur earlier than PAL40.

Baggage claim facilities are projected to be deficient by PAL25 when three new devices would be required. By PAL40, nine additional claim devices are projected to be required. Recheck facilities to serve United's international transfer passengers as they exit the FIS were assessed to be slightly deficient at the baseline activity level and are projected to worsen through the forecast period. The number of passenger security screening checkpoint lanes that serve international transfer passengers are projected to be deficient by PAL25 with a shortfall of three lanes. This shortfall is projected to increase to nine lanes by PAL40.

Table 4-10
TERMINAL A FACILITY REQUIREMENTS

Functional Element Description	Existing Provided	Estimated Requirement Planning Activity Level				Surplus (Deficiency) Planning Activity Level			
		BASE	PAL25	PAL33	PAL40	BASE	PAL25	PAL33	PAL40
DEPARTURES FUNCTIONS									
Check-in									
Number of Lobby Positions									
Agent	66	21	29	35	39	45	37	31	27
Kiosk / bag drop	--	6	9	10	11	(6)	(9)	(10)	(11)
Kiosk / no bag drop	27	4	5	6	7	23	22	21	20
Lobby Total Positions	93	31	43	51	57	62	50	42	36
Curb/Skycap	6	3	4	4	5	3	2	2	1
Total Number of Positions	**99**	**33**	**46**	**56**	**62**	**66**	**53**	**43**	**37**
Passenger Security Screening Checkpoints									
Number of Lanes									
A North	3	3	3	3	4	--	--	--	(1)
A South	3	3	4	6	7	--	(1)	(3)	(4)
Total Number of Lanes	**6**	**6**	**7**	**9**	**11**	**--**	**(1)**	**(3)**	**(5)**
Checked Baggage Screening									
Number of EDS Machines									
A North East	2	2	2	2	2	--	--	--	--
A North West	2	2	2	2	2	--	--	--	--
A South East	2	2	2	2	3	--	--	--	(1)
A South West	2	2	2	2	3	--	--	--	(1)
Total Number of EDS Machines	**8**	**8**	**8**	**8**	**10**	**--**	**--**	**--**	**(2)**
Outbound Baggage Handling									
Number of Staging Positions									
A North Bag Room	65	24	32	33	42	41	33	32	23
A South Bag Room	45	32	50	60	68	13	(5)	(15)	(23)
Total Number of Staging Positions	**110**	**56**	**82**	**93**	**110**	**54**	**28**	**17**	**--**
Number of Makeup Devices									
A North Bag Room	4	1	2	2	2	3	2	2	2
A South Bag Room	3	2	3	3	3	1	1	--	--
Total Number of Makeup Devices	**7**	**3**	**4**	**5**	**6**	**4**	**3**	**2**	**2**
ARRIVALS FUNCTIONS									
Domestic Baggage Claim									
Claim Device Frontage (LF)									
A Bag Lobby	870	440	492	614	698	430	378	256	172
Total Frontage (LF)	**870**	**440**	**492**	**614**	**698**	**430**	**378**	**256**	**172**
Number of Claim Devices	--	--	--	--	--	--	--	--	--
A Bag Lobby	6	4	4	5	6	2	2	1	--
Total Number of Devices	**6**	**4**	**4**	**5**	**6**	**2**	**2**	**1**	**--**

Source: LeighFisher, June 2013.

Table 4-11
TERMINAL B FACILITY REQUIREMENTS

Functional Element Description	Existing Provided	Estimated Requirement Planning Activity Level				Surplus (Deficiency) Planning Activity Level			
		BASE	PAL25	PAL33	PAL40	BASE	PAL25	PAL33	PAL40
DEPARTURES FUNCTIONS									
Check-in									
Number of Lobby Positions									
Agent	21	13	16	16	16	8	5	5	5
Kiosk / bag drop	--	4	5	5	5	(4)	(5)	(5)	(5)
Kiosk / no bag drop	--	2	3	3	3	(2)	(3)	(3)	(3)
Lobby Total	**21**	**20**	**24**	**23**	**23**	**1**	**(3)**	**(2)**	**(2)**
Curb/Skycap	--	2	2	2	2	(2)	(2)	(2)	(2)
Terminal B Total	**21**	**21**	**26**	**25**	**25**	**(0)**	**(5)**	**(4)**	**(4)**
Passenger Security Screening Checkpoints									
Number of Lanes									
B Lobby	4	3	4	4	4	1	--	--	--
Total	**4**	**3**	**4**	**4**	**4**	**1**	**--**	**--**	**--**
Checked Baggage Screening									
Number of EDS Machines									
B Lobby	2	2	3	3	3	--	(1)	(1)	(1)
Total	**2**	**2**	**3**	**3**	**3**	**--**	**(1)**	**(1)**	**(1)**
Outbound Baggage Handling									
Number of Staging Positions									
B Bag Room	39	75	87	87	82	(36)	(48)	(48)	(43)
Total	**39**	**75**	**87**	**87**	**82**	**(36)**	**(48)**	**(48)**	**(43)**
Number of Makeup Devices									
B Bag Room	2	4	4	4	4	(2)	(2)	(2)	(2)
Total	**2**	**4**	**4**	**4**	**4**	**(2)**	**(2)**	**(2)**	**(2)**
ARRIVALS FUNCTIONS									
Domestic Baggage Claim									
Claim Device Frontage (LF)									
B Bag Lobby	315	282	278	297	225	33	37	18	90
Total	**315**	**282**	**278**	**297**	**225**	**33**	**37**	**18**	**90**
Number of Claim Devices									
B Bag Lobby	4	3	3	3	2	1	1	1	2
Total	**4**	**3**	**3**	**3**	**2**	**1**	**1**	**1**	**2**

Source: LeighFisher, June 2013.

Table 4-12
TERMINAL C/E FACILITY REQUIREMENTS

Functional Element Description	Existing Provided	Estimated Requirement Planning Activity Level				Surplus (Deficiency) Planning Activity Level			
		BASE	PAL25	PAL33	PAL40	BASE	PAL25	PAL33	PAL40
DEPARTURES FUNCTIONS									
Check-in									
Number of Positions									
Terminal C									
Lobby									
Agent	70	24	30	39	50	46	40	31	20
Kiosk / bag drop	30	7	9	12	15	23	21	18	15
Kiosk / no bag drop	16	4	6	7	9	12	10	9	7
Lobby Total	**116**	**35**	**44**	**58**	**74**	**81**	**72**	**58**	**42**
Curb/Skycap	15	3	4	5	6	12	11	10	9
Terminal C Total	**131**	**38**	**48**	**63**	**80**	**93**	**83**	**68**	**51**
Terminal E									
Lobby									
Agent	54	24	31	57	86	30	23	(3)	(32)
Kiosk / bag drop	--	--	--	--	--	--	--	--	--
Kiosk / no bag drop	--	--	--	--	--	--	--	--	--
Lobby Total	**54**	**24**	**31**	**57**	**86**	**30**	**23**	**(3)**	**(32)**
Curb/Skycap	--	--	--	--	--	--	--	--	--
Terminal E Total	**54**	**24**	**31**	**57**	**86**	**30**	**23**	**(3)**	**(32)**
Passenger Security Screening Checkpoints									
Number of Lanes *									
C Lobby North	4	3	4	5	6	1	--	(1)	(2)
C Lobby South	4	3	4	5	6	1	--	(1)	(2)
C Garage Link	2	1	1	1	1	1	1	1	1
E Lobby	6	3	4	6	10	3	2	--	(4)
Total	**16**	**10**	**13**	**17**	**23**	**6**	**3**	**(1)**	**(7)**
*Does not include international transfer checkpoint									
Checked Baggage Screening									
Number of EDS Machines									
C/E BHS Matrix	10	8	11	14	18	2	(1)	(4)	(8)
Total	**10**	**8**	**11**	**14**	**18**	**2**	**(1)**	**(4)**	**(8)**
Outbound Baggage Handling									
Number of Cart/Container Staging Positions									
C/E BHS Matrix	184	160	183	253	308	24	1	(69)	(124)
Total	**184**	**160**	**183**	**253**	**308**	**24**	**1**	**(69)**	**(124)**
Number of Makeup Devices									
C/E BHS Matrix	23	20	23	32	39	3	0	(9)	(16)
Total	**23**	**20**	**23**	**32**	**39**	**3**	**0**	**(9)**	**(16)**
ARRIVALS FUNCTIONS									
Domestic Baggage Claim									
Claim Device Frontage (LF)									
C Bag Lobby	1,725	584	738	1,091	1,301	1,141	987	634	424
Total	**1,725**	**584**	**738**	**1,091**	**1,301**	**1,141**	**987**	**634**	**424**
Number of Claim Devices									
C Bag Lobby	11	5	6	9	11	6	5	2	--
Total	**11**	**5**	**6**	**9**	**11**	**6**	**5**	**2**	**--**

Source: LeighFisher, June 2013.

Table 4-13
TERMINAL D FACILITY REQUIREMENTS

Functional Element Description	Existing Provided	Estimated Requirement Planning Activity Level				Surplus (Deficiency) Planning Activity Level			
		BASE	PAL25	PAL33	PAL40	BASE	PAL25	PAL33	PAL40
DEPARTURES FUNCTIONS									
Check-in									
Number of Positions									
D Lobby									
Agent	61	44	48	62	71	17	13	(1)	(10)
Kiosk / bag drop	--	--	--	--	--	--	--	--	--
Kiosk / no bag drop	--	--	--	--	--	--	--	--	--
Lobby Total	**61**	**44**	**48**	**62**	**71**	**17**	**13**	**(1)**	**(10)**
Curb/Skycap	--	--	--	--	--	--	--	--	--
Total No. of Positions	**61**	**44**	**48**	**62**	**71**	**17**	**13**	**(1)**	**(10)**
Passenger Security Screening Checkpoints									
Number of Lanes									
D Lobby	4	4	5	6	7	--	(1)	(2)	(3)
Total No. of Lanes	**4**	**4**	**5**	**6**	**7**	**--**	**(1)**	**(2)**	**(3)**
Checked Baggage Screening									
Number of EDS Machines									
D East	4	2	2	3	3	2	2	1	1
D West	2	2	2	2	2	--	--	--	--
Total No. of EDS machines	**6**	**4**	**4**	**5**	**5**	**2**	**2**	**1**	**1**
Outbound Baggage Handling									
Number of Cart/ Container Staging Positions									
D East Bag Room	52	25	30	41	45	27	22	11	7
D West Bag Room	24	13	15	20	23	11	9	4	1
Total No. of Staging Position	76	38	45	61	68	38	31	15	8
Number of Makeup Devices									
D East Bag Room	4	2	2	3	3	2	2	1	1
D West Bag Room	1	1	1	1	1	0	0	0	0
Total No. of Makeup Devices	**5**	2	3	4	4	3	2	1	1

Source: LeighFisher, June 2013.

Table 4-14
FACILITY REQUIREMENTS—FIS/INTERNATIONAL ARRIVALS
UNITED INTERNATIONAL + FOREIGN FLAG CARRIERS

Functional Element Description	Existing Provided	Estimated Requirement				Surplus (Deficiency)			
		BASE	PAL25	PAL33	PAL40	BASE	PAL25	PAL33	PAL40
FIS Primary Inspection									
Number of Booths *(a)*	40	27	42	45	61	13	(2)	(5)	(21)
Queue Area (SF)	42,900	23,288	36,225	38,813	52,613	19,613	6,675	4,088	(9,713)
International Baggage Claim									
Claim Device Frontage (LF)	3,060	2,491	3,410	3,575	4,972	569	(350)	(515)	(1,912)
Number of Claim Devices	12	11	15	15	21	1	(3)	(3)	(9)
International Recheck									
Number of positions									
United	22	25	44	59	78	(3)	(22)	(37)	(56)
Other Carriers	12	7	7	9	9	5	5	3	3
Total	34	32	50	68	87	2	(16)	(34)	(53)
Passenger Security Screening Checkpoints									
Number of Lanes									
FIS	6	9	12	15	--	(3)	(6)	(9)	(9)

(a) Piggyback configuration with 2 agent positions per piggyback booth.

Source: LeighFisher, July 2013.

4.4 GROUND TRANSPORTATION AND PARKING REQUIREMENTS

This section presents the requirements for the Airport's ground transportation and parking facilities. These facilities include the Airport access and circulation roadway network, commercial and private vehicle departures and arrivals curbsides, public and employee parking facilities, rental car ready/return and service areas, taxicab and other commercial vehicle hold lot area, and the automated people mover system. The methodologies and assumptions used in assessing these facilities and the resulting adequacy levels are provided in this section.

4.4.1 Roadways

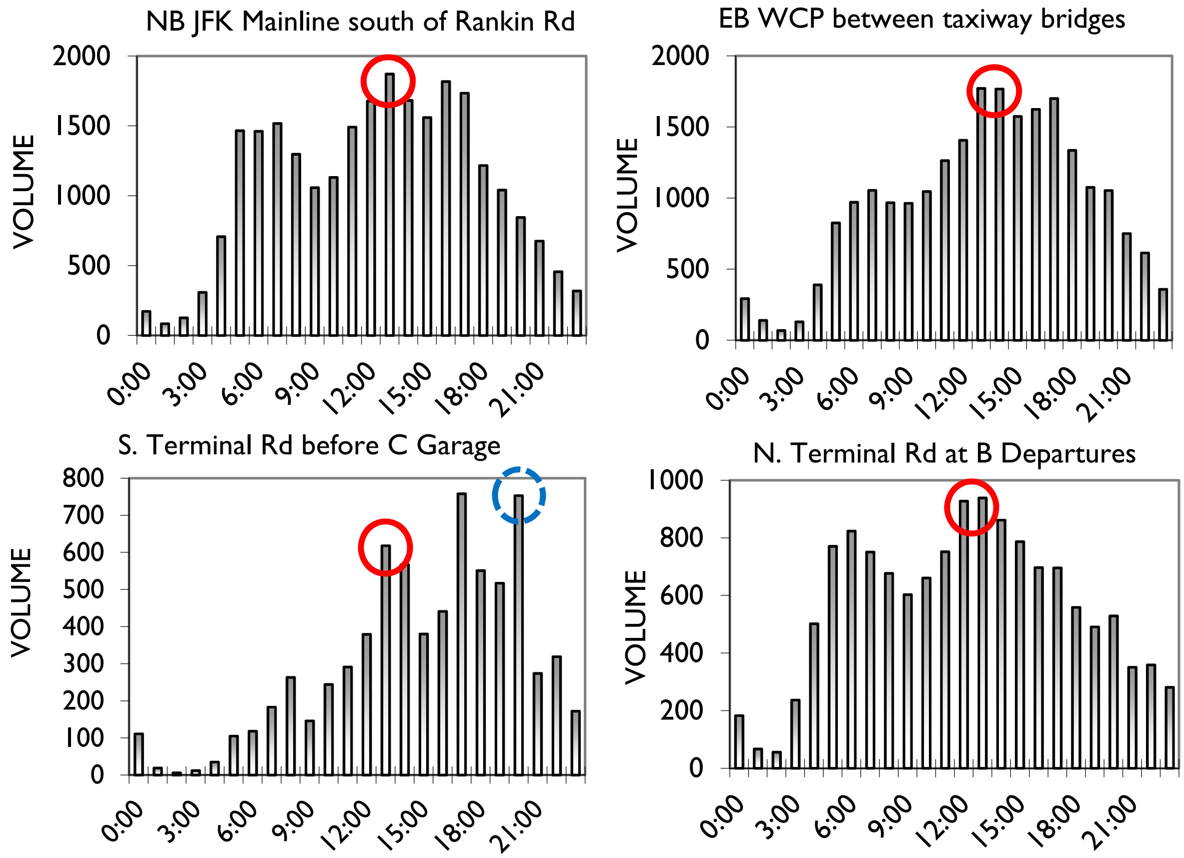
4.4.1.1 Methodology

The Airport roadway network was modeled to assess the ability of the network to accommodate peak hour demands occurring at PAL25, PAL33 and PAL40. The analysis also serves to compare each roadway segment's calculated capacity with the existing and forecast peak hour traffic volumes and determine their levels of service. The roadways were analyzed using a VISSIM model of the Airport roadway network with estimated vehicle volumes and routing decisions by mode generated using a separate model. The selection of the peak hours, development of the trip generation/trip assignment and VISSIM models, and the data outputs used to evaluate the Airport roadways are described in more detail in this section.

4.4.1.2 Selection of Peak Hours

Based on surveys of existing roadway traffic volume data, the overall Airport roadway peak hour occurs from 1:00 to 2:00 PM with additional peaks occurring during the Terminal A (5:00 to 6:00 PM) and Terminal C (8:00 to 9:00 PM) peak arrival hours. Traffic volume data, displayed in Figure 4-13, confirms the different peak timing at the Terminal C arrivals curbside, while the Terminal B departures curbside peaks at the same time as overall Airport traffic. Analyses were therefore conducted to determine the ability of the roadways and curbsides to accommodate each of the three peak hours: 1:00 to 2:00 PM, 5:00 to 6:00 PM, and 8:00 to 9:00 PM.

Figure 4-13
ROADWAY TRAFFIC VOLUMES



Legend

Airport peak hour 1:00 to 2:00 PM

Arrivals curbside peak hour 8:00 to 9:00 PM

Source: LeighFisher, July 2013.

4.4.1.3 Vehicular Trip Generation and Trip Assignment Model

A spreadsheet model was developed to generate vehicle volumes by mode and travel paths based on originating and terminating passenger volumes at each terminal. The model representing existing conditions was developed using passenger mode choice, vehicle occupancy/party size, dwell time, lead/lag time, and other data presented in the 2010 *Peak Week Survey* report and data presented in Chapter2, *Existing Conditions*. The model was calibrated using traffic volume data gathered during surveys conducted in October 2012. The outputs of the model include vehicle travel paths/volume routings by travel mode, indicating the traffic proportion of turning or diverging traffic at each decision point in the roadway network. Vehicle volumes and routing decisions for future scenarios were then generated using the same model modified to reflect the proportion of originating and terminating airline passengers at each terminal by hour of the day for the future PALs. The following key assumptions were used in developing the spreadsheet model:

- Vehicles leaving Terminals C, D, or E will exit via Will Clayton Parkway to reach John F. Kennedy Boulevard, rather than drive around Terminals A and B.
- Traffic coming from John F. Kennedy Boulevard will leave via John F. Kennedy Boulevard. Traffic coming from Will Clayton Parkway will leave via Will Clayton Parkway.
- Passengers originating or terminating at the following terminals will park in the corresponding parking garage if parking on-Airport:

Terminal	Parking Garage
A	A/B
B	A/B
C	C West and D/E
D	D/E
E	D/E

- Private vehicle trips generated by off-airport parking patrons using facilities east of the Airport were not included in the model but parking shuttle vehicles serving these parking facilities are included in the model.
- Any motorist going first to the departures curbside and then to parking or from a parking facility to the arrivals curbside is parking in an on-Airport garage.
- To reflect peak month traffic volumes (which occur in July) the traffic surveys conducted in October 2012 were adjusted based upon the relationship between July and October parking transactions.
- Airline Passenger mode choice patterns were based upon passenger survey data reported in the 2010 *Peak Week Survey*. Terminals A, B, and C surveys were based upon domestic respondents, Terminal D was based upon international respondents, and Terminal E was based upon all respondents. These mode choice percentages are shown in Tables 4-15 and 4-16.

Table 4-15
MODE OF ACCESS TO AIRPORT

Access Mode	Domestic	International	Total
Personal Car/Truck	69.9%	68.8%	69.6%
Rental Car	8.7	9.5	8.9
Commercial Shuttle	1.7	1.9	1.7
Hotel Courtesy Vehicle	2.5	2.2	2.4
Taxi	7.5	9.5	8.0
Limousine	8.9	5.6	8.1
Charter Bus	0.1	2.2	0.6
Other	0.8	0.3	0.7

Source: 2010 *Peak Week Survey*, February 2011, HNTB.

Table 4-16
MODE OF EGRESS FROM AIRPORT

Egress Mode	Domestic	International	Total
Personal Car/Truck	68.7%	64.4%	67.7%
Rental Car	9.2	8.7	9.1
Commercial Shuttle	3.4	4.7	3.7
Hotel Courtesy Vehicle	1.4	0.8	1.2
Taxi	7.5	12.2	8.6
Limousine	7.6	4.9	7.0
Charter Bus *(a)*	0.7	2.1	1.1
Other	1.6	2.1	1.7

(a) Includes METRO bus

Source: 2010 *Peak Week Survey*, February 2011, HNTB.

4.4.1.4 VISSIM Model

A microscopic simulation model (VISSIM) was used to analyze the adequacy of the Airport roadway network because conventional macroscopic models are not suitable for this purpose due to the Airport's unusual roadway geometry and operations. The unusual geometry and operations include multiple closely spaced decision points, left-hand curbside loading of passengers, and numerous lane drops and lane imbalances. Microscopic models allow for simulation and analysis of each individual vehicle using the roadways and its interaction with the surrounding vehicles; thus they are suitable for testing unusual roadway operations.

4.4.1.5 Model Development and Calibration

A base VISSIM model was built for the entire Airport roadway network reflecting the existing roadway segment lengths, number of travel lanes, free-flow operating speeds, merge and diverge locations, and vehicle dwell times at the curbsides. This model was then calibrated separately for baseline (2012) conditions for each of the three peak periods using (a) traffic volume count data gathered for individual roadway segments throughout the network, and (b) video recordings of the actual curbside congestion and vehicle queues occurring during these same peak hours.

The estimated baseline traffic volumes were compared with the actual volumes observed during the October 2012 traffic surveys (adjusted to represent peak month conditions) to confirm that the model was properly calibrated. Imaginary traffic "counters" were placed in the VISSIM model to record the estimated volumes and compare them with the actual volumes gathered at each of the more than a dozen locations. Additional counter locations were used to compare the volumes resulting from the VISSIM model with the input volumes generated by the trip generation/trip assignment model.

Estimated or modeled travel times on the entry and exit roads (between John F. Kennedy Boulevard and Will Clayton Parkway and the Terminal A and Terminal C departures and arrivals curbsides) were compared with observed travel times. The results of these travel time data are discussed in the Roadway Adequacy section of this report.

Additionally, the VISSIM model allows for the creation of visual animations of the roadway network, displaying each individual vehicle by mode. These animations provide a visual representation of problematic areas due to merging, weaving, and other inefficient operations that may reduce capacity and cause delays and queues in the network. To further assure that the model was properly calibrated, airport staff reviewed and confirmed the validity of the visual animations of peak period operations, including vehicle queues occurring at congested curbside arrivals areas.

Estimates of the PAL25, PAL33, and PAL40 roadway traffic volumes on each roadway link were prepared using the forecast hourly originating-terminating airline passenger volumes and the routing splits resulting from the trip generation/trip assignment model described above. This information was input into the calibrated base models for each of the three peak hours for each of the three future planning activity levels. The resulting future volumes are described in subsequent paragraphs.

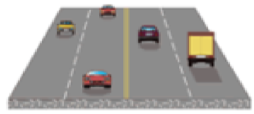
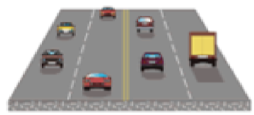
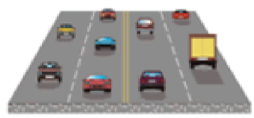
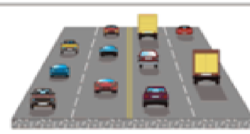
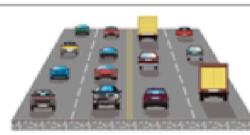
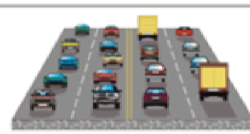
4.4.1.6 Roadway Level of Service

Roadway level of service (LOS) is defined as the ratio of the volume of vehicles using a roadway segment to the capacity of the segment (V/C ratio). Figure 4-14 displays the V/C ratio for LOS A through F, along with a description of the flow conditions experienced by drivers at each of these levels of service. The number of travel lanes is a primary consideration in determining the capacity of a roadway; however, other factors such as the length of roadway weaving segments, proportion of weaving traffic, and available decision-making distances also affect capacity, particularly in an Airport terminal area. The mix of traffic, vehicle operating speeds, and driver familiarity with the roadway network also affect the capacity of the roadway.

The capacities of diverge areas and the preceding decision-making sections are a function of the amount of information that needs to be conveyed and the complexity of the decision (i.e., binary versus a three-way decision), the time and distance available to motorists to recognize, comprehend, and react to the required decision, and the number of lanes motorists must cross at the diverge or decision point. Similarly the capacity of merging areas is a function of the number of lanes, lane balance, and the distance available for traffic streams to merge.

The capacities of weaving segments are a function of the proportion of low-speed traffic weaving operations occurring within the available weaving distance, the number of lanes in the weaving section (section width), and the type of weave (i.e., Type A, B, or C weave).

Figure 4-14
ROADWAY LEVEL OF SERVICE STANDARDS

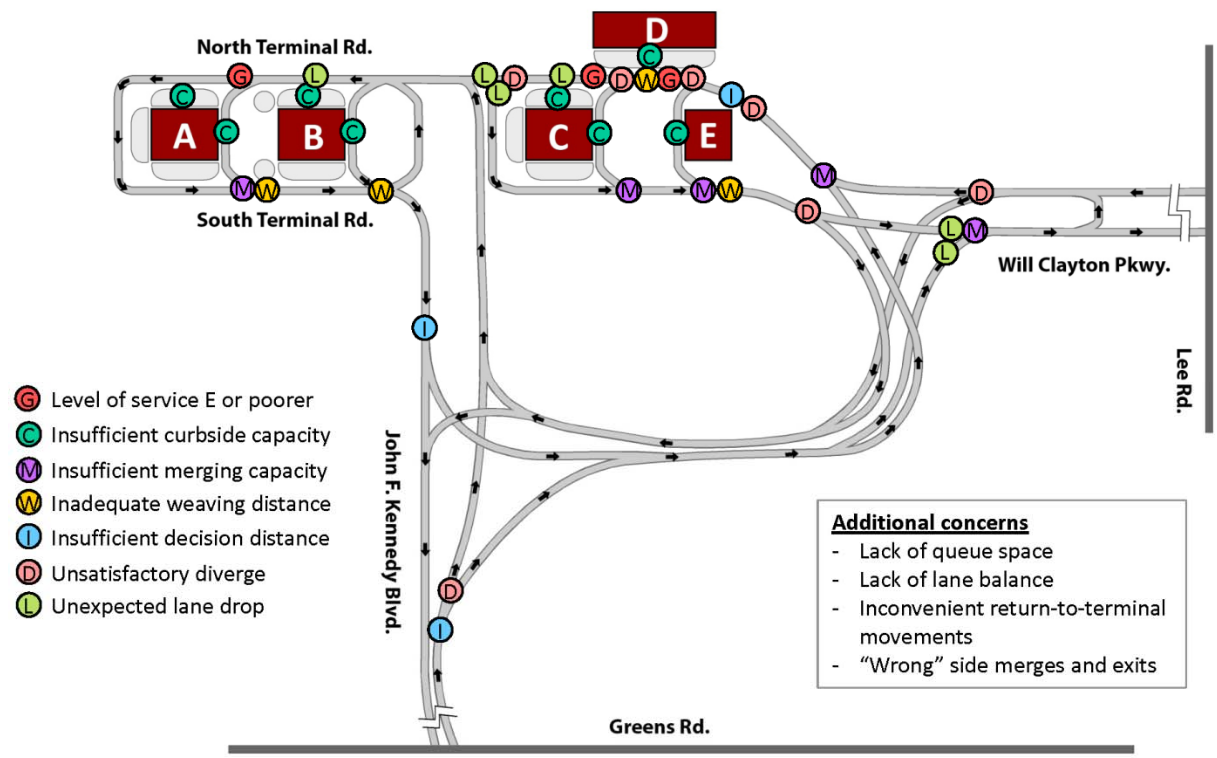
Level of Service	Max V/C Ratio	Flow Conditions	Technical Descriptions
A	0.24		Highest level of service. Traffic flows freely with little or no restrictions on maneuverability. **No delays**
B	0.37		Traffic flows freely, but drivers have slightly less freedom to maneuver. **No delays**
C	0.57		Density becomes noticeable with ability to maneuver limited by other vehicles. **Minimal delays**
D	0.78		Speed and ability to maneuver is severely restricted by increasing density of vehicles. **Minimal delays**
E	1.00		Unstable traffic flow. Speeds vary greatly and are unpredictable. **Minimal delays**
F	> 1.00		Traffic flow is unstable, with brief periods of movement followed by forced stops. **Significant delays**

Source: LeighFisher, based on 2000 HCM, Exhibit 21-3, Speed-Flow Curves with LOS Criteria for Multi-Lane Highways; and ACRP Report 40, Airport Curbside and Terminal Area Roadway Operations, Jacobs Consultancy, 2010.

4.4.1.7 Roadway Adequacy

The factors described in the previous section that contribute to a reduction in roadway capacity and the corresponding poor level of service on the Airport roadways are displayed in Figure 4-15. These include insufficient curbside and merging capacities, inadequate roadway weaving and decision distances, and unsatisfactory diverges. These operational problems, particularly on North Terminal Road in the Terminal C/D/E area, cause these roadway segments to operate at a much poorer level of service than would otherwise be calculated were the volume of vehicles, free-flow speeds, and number of lanes the only factors considered in the analysis. In reality, traffic is unable to flow smoothly as drivers unfamiliar with the roadways attempt to read signage, make multiple, complex (i.e., more than two choices) decisions, and maneuver their vehicles into the correct lanes over a short distance.

Figure 4-15
KEY ROADWAY CONSTRAINTS



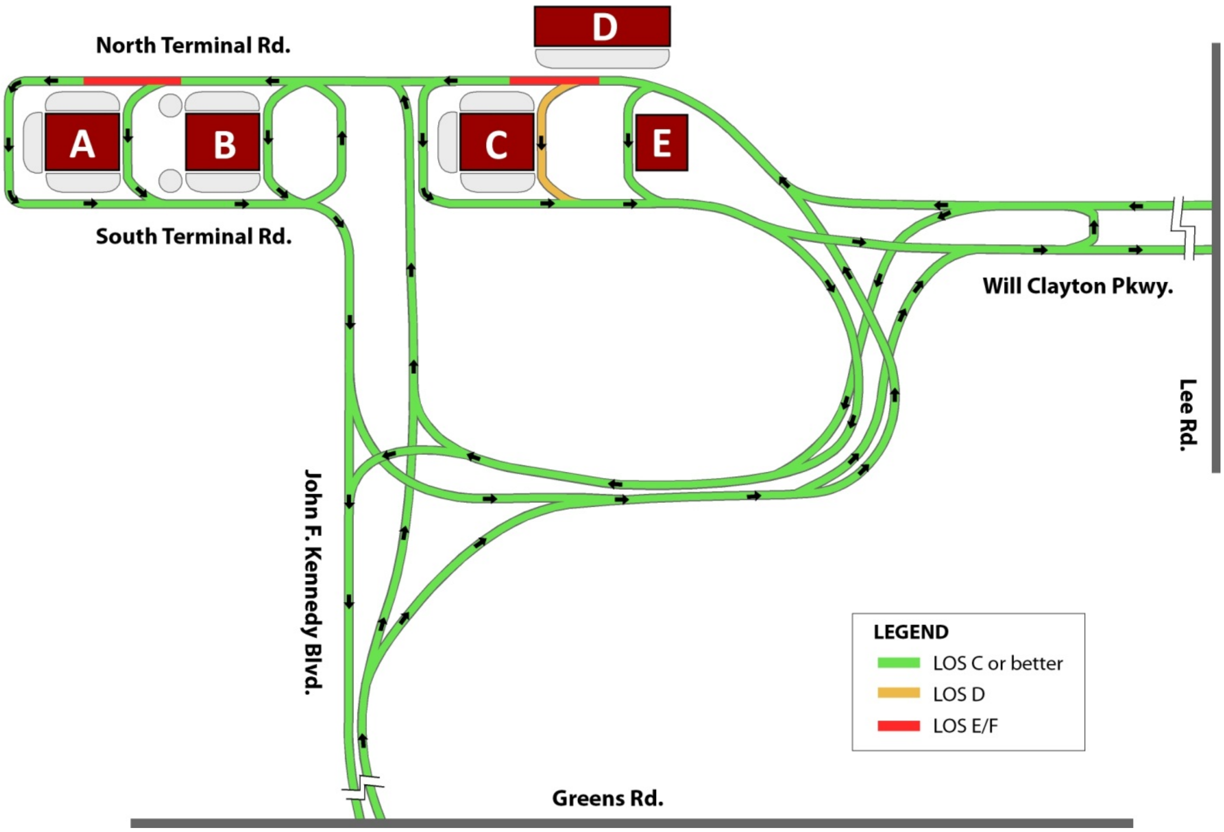
Source: LeighFisher, July 2013.

Figures 4-16 through 4-22 provide visual representations of the various levels of service on the Airport roadways expected to occur at the baseline, PAL25, PAL33, and PAL40 demand levels. The LOS displayed in the figures represents the LOS that occurs during the peak hour of each individual segment, as all roadway segments do not have the same peak hour.

4.4.1.8 Baseline Conditions

During peak hours the North Terminal Road segments approaching the Terminal A arrivals curbside and approaching Terminal C currently operate at LOS E/F. Traffic queues caused by curbside congestion and weaving movements caused by the diverging lanes at the Terminal C departures roadway contribute to the poor LOS on the roadway segment approaching Terminal C. The Terminal C departures curbside currently operates at LOS D during the peak hour.

Figure 4-16
PEAK HOUR ROADWAY LEVEL OF SERVICE – BASELINE



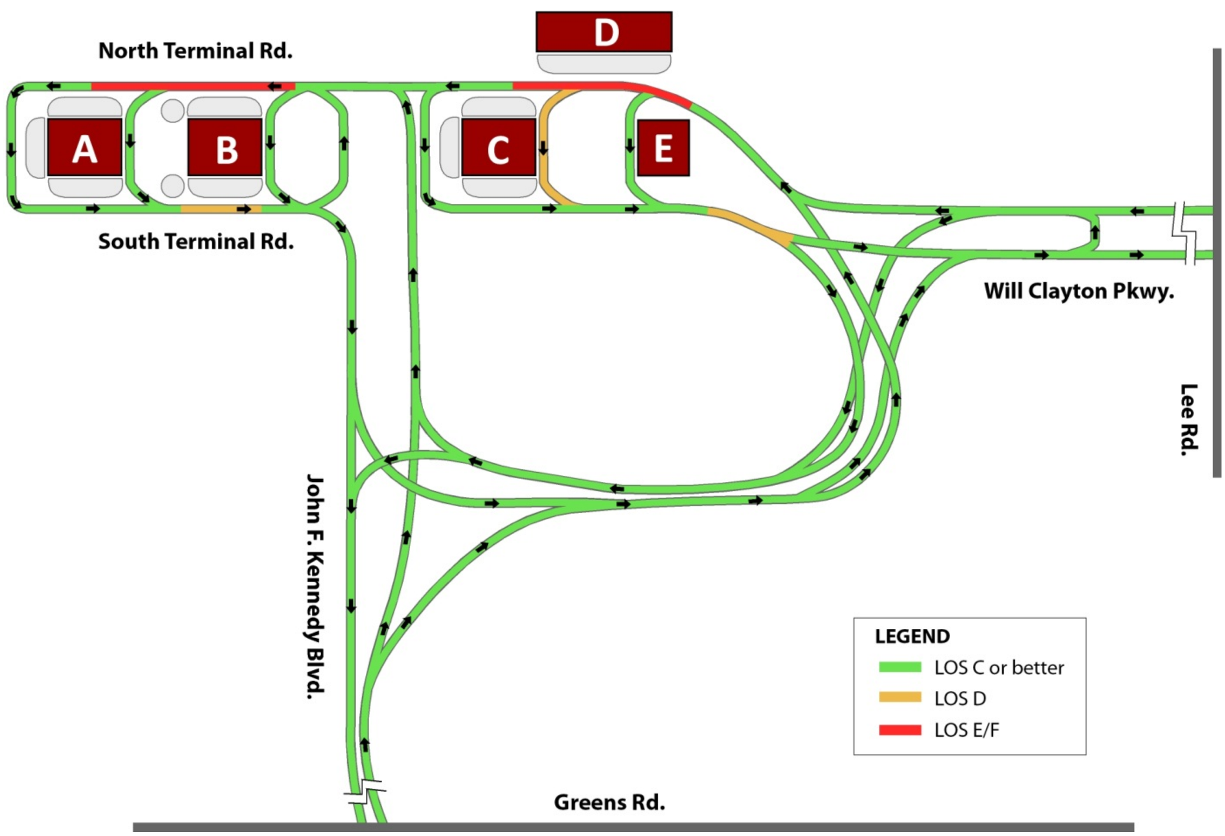
Note: LOS represents the peak hour of each roadway segment.

Source: LeighFisher, July 2013.

4.4.1.9 Planning Activity Level 25

As presented in Figure 4-17, additional segments of North Terminal Road are expected to operate at LOS E/F by PAL25. Additionally, segments on South Terminal Road are expected to operate at LOS D by PAL25. Poor roadway operations occur on South Terminal Road due to the large volume of weaving traffic caused by vehicles exiting from the Terminal A departures level roadway, exiting the A/B parking garage, exiting the Terminal B limousine circle, and changing lanes in order to enter the limousine circle and the Terminal B south curbside. These weaving maneuvers reduce capacity and create congestion on this roadway segment. The diverge on South Terminal Road at the split between eastbound Will Clayton Parkway and southbound John F. Kennedy Boulevard, past the exit from the Terminal C/D/E area, is expected to operate at LOS D by PAL25 due to lane imbalances.

Figure 4-17
PEAK HOUR ROADWAY LEVEL OF SERVICE – PAL25



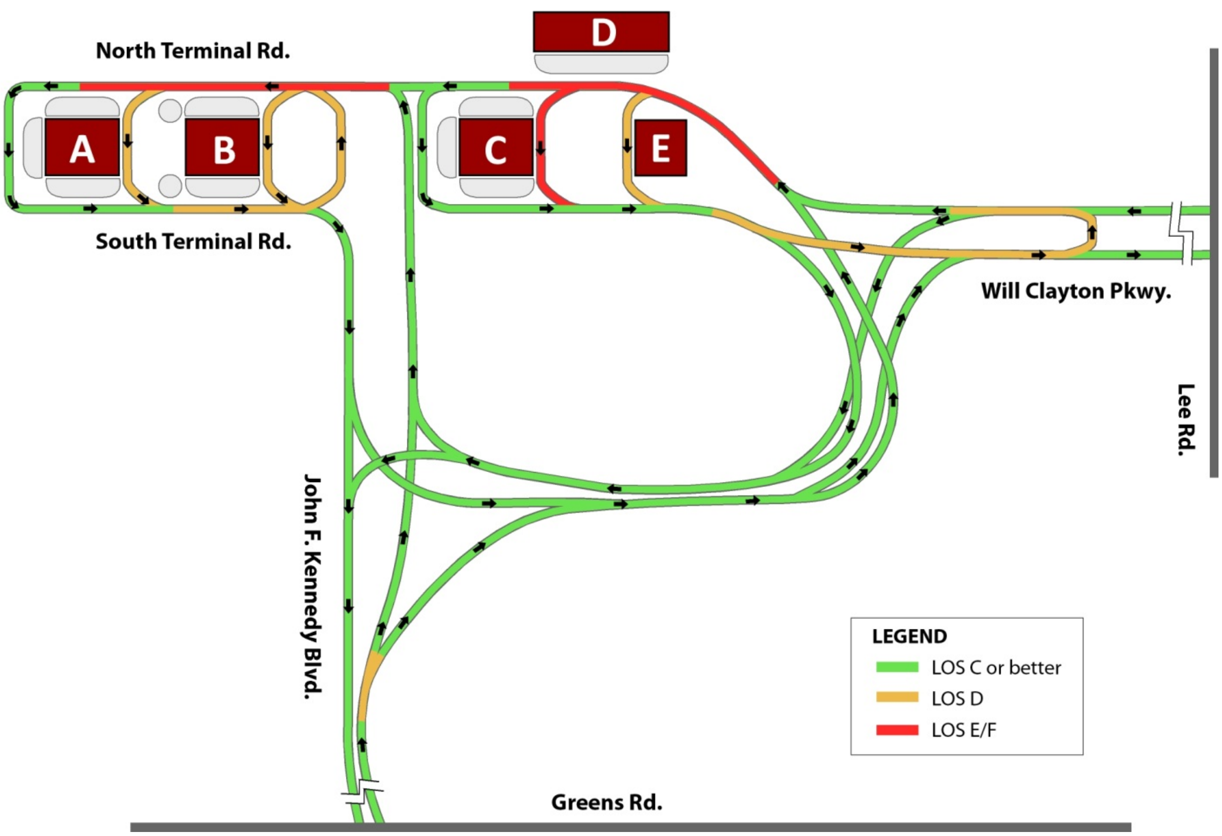
Note: LOS represents the peak hour of each roadway segment.

Source: LeighFisher, July 2013.

4.4.1.10 Planning Activity Level 33

By PAL33 almost the entire North Terminal Road is expected to operate at LOS E/F, as shown in Figure 4-18. LOS D or worse conditions are expected on the single lane northbound return-to-terminal roadway between Terminal B and the Marriott Hotel and South Terminal Road between the Terminal A departures curbside merge point and the northbound return-to-terminal roadway. Similarly, Colonel Fisher Boulevard, which serves as a return-to-terminal U-turn on Will Clayton Parkway, is expected to operate at LOS D by PAL33, as is the westbound Will Clayton Parkway diverges to Terminals A/B or Terminals C/D/E at Jetero Boulevard. The John F. Kennedy Boulevard northbound diverge to Terminals A/B or Terminals C/D/E and the departures roadways at Terminals A, B, and E are also expected to operate at LOS D by PAL33. The Terminal C departures roadway is expected to operate at LOS E/F.

Figure 4-18
PEAK HOUR ROADWAY LEVEL OF SERVICE – PAL33



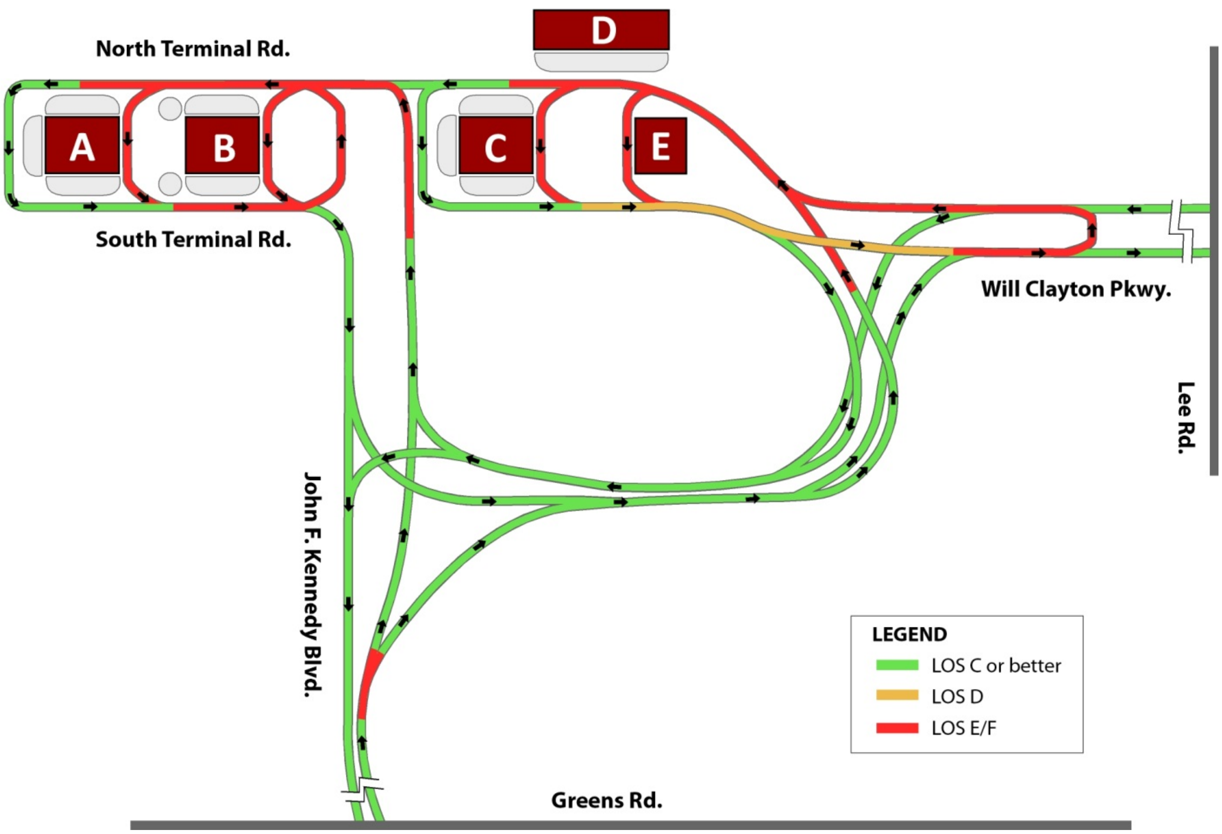
Note: LOS represents the peak hour of each roadway segment.

Source: LeighFisher, July 2013.

4.4.1.11 Planning Activity Level 40

As depicted in Figure 4-19, by PAL40, the entire North Terminal Road between the John F. Kennedy Boulevard entrance to the Terminal A/B area and the A arrivals curbside is expected to operate at LOS E/F. Westbound Will Clayton Parkway leading to the Terminals A/B and C/D/E diverge is also expected to operate at LOS E/F, as are portions of Colonel Fisher Boulevard and the eastbound section of Will Clayton Parkway prior to the Colonel Fisher U-turn. The departures curbsides at all terminals, the return-to-terminal roadway between Terminal B and the hotel, and John F. Kennedy Boulevard at the diverge to Terminals A/B and C/D/E are also expected to operate at LOS E/F by PAL40.

Figure 4-19
PEAK HOUR ROADWAY LEVEL OF SERVICE – PAL40



Note: LOS represents the peak hour of each roadway segment.

Source: LeighFisher, July 2013.

In summary, many roadway segments, particularly the North Terminal Road, are expected to operate at undesirable levels of service (LOS E/F) at PAL25, PAL33, and PAL40. The amount of congestion and delays on roadways operating at LOS E/F is expected to increase exponentially as traffic demands increase. Simulations of roadway conditions indicate that gridlock (complete stoppage of traffic flows) occurs on North Terminal Road and other roadway segments under PAL40 conditions and at some locations under PAL33 conditions. During the future peak hours conditions it is estimated that traffic will cease to move as vehicles exiting the terminal area (e.g., on westbound Will Clayton Parkway) are blocked by queues of entering vehicles extending back from the many points of congestion. If such conditions and the resultant delays were to occur, they would adversely affect the level of comfort and safety experienced by motorists on these roadways, including airline passengers and other users. Additionally, there would be a significant impact to Airport operations as increasing delays could lead to many passengers arriving at the terminals too late for time-dependent flight departures.

4.4.2 Travel Times

Estimates were prepared of the time motorists require to travel from both Airport entrances to the departures curbsides at Terminals A and C and then from these departures curbsides to the Airport exits. Estimates were also prepared for the times required to travel from both Airport entrances to the arrivals curbsides of these same terminals and then to the Airport exits. These estimates of peak period travel times were prepared for baseline, PAL25, PAL33, and PAL40 conditions. Travel times were estimated by conducting more than five simulations of traffic operations during each of the twelve baseline and future peak hours using the VISSIM roadway simulation model described above.

As explained in the roadway adequacy section, gridlock conditions are expected to occur on North Terminal Road and other Airport roadway segments as activity grows to PAL33 and PAL40. Comparisons of future travel times can be misleading when gridlock conditions occur. This is because the estimates of travel times only include the times of motorists who completed their trip between designated points (e.g., an Airport entrance and a departures curbside) within the period being simulated (i.e., a 60-minute test period). When gridlock occurs many motorists are delayed and unable to complete their trips within the period being simulated. As a result, the travel times of these delayed motorists are not recorded which results in an underestimate of the average travel times under gridlock conditions.

4.4.2.1 Travel Times to/from the Departures Curbsides

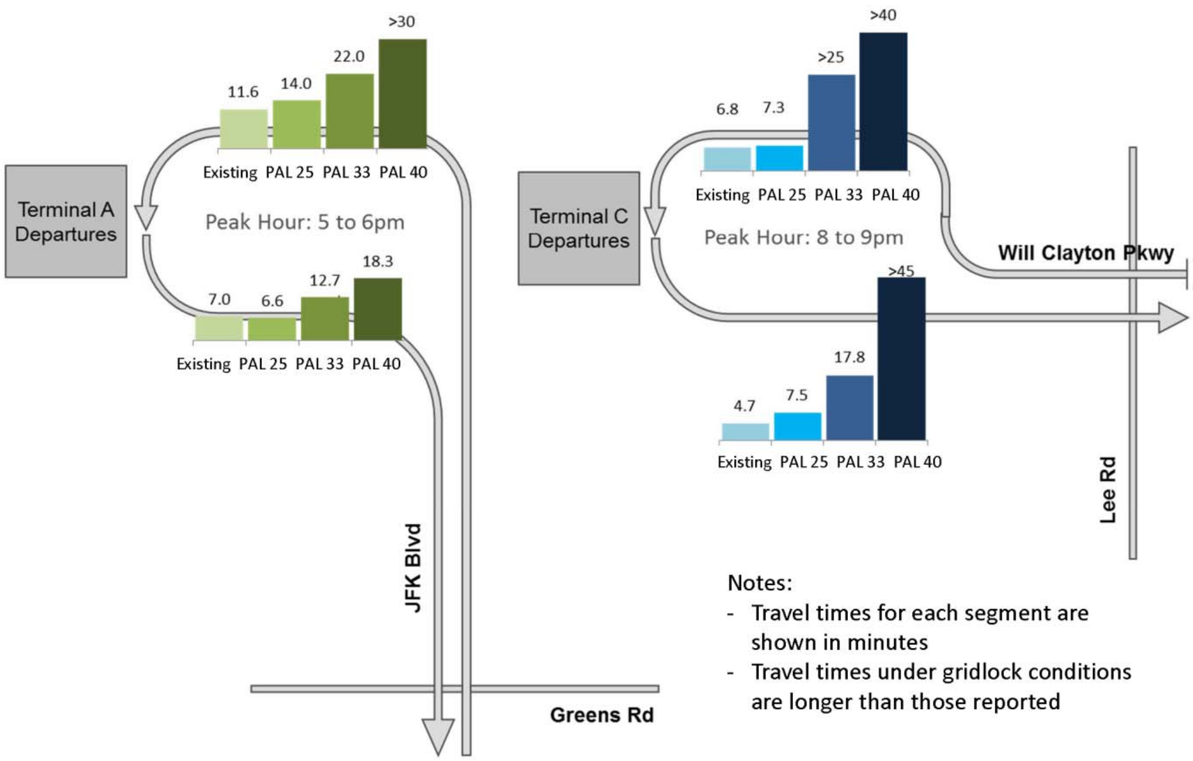
The travel times between the John F. Kennedy Boulevard and the Terminal A departures curbside and between Will Clayton Parkway and the Terminal C departures curbside are shown in Figure 4-20. Approaching Terminal A from northbound John F. Kennedy Boulevard, the travel times are expected to increase by 90 percent by PAL33 (from 11.6 minutes under baseline conditions to approximately 22 minutes by PAL33) and by more than 150 percent by PAL40 (from 11.6 minutes to over 30 minutes). Actual travel times would be even longer than 30 minutes for some motorists due to the gridlock condition described above.

Similarly, travel times from westbound Will Clayton Parkway to the Terminal C departures curbside are expected to more than triple by PAL33 (from 6.8 minutes to more than 25 minutes) and increase almost six fold by PAL40 (to more than 40 minutes). As with traffic exiting Terminal A, in the future many motorists are expected to experience travel times longer than 40 minutes due to the expected gridlock conditions.

Leaving the terminal area, the travel time from the Terminal A departures curbside to John F. Kennedy Boulevard is expected to increase 70 percent by PAL33 (from 7 minutes under baseline conditions to 12 minutes) and more than 150 percent by PAL40 (to more than 18 minutes). At PAL33 the travel time leaving the Airport is expected to decrease, as congestion approaching Terminal A on North Terminal Road meters the traffic flow on South Terminal Road but does not block the return-to-terminal roadway. During PAL33 and PAL40 delays on the return-to-terminal roadway create queues that delay vehicles exiting via John F. Kennedy Boulevard.

Vehicles traveling from the Terminal C departures exit to Will Clayton Parkway are expected to encounter much longer delays at future PALs, with travel times increasing from less than 5 minutes under baseline conditions to over 17 minutes and more than 45 minutes under PAL33 and PAL40 conditions, respectively. As with the travel time segments entering the Airport, many motorists may experience even longer travel times as roadway gridlock is expected to prevent many vehicles from reaching the Airport exit within the time period that was analyzed due to congestion on Will Clayton Parkway and Colonel Fisher Boulevard.

Figure 4-20
DEPARTURES CURBSIDE TRAVEL TIMES



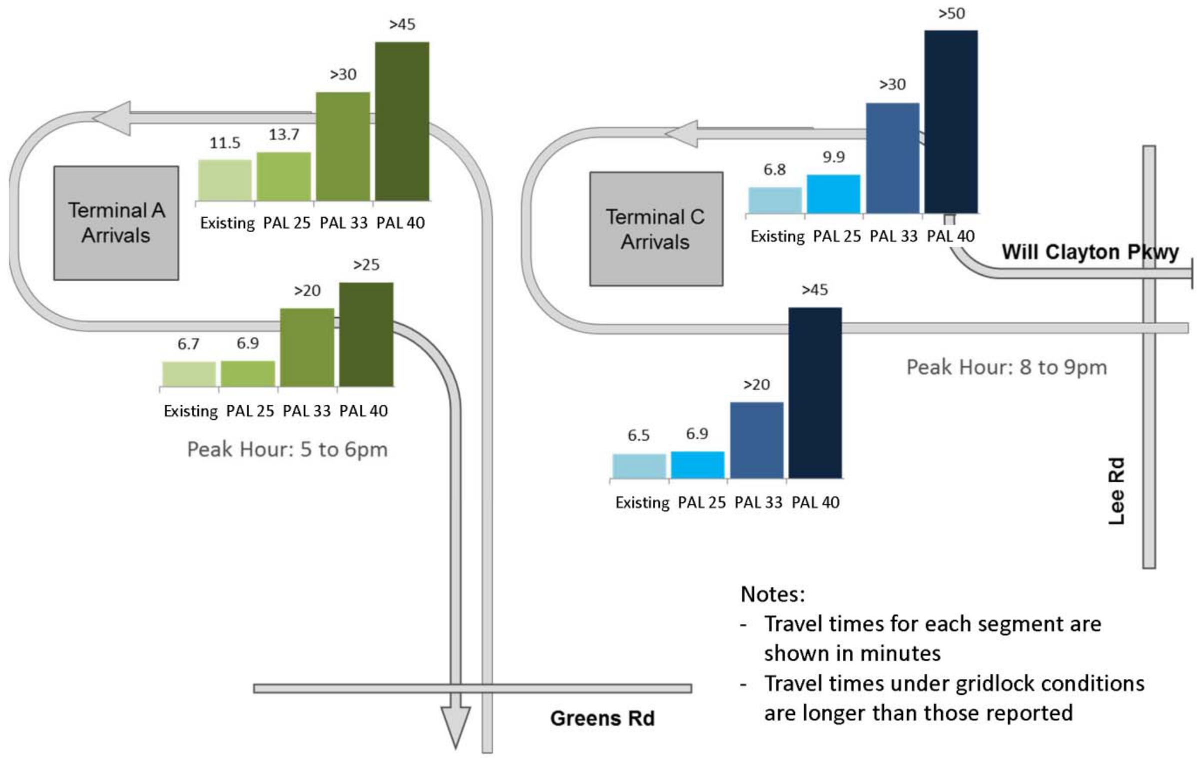
Source: LeighFisher, July 2013.

4.4.2.2 Travel Times to/from the Arrivals Curbsides

Figure 4-21 displays the travel times between the Terminal A and Terminal C arrivals curbsides and John F. Kennedy Boulevard and Will Clayton Parkway. As with the travel times to and from the departures curbsides, the travel times to and from the arrivals curbsides are also expected to increase significantly by PAL33 and PAL40. Travel times from John F. Kennedy Boulevard to the Terminal A arrivals curbside are expected to increase 170 percent by PAL33 (from 11 minutes to more than 30 minutes) and four fold by PAL40 (to more than 45 minutes). Similarly, travel times from Will Clayton Parkway to the Terminal C arrivals curbside are expected to increase from 7 minutes to more than 3 minutes and more than 50 minutes by PAL33 and PAL40, respectively.

Exiting the Airport from the Terminal A arrivals curbside to southbound John F. Kennedy Boulevard, the travel time is expected to increase from 6.7 minutes to more than 20 minutes by PAL33 and more than 25 minutes by PAL40. Travel times from the Terminal C arrivals curbside to Will Clayton Parkway are also expected to increase significantly, going from 6.5 minutes under baseline peak hour conditions to more than 20 minutes by PAL33 and more than 45 minutes by PAL40.

Figure 4-21
ARRIVALS CURBSIDE TRAVEL TIMES



Source: LeighFisher, July 2013.

4.4.3 Major Intersections

4.4.3.1 Methodology

The adequacies of the Airport roadway network's two major intersections were assessed using the publicly available traffic analysis software, Synchro. Baseline condition traffic volume data were based on turning movement counts conducted at John F. Kennedy Boulevard at Greens Road and Will Clayton Parkway at Lee Road during the October 2012 surveys. Future traffic volumes were assumed to increase in direct proportion to the volume of originating airline passengers and overall regional population growth in the primary Airport service region, the Houston Metropolitan Statistical Area. The intersections were analyzed for the busiest hour during the morning and evening; and Airport peak hours at all three planning activity levels. The intersection level of service shown in Tables 4-17 and 4-18 is defined by the poorest level of service for any movement at the intersection.

4.4.3.2 Intersection Adequacy

Table 4-17 displays the level of service for the intersection of John F. Kennedy Boulevard at Greens Road. At baseline volumes, the intersection operates at LOS D during the morning, evening, and Airport peak hours. By PAL25 it is expected to operate at LOS E during the overall Airport peak hour and LOS D during the morning and evening peak hours. By PAL33 the operations are expected to degrade to LOS F during the Airport peak and LOS E during the morning and evening peak hours. The intersection is expected to operate at LOS F during all peak hours by PAL40.

Table 4-17
INTERSECTION LOS: JOHN F. KENNEDY BLVD AT GREENS RD

	A.M. Peak 7:15-8:15	Airport Peak 13:15-14:15	P.M. Peak 16:45-17:45
Baseline	**D**	**D**	**D**
PAL25	**D**	**E**	**D**
PAL33	**E**	**F**	**E**
PAL40	**F**	**F**	**F**

Source: LeighFisher, July 2013.

The levels of service for the two intersections at Lee Road and Will Clayton Parkway are shown in Table 4 18. The intersection operates at LOS C or better during all peak hours at baseline demand levels. By PAL25 the westbound intersection is expected to operate at LOS D during the morning peak hour, and the eastbound intersection is expected to operate at LOS D during the evening peak hour. By PAL33 the operations are expected to have degraded to LOS D during the Airport peak hour (westbound intersection), LOS E during the evening peak hour (eastbound intersection), and LOS F during the morning peak hour (westbound intersection). By PAL40, the intersection pair is expected to operate at LOS F during all peak hours.

Table 4-18
INTERSECTION LOS: LEE RD AT WILL CLAYTON PKWY

	Lee Rd at WB Will Clayton Pkwy			Lee Rd at EB Will Clayton Pkwy		
	A.M. Peak 7:00-8:00	Airport Peak 13:00-14:00	P.M. Peak 16:45-17:45	A.M. Peak 7:00-8:00	Airport Peak 13:00-14:00	P.M. Peak 16:45-17:45
Baseline	C or better	C or better	C or better	C or better	C or better	C or better
PAL25	D	C or better	C or better	C or better	C or better	D
PAL33	F	D	C or better	D	C or better	E
PAL40	F	F	C or better	F	C or better	F

Source: LeighFisher, July 2013.

4.4.4 Curbsides

4.4.4.1 Methodology

The Quick Analysis Tool for Airport Roadways (QATAR) was used to analyze the Airport curbsides. Peak hour volumes, vehicle mix, dwell times, curbside geometry, and other assumptions about curbside operations discussed previously were used as inputs for this analysis. Due to the unusual terminal building curbside configurations other analytical tools were also used to assess the curbsides. Dwell times for each vehicle mode were specified for each terminal curbside based on data from the 2010 *Peak Week Survey*. Tables 4-19 and 4-20 summarize the dwell times at the arrivals curbsides and departures curbsides, respectively.

Table 4-19
VEHICLE DWELL TIMES BY VEHICLE TYPE AT ARRIVALS CURBSIDES

		AM		PM	
Terminal	Vehicle Type	Average	Std. Dev.	Average	Std. Dev.
A	Private Vehicle	04:27	05:11	01:10	00:43
	Taxi	**	**	**	**
	Commercial Bus	--	--	11:22	N/A
	Economy Shuttle	--	--	--	--
	Hotel Shuttle	01:38	N/A	00:51	00:29
	Limousine	--	--	--	--
	METRO Shuttle	01:28	00:39	--	--
	Parking Shuttle	00:41	00:30	01:18	00:49
	Rental Car Shuttle	01:36	N/A	05:01	06:36
B	Private Vehicle	04:00	05:39	04:44	06:43
	Taxi	**	**	**	**
	Commercial Bus	--	--	--	--
	Economy Shuttle	--	--	--	--
	Hotel Shuttle	00:42	00:26	01:52	01:51
	Limousine	12:17	10:57	13:14	07:45
	METRO Shuttle	--	--	--	--
	Parking Shuttle	02:44	02:54	02:22	01:34
	Rental Car Shuttle	00:59	00:42	01:29	00:55
C	Private Vehicle	03:49	04:37	06:40	06:05
	Taxi	**	**	**	**
	Commercial Bus	--	--	03:22	01:25
	Economy Shuttle	--	--	--	--
	Hotel Shuttle	02:28	02:18	01:50	01:46
	Limousine	--	--	05:03	N/A
	METRO Shuttle	07:48	02:55	06:20	04:26
	Parking Shuttle	03:41	02:23	03:32	02:14
	Rental Car Shuttle	02:50	01:29	01:49	00:46
D	Private Vehicle	--	--	03:11	04:11
	Taxi	**	**	**	**
	Commercial Bus	--	--	--	--
	Economy Shuttle	--	--	--	--
	Hotel Shuttle	--	--	00:39	00:18
	Limousine	--	--	--	--
	METRO Shuttle	--	--	--	--
	Parking Shuttle	--	--	02:16	01:14
	Rental Car Shuttle	--	--	--	--
E	Private Vehicle	04:43	06:01	01:39	01:15
	Taxi	**	**	**	**
	Commercial Bus	04:20	01:11	03:22	02:10
	Economy Shuttle	--	--	--	--
	Hotel Shuttle	--	--	01:46	01:26
	Limousine	--	--	--	--
	METRO Shuttle	--	--	--	--
	Parking Shuttle	04:11	04:56	02:34	02:22
	Rental Car Shuttle	--	--	--	--

-- Data Not Available.
** Taxis do not dwell at arrivals curbsides. They arrive at the terminal based on demand.
N/A Only one observation - standard deviation not applicable.
Source: 2010 *Peak Week Survey*: Tables 3.11, 3.12, 3.17, and 3.18, February 2011, HNTB.

Table 4-20
VEHICLE DWELL TIMES BY VEHICLE TYPE AT DEPARTURES CURBSIDES

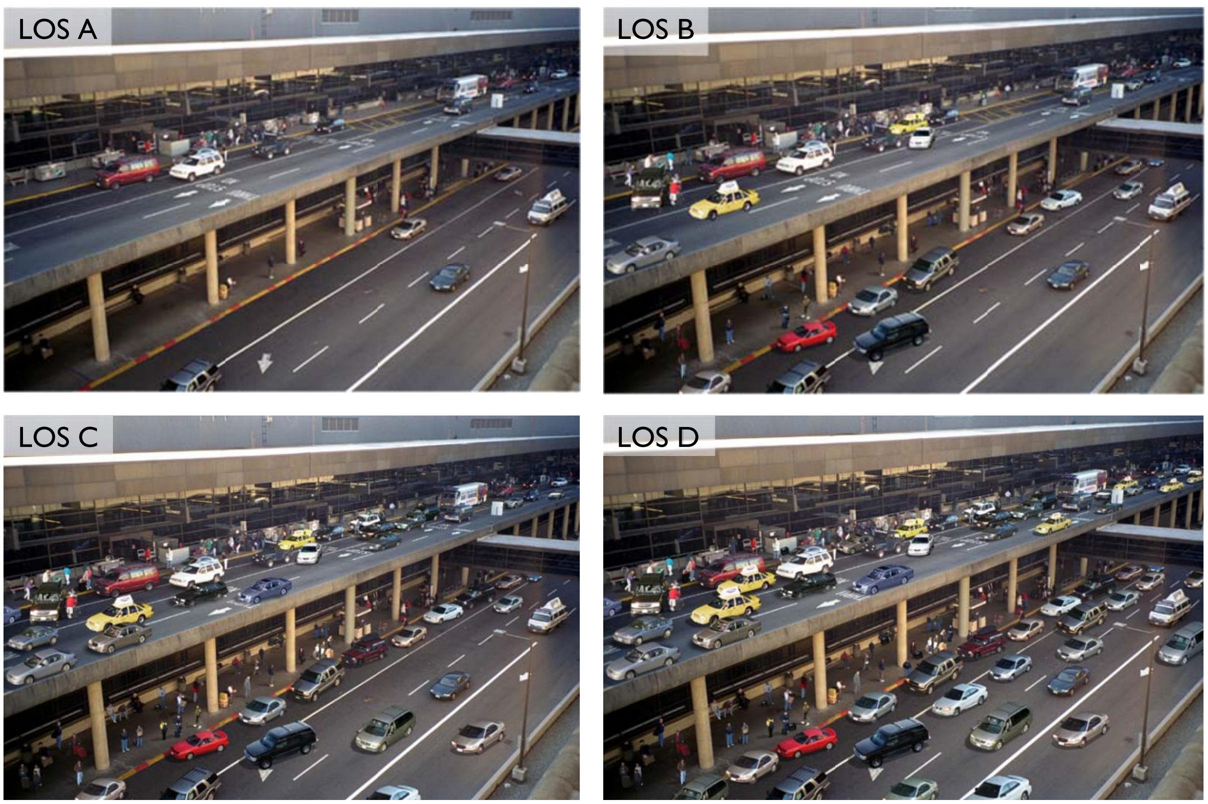
		AM		PM	
Terminal	Vehicle Type	Average	Std. Dev.	Average	Std. Dev.
A	Private Vehicle	01:28	01:00	01:57	01:38
	Taxi	02:03	01:21	01:26	00:58
	Commercial Bus	01:14	00:17	--	--
	Economy Shuttle	--	--	--	--
	Hotel Shuttle	01:43	00:59	--	--
	Limousine	02:05	N/A	--	--
	METRO Shuttle	05:40	N/A	--	--
	Parking Shuttle	01:28	01:16	00:52	00:42
	Rental Car Shuttle	01:06	N/A	--	--
B	Private Vehicle	01:50	01:28	01:38	01:30
	Taxi	01:04	01:01	01:12	00:41
	Commercial Bus	00:24	N/A	--	--
	Economy Shuttle	00:41	00:25	00:19	N/A
	Hotel Shuttle	00:39	00:16	--	--
	Limousine	01:31	00:35	00:55	01:00
	METRO Shuttle	--	--	--	--
	Parking Shuttle	00:56	01:18	00:38	00:34
	Rental Car Shuttle	02:19	03:04	01:22	01:12
C	Private Vehicle	01:41	01:00	01:04	01:16
	Taxi	00:41	N/A	00:44	00:38
	Commercial Bus	--	--	--	--
	Economy Shuttle	--	--	00:15	N/A
	Hotel Shuttle	00:42	00:02	00:45	N/A
	Limousine	--	--	--	--
	METRO Shuttle	--	--	--	--
	Parking Shuttle	00:59	00:41	00:51	00:52
	Rental Car Shuttle	--	--	00:29	00:03
D	Private Vehicle	--	--	02:39	02:23
	Taxi	--	--	02:43	01:31
	Commercial Bus	--	--	03:01	03:06
	Economy Shuttle	--	--	--	--
	Hotel Shuttle	--	--	01:03	00:33
	Limousine	--	--	--	--
	METRO Shuttle	--	--	--	--
	Parking Shuttle	--	--	00:51	00:52
	Rental Car Shuttle	--	--	01:52	00:24
E	Private Vehicle	02:15	01:50	02:58	03:30
	Taxi	02:23	02:01	01:37	01:31
	Commercial Bus	03:48	01:34	02:30	01:47
	Economy Shuttle	--	--	--	--
	Hotel Shuttle	02:19	01:48	02:37	02:41
	Limousine	01:28	01:59	01:35	01:16
	METRO Shuttle	--	--	02:04	01:00
	Parking Shuttle	01:11	00:50	01:32	01:31
	Rental Car Shuttle	02:30	N/A	--	--

-- Data Not Available
N/A Only one observation - standard deviation not applicable.
Source: 2010 *Peak Week Survey*: Tables 3.11, 3.12, 3.17, and 3.18, February 2011, HNTB.

4.4.4.2 Curbside Level of Service

Curbside roadway LOS provides an overall indication of the quality of the experience of drivers and passengers using the curbside roadway. The primary element defining the LOS at an airport curbside roadway is the ability of a motorist to enter and exit the curbside space of their choice (e.g., one near their airline door or other chosen destination). As roadway demands and congestion increase, motorists are required to stop in spaces further away from their preferred destination. This requires the motorist to either stop in a downstream curbside space, double-park, or in an extreme case, circle past the curbside area multiple times while searching for an empty space. Examples of LOS standards are shown in Figure 4-22.

Figure 4-22
CURBSIDE LEVEL OF SERVICE STANDARDS



Source: ACRP Report 40, *Airport Curbside and Terminal Area Roadway Operations*, May 9, 2010.

The key performance measures defining the LOS of a curbside roadway are the:

1. Number of vehicles parked or stopped in the curbside lane, and the percent that are double-parked, triple-parked, or otherwise stopped in a position that interferes with the flow of traffic in adjacent lanes. These measures are a function of the curbside demand versus the available capacity.

2. Duration and length of queues at the entrance to the curbside area.

3. Average delay encountered by private and commercial vehicles entering and exiting the curbside areas.

4. Curbside utilization ratio, which is a comparison of the linear length of vehicles stopped along the curbside and the effective length of the curbside (i.e., the total length less the space occupied by crosswalks or other areas in which vehicles, or certain classes of vehicles, cannot stop).

5. Volume-to-capacity ratio (v/c) of the total vehicles using the roadway, divided by the capacity (which reflects the curbside utilization ratio).

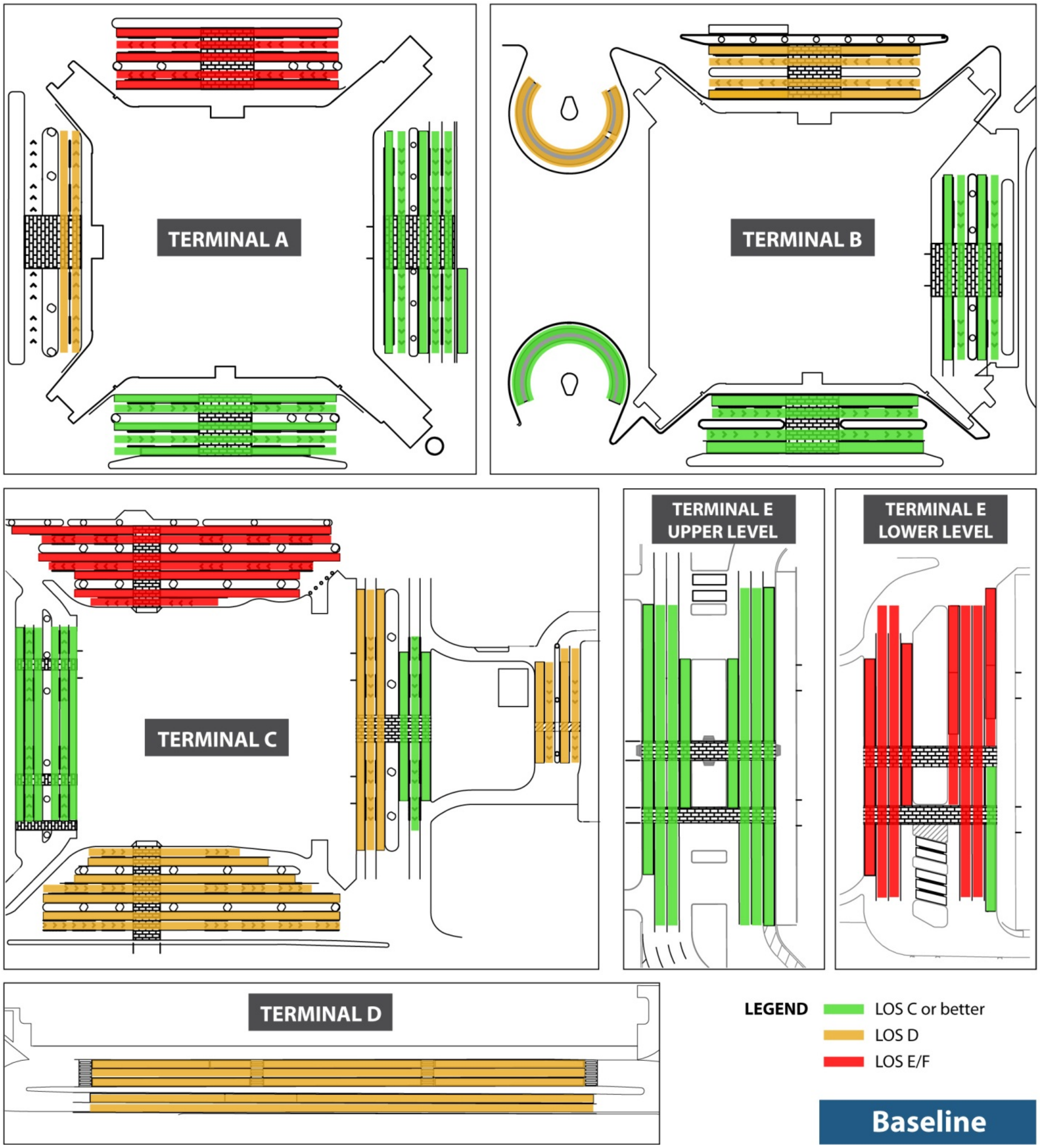
While level of service "C" is desirable at a new facility, level of service "D" is acceptable for an existing facility at large-hub airports, recognizing that during peak hours and days of the year the level of service may fall to "E" or less. Level of service on curbside roadways is estimated separately for through traffic and for curbside loading/unloading traffic, but the overall LOS is governed by the poorer of the two components.

4.4.4.3 Curbside Adequacy

The curbside adequacy levels for the baseline, PAL25, PAL33, and PAL40 conditions are displayed in Figures 4-23 through 4-26. The changes from the baseline level of activity through PAL40 are summarized below:

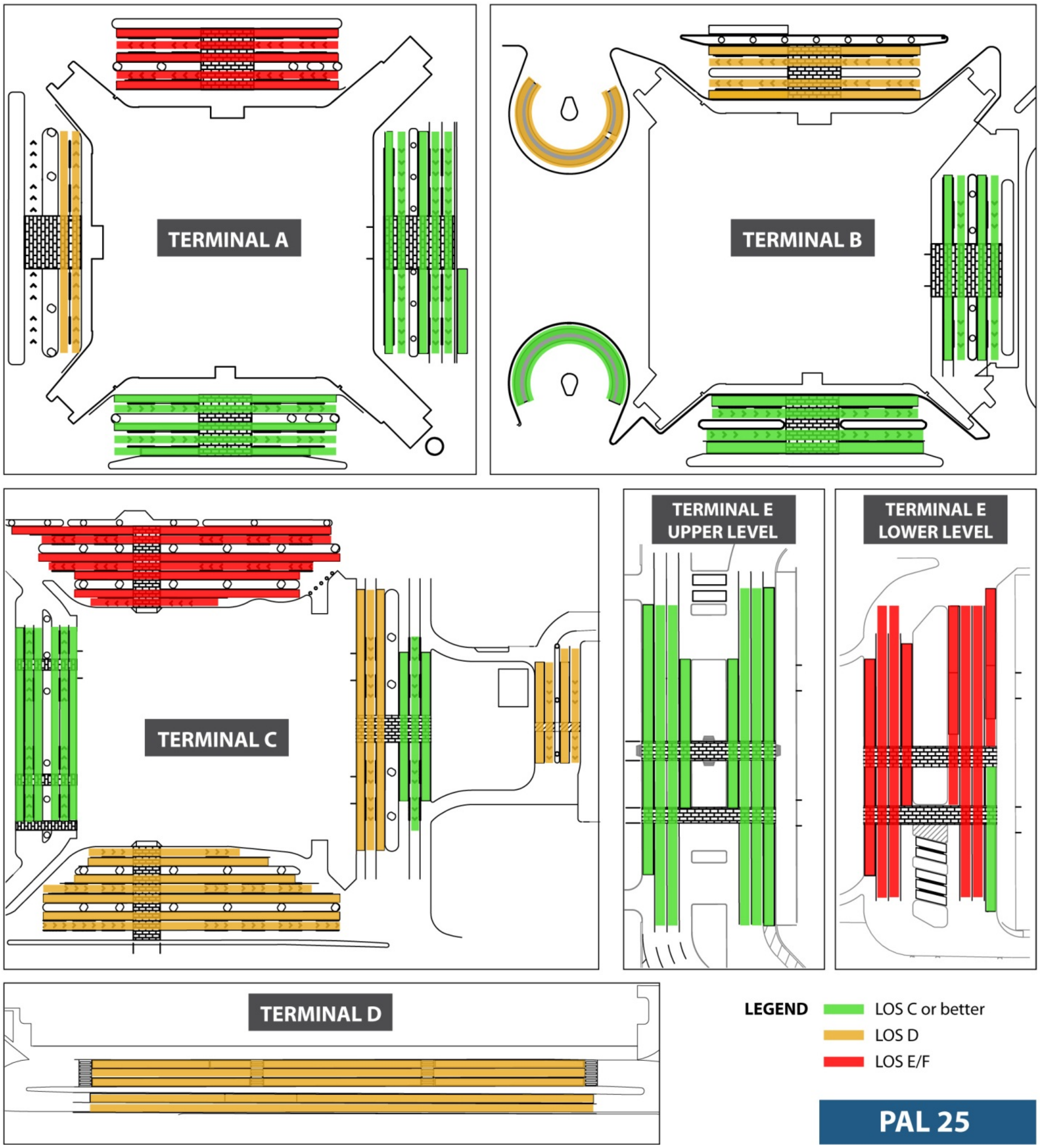
- Under existing conditions, during the peak hours the Terminal A, Terminal C, and Terminal E private vehicle arrivals curbsides are operating at an unacceptable LOS E or F, with the Terminal C and Terminal D departures and several of the commercial vehicle curbsides operating at LOS D.
- By PAL33 the Terminal A courtesy vehicle curbside, Terminal B private vehicles arrivals curbside and shuttle loop, and the Terminal C departures and courtesy vehicle curbsides are also expected to operate at LOS E/F. The Terminal A, Terminal B, and Terminal E departures curbsides are expected to operate at LOS D in PAL33.
- By PAL40 all of the departures curbsides are also expected to operate at LOS E/F. Taxicab lanes at the curbsides are assumed to continue to operate at LOS C or better, as the vehicles are called to the curbside based on demand.

Figure 4-23
CURBSIDE LEVEL OF SERVICE – BASELINE



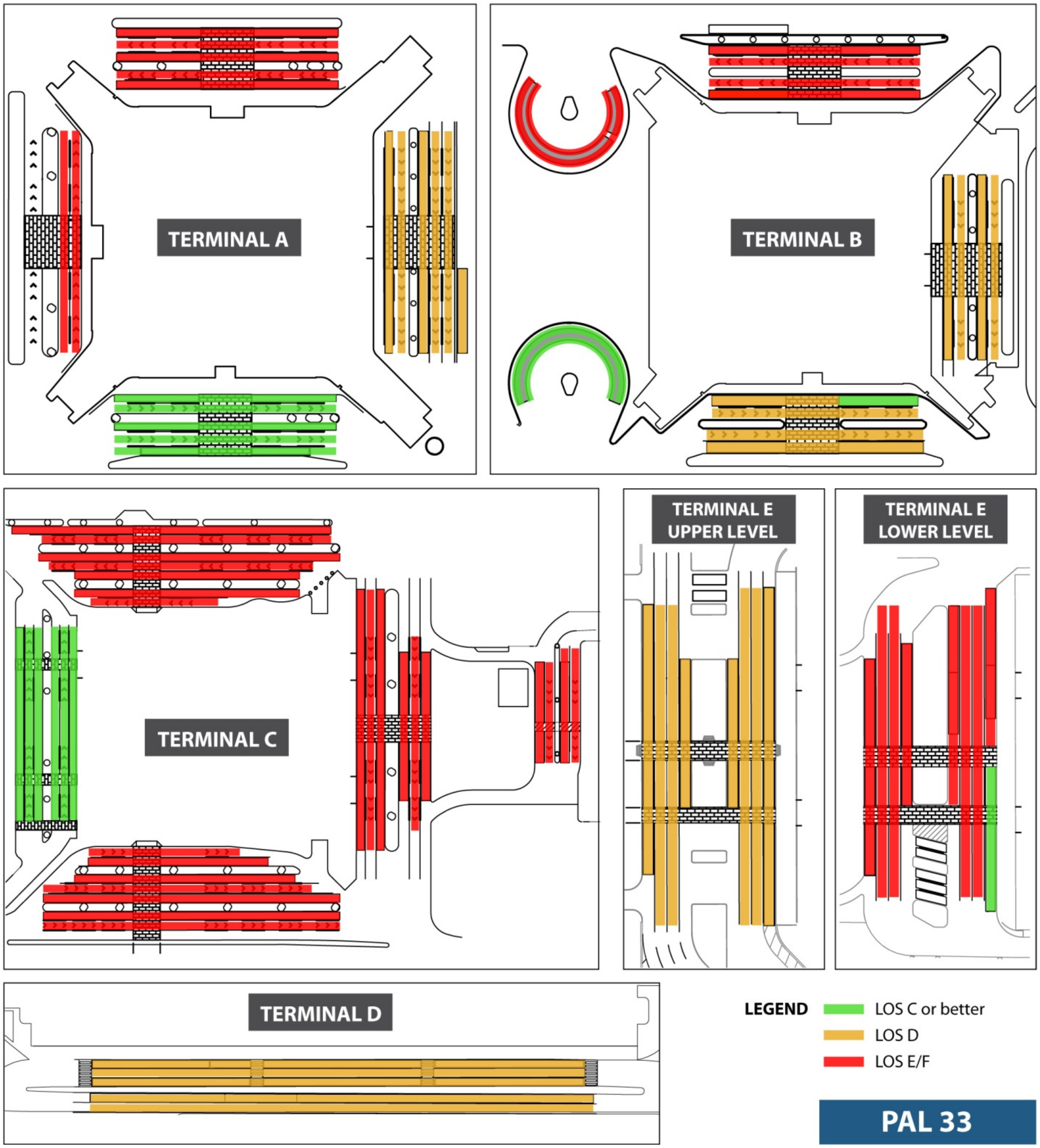
Source: LeighFisher, July 2013.

Figure 4-24
CURBSIDE LEVEL OF SERVICE – PAL25



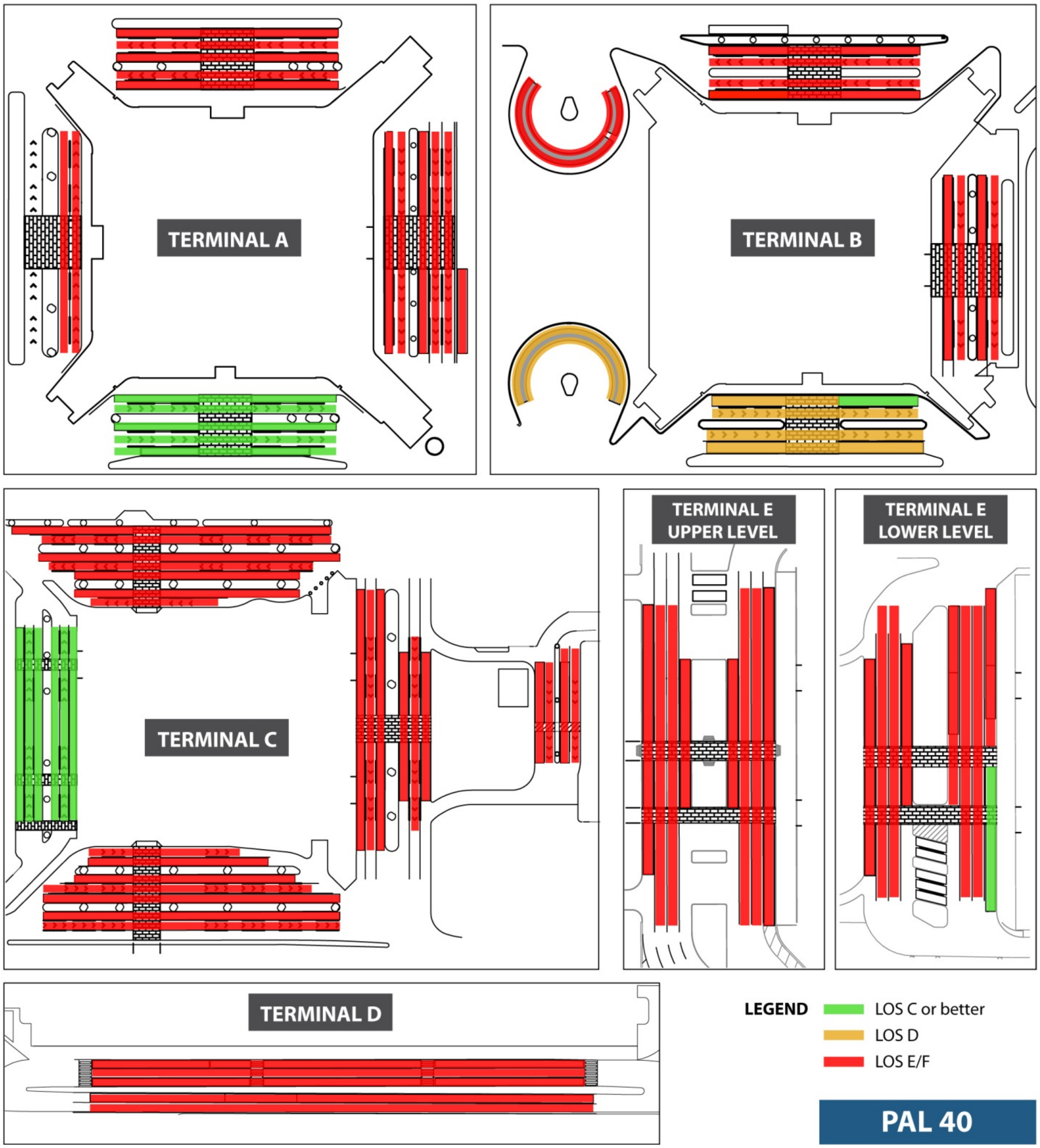
Source: LeighFisher, July 2013.

Figure 4-25
CURBSIDE LEVEL OF SERVICE – PAL33



Source: LeighFisher, July 2013.

Figure 4-26
CURBSIDE LEVEL OF SERVICE – PAL40



Source: LeighFisher, July 2013.

4.4.5 Parking and Rental Car Facilities

4.4.5.1 Methodology

To estimate future parking requirements, public and employee parking activity data provided by HAS staff was reviewed, including current and historical peak period occupancies by facility. In addition, occupancy data from a 2012 survey of off-airport parking operators was used to estimate current off-Airport parking space usage. Furthermore, historical relationships between annual originating-terminating airline passengers and public parking requirements were examined. The future requirements were based on a design day that represents a typical busy day during a peak month but does not represent the busiest day of the year, as there are a limited number of days such as holidays when Airport parking demand is expected to be significantly higher than other days during the year.

The following assumptions were used in developing the future parking requirements:

- In future years there will be no significant change in parking duration patterns (i.e., customer length of stay) or seasonal variations
- In future years, there will be no significant increase in the use of transit or non-private vehicles by parking customers or employees
- It was assumed that all growth in public parking requirements would be accommodated on the Airport recognizing that existing off-Airport parking businesses could potentially be redeveloped for alternative uses and to assure that adequate Airport property is reserved for this land use
- Public parking demands will increase at the same rate as originating and terminating airline passengers, consistent with historical relationships
- Employee parking demands will increase in proportion to a blend of the forecast growth rates for airline passengers and aircraft operations
- There will be no significant change in the proportion of customers renting or returning rental cars at the airport.

The reported space occupancies observed on a typical busy day in October 2012 represent peak month conditions based upon a review of monthly parking revenues for calendar years 2010, 2011, and 2012. Future parking space requirements were also adjusted to incorporate a circulation factor of 10 percent to reflect the difficulty motorists have in locating the last available parking spaces in a large facility, vehicles circulating within a parking structure, and to allow for improperly parked vehicles and other inefficiencies.

4.4.5.2 Parking Level of Service

Parking level of service measures reflect the ease with which customers can find a conveniently located parking space near their destination, whether in the terminal area or in a remote parking space. An acceptable level of service occurs when parking occupancies for a facility are low enough to permit a customer to easily find a space in the facility on a typical busy day at the Airport. Another consideration is the proportion of covered spaces available in the terminal area or within a convenient walk of the ticketing lobby and baggage claim areas. Once occupancies exceed 85 percent of the parking facility capacity, the level of service deteriorates as it becomes more difficult to find a space and customers are forced to park in another less desirable facility.

4.4.5.3 Public Parking Requirements

As shown in Table 4-21, the current terminal area parking facilities are expected to be insufficient to meet demand levels by PAL25, while it is expected that there will be sufficient remote parking spaces to accommodate demand through the end of the planning horizon. As mentioned in the assumptions section, it was assumed that all growth in public parking requirements would be accommodated on the Airport. Assuming the existing capacity in off-airport parking facilities remains the same, the total public parking facilities are expected to be insufficient to accommodate estimated requirements by PAL33, with approximately 5,010 additional spaces expected to be required by PAL33 and 14,230 additional spaces required by PAL40. It should be noted that providing appropriate parking facilities in the terminal area is challenging given the existing unit terminal configuration. Specifically, there currently are imbalances in parking demand at parking facilities between the terminals and this will continue to be driven by the type and level of operations in each unit terminal.

Table 4-21
PUBLIC PARKING REQUIREMENTS

	Existing	Estimated requirements *(b)*			
	Facilities	Baseline	PAL25	PAL33	PAL40
Origin-destination enplaned passengers (millions)	9.1	9.1	11.4	15.1	18.1
Public Parking					
Terminal area	13,190	11,490	16,890	25,500	32,680
Remote *(c)*	8,550	3,250	4,770	7,200	9,230
Total	21,740	14,740	21,660	32,700	41,910
Off-Airport Public Parking	18,440	12,490	12,490	12,490	12,490
Total Public Parking	40,180	27,230	34,150	45,190	54,400

(a) Passenger forecast prepared by LeighFisher, 2012.
(b) Includes a 10 percent circulation factor.
(c) Assumes off-Airport parking supply remains constant and all additional growth is accommodated on-Airport.

Source: LeighFisher, July 2013.

4.4.5.4 Employee Parking Requirements

Table 4-22 summarizes the future estimated employee parking requirements. As shown, employee parking demand is expected to exceed capacity by PAL25, both in the main employee parking areas and in the United Airlines section of the EcoPark lot. An additional 824 employee spaces are expected to be needed by PAL40, with an additional 927 spaces required for the United Airlines section of EcoPark.

Table 4-22
EMPLOYEE PARKING REQUIREMENTS

	Existing	Baseline	PAL25	PAL33	PAL40
Projected aircraft operations (thousands)	518	512	620	736	809
Non-United Employee Parking *(a)*	2,106	1,850	2,280	2,860	3,300
United Employee Parking *(a, b)*	3,500	3,080	3,800	4,760	5,480

(a) Existing employee parking facilities are assumed to be 80 percent full. A 10 percent circulation and level-of-service factor was added.
(b) Number of spaces leased by United Airlines to be confirmed.

Source: LeighFisher, July 2013.

4.4.5.5 Rental Car Requirements

The facilities used by the rental car companies at the Rental Car Center (RCC) are divided into three distinct facilities: (a) ready/return spaces, (b) customer service building, and (c) the service sites with quick-turn around (QTA) facilities. The bus maintenance facility, for the RCC bus fleet, was also analyzed. Questionnaires regarding the capacity of existing facilities and the existing demand were distributed to each of the companies. The questionnaires were followed by a series of interviews to best understand the questionnaire responses. Using the data collected through the questionnaire, and using benchmarks from peer airports, the ability of the existing facilities in the RCC to accommodate existing demand was determined.

Growth in rental car facility requirements was primarily based on the forecast growth in O&D passengers. A trend analysis of the ‘propensity to rent a car’ was also conducted. This propensity is measured by calculating the transaction days per originating-enplanements. The propensity to rent a car has increased by an annual average of 4.6% since 2010. This indicates the demand for rental car facilities is increasing faster than the growth in passengers. The future requirements were adjusted accordingly.

Ready/Return Facility

‘Ready’ vehicles refer to vehicles waiting to be picked up by customers. Typically, a rental car facility should accommodate 5 percent of the fleet in ‘ready’ stalls. ‘Return’ vehicles refer to vehicles being dropped-off and checked-in to their respective companies. Typically, a rental car facility should accommodate 3 percent of the fleet in ‘return’ stalls. These assumed percentages count spaces that can be used for both ‘ready’ operations and ‘return’ operations, depending on peak pick-up or peak drop-off periods, referred to as ‘flex’ spaces.

The combined ready/return facility requirements are shown in Table 4-23. The space requirements are converted to areas to facilitate a comparison to the existing facility. The existing ready/return facility is 1,224,000 square feet while today's requirements are approximately 916,000 square feet. The existing ready/return facility is expected to accommodate demand until almost PAL 33. To accommodate PAL 40 demands, an additional 568,000 square feet are required. The design of the existing ready/return car garage accommodates expansion to the north and south..

Customer Service Building

The analysis of the customer service building was limited to the mini-mall suites operated by the companies. The suites include the customer service lobby, customer service counters, and the back-office administrative space used by each company. Each company is allowed to develop their suites to their preference, eliminating the need to develop requirements at a greater level of detail. The areas of the customer service building dedicated to circulation, open-lobby, restrooms, and utilities are assumed to meet all future demands.

Due to the increase in the use of technologies and company loyalty programs, which allow customers to bypass the counters and go directly to their rental vehicle, the requirements for the customer service suites are not expected to increase at the same rate as the other components of the RCC. As a result, the growth in the customer service suite requirement is estimated to occur at half the growth rate used for other RCC facility components.

The combined customer service suite requirements are shown in Table 4-23. The existing suites provide approximately 31,480 square feet while today's requirement is approximately 27,100 square feet. The total area dedicated to company suites is expected to meet demand almost to PAL 33. To accommodate PAL 40 demands, an additional 8,520 square feet is required.

Service Sites

The service sites east of the RCC garage include Quick Turn-Around (QTA) facilities, heavy maintenance facilities, and small office buildings. The QTA accommodates fueling facilities, wash bays, maintenance bays, and vehicle storage/parking. Each company has developed their allocated service sites to their preferences. The majority of the area in the service sites is dedicated to various forms of vehicle parking. As a general rule, rental car companies assume60 percent of their fleet can be accommodated in either the ready/return facilities or within the QTA. Vehicle parking occurs in three phases: stacking (queuing for wash/fuel), staging (awaiting move to 'ready' spaces), and storage (long-term storage for peak periods). Additional parking areas are required for damaged vehicles and in-fleeting/de-fleeting.

The combined service site area requirements are shown in Table 4-23. Currently, the service sites comprise of approximately 54.9 acres, while current demand is for 42.4 acres. While individual companies may need to expand, the total area dedicated to service sites is expected to accommodate demands beyond PAL 25. An additional 28 acres for service sites are expected to be needed by PAL 40. However, large plots of undeveloped land, within the service site complex, are reserved specifically for service site expansion, and are expected to accommodate all needs through the planning period.

Bus Maintenance Facility

The current rental car shuttle bus facility is contained in a 5,900 square feet building containing four bus maintenance bays. By PAL40 an additional four bus maintenance bays will be required, resulting in a total building size of 11,800 square feet. Additionally, the paved area providing bus parking and circulation will need to be expanded to the south by approximately 44,000 square feet, corresponding to the maintenance bay expansion.

Table 4-23
RENTAL CAR REQUIREMENTS

	Existing	Baseline	PAL25	PAL33	PAL40
O&D MEP	9.8	9.8	13.7	17.6	18.7
Ready/Return (SF)	1,224,000	916,000	1,090,000	1,440,000	1,790,000
Customer service suites (SF)	31,480	27,060	30,000	34,600	40,000
Service Site Area (acres) *(f)*	54.9	42.4	49.5	66.7	83.0

Source: LeighFisher, April 2015.

4.4.5.6 Taxicab and Miscellaneous Hold Areas

Hold lot requirements are presented in Table 4-24. The required taxicab and miscellaneous hold areas were assumed to increase in direct proportion to terminating airline passengers. Based on observation, it is assumed that there is a 10 percent overflow demand outside of the existing 239,720 square foot taxicab hold lot. By PAL40 it is expected that an additional 288,150 square feet of space will be required to accommodate the increased demand for the taxicab hold lot.

The miscellaneous hold area has sufficient capacity to accommodate demand for limousines, shared-ride vans, and charter buses through the end of the planning period. The excess capacity in the miscellaneous hold lot is expected to be sufficient to accommodate the additional taxicab demand until PAL33.

Table 4-24
HOLD LOT REQUIREMENTS

	Existing	Baseline	PAL25	PAL33	PAL40
O&D (MEP)	9.1	9.1	11.4	15.1	18.1
Taxicab Hold Lot (SF) *(a)*	239,720	263,690	330,750	437,660	526,870
Acres	5.5	6.1	7.6	10.0	12.1
Misc. hold lot (SF) *(b, c)*	151,800	30,360	38,080	50,390	60,660
Acres	3.5	0.7	0.9	1.2	1.4

(a) Existing taxicab hold lot demand assumed to include 10 percent overflow demand.
(b) Serves limousines, charter buses, and other miscellaneous commercial vehicles.
(c) Assumes existing hold area is only 20 percent full during peak occupancy.

Source: LeighFisher, July 2013.

4.4.6 Automated People Mover Systems

The Airport operates two automated people mover systems. TerminaLink, which operates post security at the upper level, transports connecting airline passengers as well as employees travelling between terminal buildings. The Inter-Terminal Train (ITT) transports non-secure passengers between the terminals, the Marriott Hotel, and terminal area parking facilities at a below-grade level. ITT passengers include those who parked and departed out of one terminal and returned to another (displaced parkers), hotel guests, Airport visitors, and Airport employees. This section describes the methodology, estimated demands, and existing constraints of the two APM systems at the Airport.

4.4.6.1 Methodology

To estimate future requirements for the two APM systems, information provided by HAS staff was reviewed.

TerminaLink requirements are a function of the volume of peak hour connecting passengers who must travel between terminal buildings to complete their journey. Since most of the connecting passengers at the Airport are flying aboard United Airlines or its Star Alliance Partners, the volume of connecting passengers is determined by (a) where United Airlines arriving and departing aircraft are parked, (b) the number of connecting passengers aboard each aircraft, and (c) the proportion of these passengers who choose to walk to their next gate versus those who must use TerminaLink.

HAS staff and casual observations indicate the largest proportion of ITT passengers are hotel guests and employees working at the Airport. ITT requirements, therefore, are a function of the numbers of hotel guests and staff using the system. Staff may use the ITT to move between places of work during the course of the day or to travel between their assigned parking facility and their place of work.

APM capacities are determined using the following assumptions:

- The size of the train: TerminaLink uses Bombardier Innovia 100 vehicles operated in two-car trains. The ITT uses vehicles originally furnished by WED Transportation Systems operated in three-car trains.
- The capacity of each vehicle: TerminaLink vehicles provide capacity for approximately 60 to 70 passengers, assuming only hand/carry-on baggage is allowed on the vehicles. The ITT vehicles provide capacity for six seated and six standing passengers for a total capacity of 12 passengers per vehicle. Passengers are allowed to have both carry-on and checked baggage but baggage carts are prohibited aboard the vehicles on this non-secure system.
- The system headways: TerminaLink currently operates on 90 second headways. The ITT operates on three-minute headways.

As a result of these assumptions, the estimated capacity of the TerminaLink is about 5,400 passengers per hour per direction (45 trains per hour each having capacity for 120 passengers and their baggage). The capacity of the ITT is about 720 passengers per hour per direction (20 trains per direction each having capacity for 36 passengers and their baggage).

4.4.6.2 Demands

To support 2006 analyses of the APM systems, Continental Airlines provided data indicating that between 10 percent and 15 percent of on-line domestic connecting passengers travelled between terminals and between 25 percent and 35 percent of international arriving passengers travelled between terminals. It was assumed that less than 2 percent of all connecting passengers use the ITT.

Analyses presented in the 2006 Airport Master Plan estimated that during the peak 15-minutes there were about 420 riders on the TerminaLink between the two busiest stations (Terminals B and C). This peak demand was approximately 80 percent of the TerminaLink system's capacity at that time and approximately 30 percent of the current capacity. During most 15-minute periods less than 300 passengers rode the TerminaLink between any station pair.

The 2006 Airport Master Plan estimated that the peak 15-minute demands on the ITT were about 110 passengers which is equivalent to about 440 passengers per hour per direction. This demand is approximately 60 percent of the ITT system capacity. These demands occurred only during the peak 15-minute period with most hours of the day serving significantly less than 200 passengers per direction on the ITT.

4.4.6.3 Existing Constraints on System Capacities

The capacity of the TerminaLink is constrained by the locations of cross-over switches leading into and out of each station. The location of these switches precludes the use of three-car trains.

The capacity of the ITT is constrained by the guideway geometry, which limits vehicle speeds. HAS has conducted numerous studies to analyze this system, which is now more than 30 years old and difficult to maintain. Specifically, replacement parts are no longer available for this system, and HAS routinely has custom-made parts manufactured. Prior studies evaluated realigning the guideway to improve vehicle speeds (which was determined to be prohibitively expensive because of the locations of structures supporting the terminals and other buildings), replacing the ITT with moving sidewalk or buses operating on the roadways (which were found to add to existing roadway and curbside congestion), or replacing the ITT with a more modern technology such as a Personal Rapid Transit (PRT) system which could operate within the constrained guideway. Airport staff indicates that the ITT system provides adequate capacity and, due to the efforts of the system maintenance staff, maintains operational reliability of approximately 99 percent. The key concerns are the dated appearance of the vehicles and stations, not the system performance.

4.5 AIRPORT AND AIRLINE SUPPORT FACILITY REQUIREMENTS

This section documents facility needs throughout the planning period for airport support functions. The following airport support functions are included in this analysis:

- General Aviation Facilities
- Airline Air Cargo Facilities
- Integrated Air Cargo Facilities
- Airport Support Facilities
- United Airlines Support Facilities
- Other Support Facilities

4.5.1 General Aviation Facilities

On a national basis, general aviation (GA) activity has been declining for several decades. General aviation activity at IAH has mirrored the national trends, although a slight increase was experienced in 2011. With the limited growth in GA activity nationally and at IAH, many of the existing facilities are operating below capacity for current demand.

The GA facilities are categorized into the following two groups and are described in detail:

- Fixed Based Operators (FBOs) – tenants providing services to the general aviation public such as fueling, maintenance, hangar storage, aircraft parking, and pilot and passenger amenities for based and itinerant aircraft
- Corporate Based Operators (CBOs) – tenants that own and operate facilities for their exclusive use

4.5.1.1 FBOs

There are two FBOs at IAH; Atlantic Aviation and Standard Aero/Landmark Aviation (Landmark). Atlantic Aviation is a full service FBO providing diverse facilities and services. Landmark Aviation is a limited service FBO whose services currently focus on aircraft maintenance. Table 4-25 presents information on these FBOs.

The two FBO facilities have adequate space for existing operations. Atlantic has leased supplemental hangar and apron space to combine with their existing facilities. Discussions with FBOs indicate their facilities and lease areas are adequate through the planning period.

Table 4-25
TOTAL FBO LEASE AREAS

FBO	Lease area (SF)	Developed area (SF)	Terminal area (SF)	Hangar Area (SF)	Hangar Aircraft (position)	Apron Area (SF)	Apron Aircraft (position)	Auto Parking (SF)	Fuel Area (SF)
Atlantic	668,566	581,362	37,026	82,600	7	369,389	14	40,946	51,401
AFCO (Atlantic)	308,595	194,586	12,926	37,864	6	66,563	4	76,129	0
Subtotal	977,161	775,948	49,952	120,464	13	435,952	18	117,075	51,401
Landmark	784,080	224,770	8,712	0	0	88,427	6	118,919	8,712
Total	1,761,241	1,000,718	58,664	120,464	13	524,379	24	235,994	60,113

Source: Houston Airport System, LeighFisher, November 2012.

4.5.1.2 Corporate Based Operators

There are 11 Corporate Based Operator facilities at IAH. All are located adjacent to the Runway 15L-33R and 15R-33L complex, as shown in Figure 4-27.

Figure 4-27
TOTAL CBO LEASE AREAS

Source: Houston Airport System, LeighFisher, November 2012.

A total of 67.0 acres of land area are leased to the 11 CBOs. Two of the existing CBO sites are vacant and available for lease. Many of the site leases are not fully developed. On average, the developed area to total site lease area averages 66 percent. Fully developed sites have developed area to lease area ratios of 85 percent. Expansion of existing facilities within the existing sites is possible and represents, in the aggregate, approximately 20 percent of available land.

With two existing CBO sites currently vacant and many of the CBO lease sites not fully developed, additional expansion is not anticipated during the forecast period.

4.5.2 General Aviation Facilities Summary

4.5.2.1 GA Aircraft Demand

Two key parameters are indicative of future GA facility demand: total forecast GA aircraft operations and total based GA aircraft. Annual GA demand in 2012 totaled 12,159 operations for all users. Monthly demand in 2012 exhibited peaks in February, March and October with approximately 1,065 operations, which translates to 41 operations on an average day. Considering that these operations are not necessarily turns, the number of peak aircraft is estimated to be 21 aircraft per day. It is recognized that GA aircraft may peak on certain days of any given month. Itinerant aircraft in particular are at times event-driven.

Table 4-26 shows the forecast annual GA aircraft demand along with an estimate of the peak month average day operations and aircraft. These are further allocated to FBO and CBO users based upon assumptions related to inventory information. As shown, the majority of the estimated average day peak month GA aircraft operations are allocated to itinerant aircraft operators that would use FBO facilities. The remaining operations are by CBO tenants. The lower allocation reflects the fact that based aircraft typically do not operate every day.

The allocation between the two FBOs reflects the existing dominant use of Atlantic Aviation by itinerant users. Landmark, with a dominant focus on aircraft maintenance, does not cater to itinerant aircraft not seeking maintenance support.

Table 4-26
ALLOCATED FORECAST GA AIRCRAFT OPERATIONAL DEMAND

		ADPM		Itinerant Aircraft Demand (aircraft positions)		
				FBO		CBO
Level of demand	Annual GA operations	Operations	Aircraft (positions)	Atlantic	Landmark	All
2012 *(a)*	12,159	41	21	17	2	2
PAL25	13,230	45	23	18	2	2
PAL33	14,469	49	25	20	2	2
PAL40	15,359	52	26	21	3	3

(a) 2012 represents the requirement at 2012 demand levels.

Source: LeighFisher, April 2013.

The number of based aircraft is the second prominent aspect of GA facilities definitions. The existing based aircraft by aircraft type are shown in Table 4-27. There are 38 total aircraft based at IAH. The majority of based aircraft are large corporate jets.

Table 4-27
EXISTING BASED AIRCRAFT

Aircraft type	Number
B767	1
Gulfstream GV/G550	11
Gulfstream GIV/G450	6
G150	3
Falcon 2000	2
Hawker 850	2
Challenger 300	5
Citation	3
Prop	5
Total	38

Source: LeighFisher, April 2013.

4.5.2.2 GA Apron Demand

Large GA aircraft dominate the itinerant aircraft demand at IAH. The Gulfstream G-V is a significant part of the itinerant demand and one of the largest GA aircraft with an area requirement (aircraft wingspan multiplied by aircraft length) of 9,600 SF. This aircraft area is exclusive of wingtip clearances and taxilane areas. Including these areas, the average aircraft area for the purposes of apron calculations is defined to be 1.5 times the G-V spatial requirement, or 14,400 SF.

The apron demand by non-based itinerant aircraft at the two existing IAH FBOs is presented in Table 4-28. As shown, the total current apron demand is for 9.2 acres of apron space that includes aircraft parking area and taxilane/aircraft circulation area. Assuming future apron requirement needs grow in proportion to annual GA operations at historical ratios, the apron would need to be expanded to a total of about 11.7 acres by PAL40.

Table 4-28
FBO ITINERANT APRON DEMAND

Level of demand	Annual GA operations	Itinerant Aircraft Demand *(b)* FBO			Average acres per aircraft	Itinerant Apron Requirements: Total Area Required		Itinerant Apron Requirements: Allocated area (acres)	
		Atlantic	Landmark	Total		Square feet	Acres	Atlantic	Landmark
2012 *(a)*	12,159	17	2	19	14,400	402,686	9.2	8.2	1.0
PAL25	13,230	18	2	20	14,400	438,155	10.1	8.9	1.1
PAL33	14,469	20	2	22	14,400	479,189	11.0	9.8	1.2
PAL40	15,359	21	3	24	14,400	508,664	11.7	10.4	1.3

(a) 2012 represents the requirement at 2012 demand levels.
(b) Average day aircraft demand.

Source: LeighFisher, April 2013.

The non-based itinerant GA apron demand/capacity is shown in Table 4-29. As shown, the Atlantic apron is estimated to be used at about a 97 percent for current demand, while the Landmark occupancy rate is 49 percent. Assuming ADPM conditions, Atlantic will need to increase their apron space needs by 22 percent, while Landmark will require 64 percent of their current capacity at PAL40.

Table 4-29
FBO ITINERANT APRON AVERAGE DAY DEMAND/CAPACITY

Level of demand	Annual GA operations	Existing area (acres)		Required area (acres)		Demand/Capacity	
		Atlantic *(b)*	Landmark	Atlantic	Landmark	Atlantic	Landmark
2012 *(a)*	12,159	8.5	2.0	8.2	1.0	97%	49%
PAL25	13,230	8.5	2.0	8.9	1.1	105	55
PAL33	14,469	8.5	2.0	9.8	1.2	115	60
PAL40	15,359	8.5	2.0	10.4	1.3	122	64

(a) 2012 represents the requirement at 2012 demand levels.
(b) Excludes AFCO and sublease area.

Source: LeighFisher, April 2013.

4.5.2.3 GA Hangar Demand

The FBO and CBO hangar demand to capacity is presented in Table 4-30. The average size of an aircraft based at IAH is approximately 7,200 SF, which was used to estimate future hangar area requirements.

As shown, the estimated current demand/capacity is about 47 percent reflecting the presence of several vacant existing hangars. An increase in the average size of based aircraft is assumed over the forecast period.

Table 4-30
FBO AND CBO HANGAR DEMAND/CAPACITY

Level of demand	Forecast based total	Assumed storage type		Average aircraft area (SF)	Total hangar area			Demand/ Capacity
					Required		Existing capacity	
		Apron	Hangar		SF	Acres	Acres	
2012 *(a)*	38	8	30	7,200	216,000	5.0	10.5	47%
PAL25	41	9	32	7,500	240,000	5.5	10.5	52
PAL33	44	11	33	8,100	267,300	6.1	10.5	58
PAL40	45	12	33	8,400	277,200	6.4	10.5	61

(a) 2012 represents the requirement at 2012 demand levels.

Source: LeighFisher, April 2013.

Considering both an increase in the number of based aircraft and an increase in the average size of based aircraft, the existing hangar facilities available at IAH including the FBO and CBO facilities are expected to remain adequate throughout the planning period.

4.5.3 Airline Air Cargo Facilities

IAH has become a major cargo hub with growing annual cargo and freight tonnages. Air freight handling has evolved over the years in terms of airport accommodation and facilities. A growing trend in air cargo is that airlines have a declining role in the sales, collection and distribution of air cargo. Rather, airlines have focused on being the transport mechanism for the cargo. Consolidators and forwarders have risen to prominence as the primary collectors and distributors of air cargo. These operators are typically located off-airport due to the costs of facilities on-airport. At IAH, several of the large consolidator and forwarder companies as well as distribution facilities for larger single operators, are located off-airport east of the East Cargo Area and along Greens Road to the south. These companies and facilities serve all modes of cargo transport and reflect the industry trend in airlines no longer being consolidators of air cargo. Airlines now focus predominately on flying cargo, most notably in available aircraft belly space. More off-airport cargo facility development can be expected in the future. This section focuses on the on-airport cargo facilities, including:

- On airport cargo buildings
- All cargo aircraft operations and parking
- Air cargo related support facilities

There are two on-airport areas that house air cargo buildings: the East Cargo Area and the Central Cargo Area.

4.5.3.1 East Cargo Area

The East Cargo Area has three cargo buildings, depicted on Figure 4-28 as CB#1, CB#2, and CB#3. These were privately developed buildings and are privately operated. Aircraft apron areas were developed by the HAS and are operated by HAS as common use areas.

Figure 4-28
EAST CARGO AREA

Source: LeighFisher, July 2013.

The tenants of the East Cargo area are presented in Table 4-31.

Table 4-31
EAST CARGO AREA TENANTS

	CB #1	CB #2			CB #3	
		AeroTerm				
Owner Handler	Prologis	CAS TX	ESC Cargo	ServicAir	AeroTerm Integrated	Air General
Tenants	Air France/KLM DHL Schenker	Air Canada Antonov US Airways Alaska Arrow Air Atlas/Polar Cathay Pacific Lan Chile Lufthansa Saudi Arabian Polet Air Ruslan Int'l. SAS	Platinum Air China Airlines Emirates	AeroMexico Alitalia Delta Frontier Japan Airlines	Eva Korean Singapore	British Airways Qatar

Source: Houston Airport System, LeighFisher, February 2013.

Table 4-32 presents the physical characteristics of the three East Cargo Buildings and the associated areas. As shown, the East Cargo Area totals approximately 49 acres. The cargo buildings total about 10.5 acres and the apron/taxilane facilities total 21.7 acres.

Table 4-32
EAST CARGO BUILDING SITES

		Site Area (square feet)					
Owner	Building	Building *(a)*	Apron	Airside	Truck/ auto	Access	Total
Prologis	CB #1	3.5	7.3	1.1	3.8	0.9	16.6
AeroTerm	CB #2	3.3	7.0	1.1	4.2	0.7	16.2
AeroTerm	CB #3	3.8	7.4	1.1	3.4	0.7	16.2
Total		10.5	21.7	3.2	11.3	2.3	49.0

(a) Includes building footprint and not total floor area.

Source: LeighFisher, February 2013.

Table 4-33 depicts the percent of leased space along with the estimated utilization of the leased spaces. It is estimated that about 82 percent of the total East Cargo available area is leased, and of that space, it is being utilized at about 71 percent of capacity. This implies that these existing buildings can accommodate increased activity for some time in the future.

Table 4-33
EAST CARGO BUILDING AREAS AND UTILIZATION

Owner	Building	Total building (SF)	Building footprint (SF)	Office (SF)	Total % leased	Total % utilized
Prologis	CB #1	164,932	150,932	14,000	75%	45%
AeroTerm	CB #2	165,918	144,418	21,500	100	85
AeroTerm	CB #3	168,954	163,454	5,500	71	65
Total		499,804	458,804	41,000	82%	71%

Source: LeighFisher, February 2013.

4.5.3.2 Central Cargo Areas

The Central Cargo Area includes 10 cargo buildings. These buildings accommodate a variety of tenants, not all of whom are cargo operators. There are no buildings with dedicated aircraft parking. Any aircraft parking demand by Central Cargo Area users are assigned parking positions by HAS at the common Central Cargo Ramp. Most of the buildings in the Central Cargo area were developed decades ago. The design standards for these building are not compatible with those now accepted in the cargo industry in terms of ceiling height, truck dock depth and truck circulation. Several of the buildings have been demolished to provide support areas (auto parking) for the buildings that remain. Figure 4-29 shows the Central Cargo Area.

Figure 4-29
CENTRAL CARGO AREA

Source: LeighFisher, February 2013.

4.5.3.3 Total Cargo Demand

The forecast demand for domestic and international cargo and freight has been allocated to the key areas/users of the cargo facilities at IAH. The allocation reflects the percentages of the total served by each company in 2012. These percentages are assumed to remain constant throughout the forecast period. Table 4-34 shows the allocated forecast cargo demand.

As shown in Table 4-34, the total cargo demand has been allocated between all cargo operators. The largest cargo handlers including the integrated cargo carriers, FedEx and United Parcel Service (UPS), and United Airlines are segregated as a group and referred to as the “primary users.” The primary users handle cargo volumes large enough to operate independent facilities. Remaining users are referred to as “other users” who are smaller users that collectively operate in either the East Cargo or Central Cargo Area. The requirements of United Airlines are included in the assessments of facility requirements for the Central Cargo Area. This distribution of future forecast cargo volumes are used as the basis for the definition of requirements for each group.

Table 4-34
TOTAL FREIGHT AND CARGO DEMAND ALLOCATION

	Annual Freight and Cargo (millions of pounds)							
		Primary Users				Other Users		
Level of demand	Total forecast	United	FedEx	UPS	Total	East	Central	Total
2012 *(a)*	929.6	185.9	203.6	115.3	504.8	403.6	21.2	424.8
PAL25	1,148.5	229.7	251.5	142.4	623.7	498.6	26.2	524.9
PAL33	1,492.2	298.4	326.8	185.0	810.3	647.8	34.1	681.9
PAL40	1,776.9	355.4	389.1	220.3	964.8	771.4	40.6	812.0

(a) 2012 represents the requirement at 2012 demand levels.

Source: LeighFisher, June 2013.

4.5.3.4 Cargo Requirements

East Cargo Area Requirements

The total East Cargo Building and site requirements are shown in Table 4-35 below. The future requirements were primarily based upon the building operator information on leased areas and utilization of leased areas presented in Table 4-33. As shown, the existing buildings will be adequate until at least 2021 considering unleased and underutilized leased spaces in the existing facilities. At PAL25, the demand to capacity ratio will reach 90 percent, at which time expansion should be considered.

Table 4-35
TOTAL EAST CARGO BUILDING AND SITE REQUIREMENTS

Level of demand	East cargo freight and cargo forecast (millions of pounds)	Cargo building area (square feet)			Site area (acres)	
		Existing	Required	Building footprint	Existing	Required
2012 *(a)*	403.6	500,000	390,000	358,020	49.0	38.2
PAL25	498.6	500,000	448,770	411,971	49.0	44.0
PAL33	647.8	500,000	570,103	523,354	49.0	55.9
PAL40	771.4	500,000	678,851	623,186	49.0	66.5

(a) 2012 represents the requirement at 2012 demand levels.

Source: LeighFisher, June 2013.

Central Cargo Area Requirements

United Airlines is the largest user in the Central Cargo Area. All other users of the Central Cargo Area accommodate a small portion of the total cargo volumes for both current and future conditions. In the absence of facility redevelopment, future cargo operators are likely to prefer the East Cargo Area to the Central Cargo Area due to facility design limitations in the Central Cargo Area. The United Cargo building is currently 115,000 square feet. The buildings of the other carriers total 400,000 square feet.

Building space analysis based upon tons per square foot was used to estimate requirements for the Central Cargo Area buildings. For United, 1.0 tons per thousand square foot was used, while 0.5 tons per thousand square foot was used for the other Central Cargo buildings given their older designs. The Central Cargo Area building requirements are shown in Table 4-36.

Table 4-36
CENTRAL CARGO BUILDING AND SITE REQUIREMENTS

	UA Cargo				Other Central Cargo			
	Forecast cargo volume		Requirement		Forecast cargo volume		Requirement	
Level of demand	Millions of pounds	Metric tons	Building (square feet)	Site (acres)	Millions of pounds	Metric tons	Building (square feet)	Site (acres)
2012 *(a)*	185.9	84.5	84,509	3.2	21.2	9.7	19,310	0.7
PAL25	229.7	104.4	104,411	4.0	26.2	11.9	23,858	0.9
PAL33	298.4	135.7	135,655	5.2	34.1	15.5	30,997	1.2
PAL40	355.4	161.5	161,532	6.2	40.6	18.5	36,910	1.4

(a) 2012 represents the requirement at 2012 demand levels.

Source: LeighFisher, June 2013.

As shown, the United Cargo building is currently operating at an adequate level of service. Expansion of the building and site area of this facility is not anticipated until approximately PAL33. The remaining Central Cargo Area buildings are collectively operating at low utilization rates and no expansion is foreseen in the forecast period.

4.5.3.5 All Cargo Aircraft Aprons

It is estimated that total scheduled and non-scheduled ADPM all cargo apron demand totals 11 to 13 aircraft per day for current conditions. Table 4-37 shows the forecast all cargo aircraft demand along with a distribution among the dedicated cargo aircraft operators. The distribution uses the 2012 proportions and assumes this remains constant over the forecast period.

Table 4-37
ALL CARGO AIRCRAFT PARKING REQUIREMENTS

PAL	Annual All Cargo Ops	Annual All Cargo Aircraft (positions)	Distribution (positions) *(a)* 26.1% FedEx	19.3% UPS	54.6% Other	ADPM Apron Demand (positions) *(b)* FedEx	UPS	Other
2012 *(a)*	10,228	5,114	1,279	972	2,864	5	4	14
PAL25	12,767	6,384	1,596	1,213	3,575	7	5	17
PAL33	14,913	7,457	1,864	1,417	4,176	8	6	20
PAL40	16,971	8,486	2,121	1,612	4,752	9	7	23

(a) 2012 represents the requirement at 2012 demand levels.
(b) Annual all-cargo aircraft distribution.

Source: LeighFisher, June 2013.

As shown, FedEx and UPS are the two major individual all cargo aircraft operators and all other all cargo aircraft operators are included as a collective group that use the HAS common aircraft parking aprons. The FedEx and UPS apron requirements are discussed in greater detail in the following section of this report. The future "other" all cargo aircraft parking requirements that would use the HAS common use parking positions has the potential to increase by as many as 11 aircraft to 23 per day. The existing all cargo aprons are being utilized at about a 60 percent of capacity at the present time. It is noteworthy that some all-cargo aircraft have extended ground times and may increase the number of aircraft on the ground using aircraft parking positions in excess of the estimated daily demand. In addition, the existing all-cargo apron areas are used for other aircraft parking needs that includes idle aircraft storage and some aircraft maintenance activities. These current uses are assumed to be a lower priority for available all-cargo aircraft parking and will be relocated to other aprons in the future. It is also noteworthy that the existing aircraft parking positions were initially designed for the B747-400. Recent changes converted about half to B747-8 aircraft parking positions. All future positions are recommended to be B747-8 capable positions. In addition, the depth of the existing parking aprons is less than desirable. Many of the IAH dedicated cargo aircraft are nose loaded and the current 300-foot apron depths represent a limitation for operations. An apron depth of 350 feet is recommended for the future apron areas.

The apron areas associated with the additional aircraft parking requirements is shown in Table 4-38. As shown, the existing 57.0 acres of common use all cargo apron area should provide adequate capacity for all cargo aircraft through PAL25. Limited expansion will be desirable prior to PAL33.

Table 4-38
OTHER ALL CARGO AIRCRAFT APRON AREA REQUIREMENTS

Level of demand	ADPM apron demand (positions)	Requirement: Parking area (acres)	Taxilane area (acres)	Apron area (acres)
2012 *(a)*	14	27.6	16.5	44.1
PAL25	17	34.4	20.7	55.1
PAL33	20	40.2	24.1	64.3
PAL40	23	45.8	27.5	73.2

(a) 2012 represents the requirement at 2012 demand levels.

Source: LeighFisher, June 2013.

4.5.3.6 GSE Storage

The majority of the cargo handling in the East Cargo Area is performed by CAS TX. This aircraft ground handling company provides labor and equipment for loading and unloading cargo aircraft. Their existing equipment includes lower and main deck loaders, pallet dollies, tugs and related equipment. At the present time, two gates are used for the storage of GSE along with apron perimeter areas. These areas approximate 175,000 square feet to 200,000 square feet (4.0 to 4.6 acres). At the present time, the loss of existing aircraft parking positions while not desirable can be tolerated with aircraft parking demand less than capacity. A separate GSE storage yard is desirable after PAL33 based upon aircraft parking position needs as presented in Table 4-38.

4.5.3.7 Special Air Cargo Facilities

HAS developed several special use air cargo support facilities that are a part of the requirements to accommodate and address all aspects and interests of both air cargo shippers and carriers and federal processing of inbound, outbound and transfer cargo. These facilities reflect HAS policy to develop IAH as a major air cargo hub through the provision of support facilities that make the Airport a preferred location for air cargo shipments. These special facilities are described in the sections that follow.

Fumigation Facility

The HAS constructed a facility operated by the U.S. Department of Agriculture for fumigating inbound fruits, vegetables, flowers and other items that are suspected of transporting insects and cargo that has been determined to include dangerous insects. The facility contains three drive-through lanes for the application of insecticides as well as two inspection lanes. Total building area is approximately 14,300 square feet and the total site is approximately 1.9 acres. The facility was constructed to serve current need as well as anticipated future volumes. The current facility is operating at an estimated 10 percent of capacity; accordingly, no expansion is expected throughout the forecast period.

CBP Inspection Facility

The Customs and Border Protection (CBP) constructed a facility in 2005 that provides a centralized location for all of the CBP agencies including Customs, U.S. Fish and Wildlife and the U.S. Department of Agriculture. This state-of-the-art facility is unique as it includes management and staff offices, support facilities and laboratories to process, inspect, and identify issues related to the inbound and outbound cargo. It serves a local and regional function. The total site area is approximately 123,750 square feet (2.8 acres) with a supplemental parking area totaling an additional 0.6 acres. Based on discussions with management personnel, this facility is adequate for the long term requirements of the CBP and no expansion is expected throughout the forecast period.

Refrigeration Facility

Trammell Crow constructed a refrigeration facility adjacent to the UPS and CBP inspection facility in the East Cargo Area. This facility became operational circa 2002 and is available to all carriers for the temporary storage, clearing and processing of outbound, inbound or in-transit perishable cargo requiring refrigeration. This facility has 51,000 square feet of floor space and about 10,000 square feet of office area. The facility has both landside and airside access. There are 20 truck doors on the landside and 6 doors airside. The building was designed such that the entire floor is insulated to permit expansion of the refrigerated area when needed. Total site area is approximately 131,400 square feet (3.0 acres).

At the present time only 12,000 square feet of the building have been outfitted with refrigeration equipment. The refrigeration area can be expanded through the addition or relocation of interior partitions and refrigeration equipment. About 25 percent of the facility is now refrigerated. This area is operating at approximately 60 percent of capacity. Based on discussions with this facility manager, no future expansion is anticipated throughout the forecast period.

Livestock Quarantine

A livestock quarantine area is located south and west of the East Cargo Area. This area includes animal pens, a truck loading/unloading area, a CBP operations area and truck access and auto parking. This facility encompasses approximately 1.5 acres and has a limited opportunity for expansion of the animal pen area. Based on current and projected utilization patterns, no expansion is expected throughout the forecast period.

Bonded Storage

Areas are needed for the temporary storage of inbound and outbound cargo that requires processing prior to or following placement/removal onto an aircraft. Accepted cargo that required additional waybill processing by CBP must be stored in a secure area between the time of acceptance and shipment outbound and from the time of acceptance and release inbound. Small bonded areas are located in the existing cargo buildings but the volume and types of cargo now using IAH has exceeded the current capacity. The apron areas are now used for storage diminishing apron efficiency. This is considered a significant limitation of the existing cargo facilities. An area of at least 1 acre should be designated for current uses and larger areas in the future.

Other Aircraft Parking Demands

The common East Cargo aircraft parking aprons are used for the temporary and in some cases long term aircraft parking. Atlas Airlines uses IAH for idle aircraft parking for up to two B747-400 and two B767 aircraft. In addition, United Airlines has used the East Cargo aprons for the storage of the B787 awaiting repair and maintenance clearances, and Delta has occasionally used the East Cargo Apron for aircraft interior change-outs. These users are currently using excess capacity for these idle aircraft. At some time, either these aircraft will have to be relocated, or active all cargo aircraft will not have parking locations. The United Airlines use was irregular, but these needs are likely to continue to arise in the future. A requirement for four B747-8 aircraft parking positions is desirable for anomalous use. An apron area of 500,000 square feet for four aircraft parking positions including a taxilane and service roads should be provided.

4.5.4 Integrated Air Cargo Facilities

Two operators at IAH are categorized as integrated cargo carriers. An integrated carrier is one that provides local/regional collection and distribution services and air transport on a not-for-hire basis. They include FedEx and UPS.

4.5.4.1 FedEx

FedEx operates a facility that include a processing building, aircraft parking, landside truck operations area, employee parking and a GSE storage area totaling almost 8.0 acres in the Central Cargo Area. The aircraft parking portion consists of approximately 4.54 acres.

The March 2013 flight activity of FedEx is shown in Table 4-39 below. A total of 23 flights are operated per week. All five of the existing aircraft parking positions are used three days per week. On remaining week days, three to four positions are used.

Table 4-39
FEDEX WEEKLY FLIGHT ACTIVITY

Aircraft	Week Frequency
MD11	5
DC10	9
A 300	5
C208	4
Total	23

Source: LeighFisher, March 2013.

FedEx reports that their facility is operating within its capacity and that any future building, truck area and related expansion is not envisioned for the long term future. A potential need for one additional aircraft parking position was noted as the lone future expansion requirement. A single widebody aircraft parking position totaling approximately 1.1 acres is defined as their future requirement as shown in Table 4-40.

Table 4-40
FEDEX APRON REQUIREMENTS

Level of demand	Required aircraft frontage (LF)	Required aircraft apron area (acres)
2012 *(a)*	810	4.65
PAL25	810	4.65
PAL33	1,000	5.74
PAL40	1,000	5.74

(a) 2012 represents the requirement at 2012 demand levels.

Sources: FedEx, LeighFisher, June 2013.

4.5.4.2 United Parcel Service

UPS operates a regional facility at IAH. Facility provision is limited to an administrative and employee structure. Daily inbound and outbound shipment processing and sorting is completed in an outside sort area on the ramp. The UPS operation is more of a direct truck to aircraft operation where freight containers are transferred between the two modes. The UPS aircraft transport shipments to and from their hub sort facility located in Louisville, Kentucky.

The total site area is approximately 5.0 acres, including an exclusive aircraft parking area of 3.5 acres with capability to accommodate four aircraft.

UPS personnel report that the sort and employee areas are operating efficiently at the present time and that future growth can be accommodated without an expansion of the landside areas. Increased aircraft lift capability is expected with increasing future freight volumes. Fleet mix changes are anticipated that will increase the apron requirement. In addition, UPS is planning to add winglets to their existing B767 fleet, an action that will increase the aircraft parking frontage requirements. As seen in Table 4-41, an expansion of available aircraft frontage and apron area is recommended at PAL33.

The aircraft apron area is defined to accommodate the non-peak periods for UPS operations. During the holidays, the freight volumes peak and supplemental aircraft parking (in addition to their apron lease area) are required to accommodate the increased aircraft demand. These holiday demand increases in aircraft parking are not included in the estimated future requirements, as shown in Table 4-41. Holiday peak requirements are addressed in general all cargo aircraft apron requirements.

Table 4-41
UPS ARPON REQUIREMENTS

Level of demand	Required aircraft frontage (LF)	Required aircraft apron area (acres)
2012 *(a)*	600	3.50
PAL25	600	3.50
PAL33	820	4.71
PAL40	820	4.71

(a) 2012 represents the requirement at 2012 demand levels.

Sources: FedEx, LeighFisher, June 2013.

4.5.5 Airport Support Facilities

Airport support facilities include Aircraft Rescue and Fire Fighting, the Airport Maintenance Complex, and HAS Administrative Offices, discussed in the following sections.

4.5.5.1 Aircraft Rescue and Fire Fighting

The requirements for Aircraft Rescue and Fire Fighting (ARFF) services at commercial service airports are defined in FAR Parts 139.315, 139.317 and 139.319. These requirements are mandatory and vary as a function of the types of aircraft using the airport. ARFF requirements are first based upon a determination of its applicable Index. The Index is used to define the number and type of vehicles and fire suppression agents required. Lastly, a sufficient number of ARFF stations must be provided and strategically located such that prescribed response times to each runway are met.

The ARFF requirements are based upon defined airport categories (Index A through Index E with Index E representing the greatest requirement) that are based upon the length of aircraft providing an average of five or more departures per day. For IAH, the longest aircraft is 248 feet long with numerous other aircraft operating with lengths greater than 200 feet on a daily basis. The Airport is therefore categorized as an Index E airport. The vehicle and agent requirements for Index E are as follows:

- One vehicle carrying extinguishing agents 500 pounds of sodium-based dry chemical, halon 1211 or clean agent, or 450 pounds of potassium-based dry chemical and water commensurate with a quantity of aqueous film forming foam (AFFF) to total 100 gallons for simultaneous dry chemical and AFFF application

- Two vehicles carrying an amount of water and the commensurate quantity of so the total quantity of water for AFFF production carrier by the three vehicles is at least 6,000 gallons

These requirements are tabulated in Tables 4-42 and 4-43.

Table 4-42
ARFF VEHICLE AND AGENT REQUIREMENTS – INDEX E

Vehicle	Agent Quantity	Agent Type
1	500 lbs.	Sodium-based Dry Chemical Halon 211 Clean Agent
	450 lbs.	Potassium-based Dry Chemical and 100 gals water and AFFF
2 & 3 Combined Requirement	6,000 gals	Water and commensurate AFFF

Source: Houston Airport System, February 2013.

Table 4-43
ARFF VEHICLE DISCHARGE REQUIREMENTS – INDEX E

Vehicle	Agents	Truck Capacity	Dispense Type	Turret Discharge (GPM) Min	Max
1	Sodium-based Dry Chemical Halon 1211 Clean Agent Potassium-based Dry Chemical and 100 gals water and AFFF		Hand Line Turret	5 lbs./sec 16 lbs./sec	
2	Water and commensurate AFFF	500 to 2,000 gal Greater than 2,000 gals	Turret Turret	500 gpm 600 gpm	1,000 gpm 1,200 gpm

Source: Title 14, CFR Part 139, January 2012.

Additional requirements include operational response requirements that relate to the location of the stations relative to the airport runways. The operational response requirements are as follows:

- Within 3 minutes of the time of the alarm, at least one required ARFF vehicle must reach the mid-point of the farthest runway serving air carrier aircraft from its assigned post, or reach any other specified point of comparable distance on the movement area, and begin application of extinguishing agent

- Within 4 minutes from the time of alarm, all other required vehicles must reach the mid-point of the farthest runway serving air carrier aircraft from its assigned post, or reach any other specified point of comparable distance on the movement area, and begin application of extinguishing agent

Meeting these requirements at airports with a large, multiple-runway airfield may require more than one ARFF station to meet operational response requirements with the required agents. There are three ARFF stations provided at IAH, with the general coverage of each as follows:

- West Station # 99 – First response to Mid-point of Runway 15L/33R and Runway 15R/33L
- North Station # 54 – First response to Mid-point of Runway 8L/26R and Runway 8R/26L
- South Station # 99 – First response to Mid-point of Runway 9/27

Collectively these three ARFF stations meet the required operational response with facility and equipment details presented in Table 4-44. The ability to meet the operational response requirements must be demonstrated. For IAH, the most recent demonstration was conducted in April 2012 during the FAA's FAR Part 139 inspection. IAH has consistently demonstrated its ability over the years to meet the operational FAR Part 139 ARFF operational requirements. These requirements and the ability for IAH to maintain current response capabilities relate to the existing airfield only. Following the definition of airfield requirements and any recommended new runway locations, the ARFF station requirements will be revisited to assure continued compliance with FAR Part 139 operational requirements.

Table 4-44
IAH ARFF EQUIPMENT

	Vehicles			Agents				Hose Discharge			Turret Discharge	
Station	Number	Make	Year	Dry Chemical		Water	AAAF	Length	Type		Min	Max
				Lbs.	Type	Gal	Gal	Feet	GPM	#/sec	GPM	GPM
54	AR-2	F-550	2007	450	Purple K	94	6	100	60	7	60	60
	AR-3	Rosenbauer	2007	460	Halotron 1	3000	400	150		7	500	1000
	AR-4	Rosenbauer	2006	450	Purple K	3000	400	100	60	7	600	1200
92	AR-5	Rosenbauer	2006	450	Purple K	3000	400	100	60	7	600	1200
	AR-6	E-One	2003	460	Halotron 1	3000	400	150		7	500	1000
	AR-7	F-550	2003	450	Purple K	94	6	100	60	7	60	60
99	AR-16	E-One	2003	450	Purple K	1500	200	100	60	7	300	300
	AR-17	Rosenbauer	2006	450	Purple K	3000	400	100	60	7	600	1200
	AR-18	E-One	2003	460	Halotron 1	3000	400	150		7	500	1000

Source: Houston Airport System, February 2013.

4.5.5.2 Airport Maintenance Complex

The Airport Maintenance Complex is centrally located south and east of the passenger terminal area. It is noteworthy that the Airport Maintenance Complex occupies land adjacent to the terminal area that may be suited for different functions. The low density development of the site area and the relatively inexpensive facilities may be a consideration for a change in land use and relocation. A much smaller site would be adequate to accommodate the required facilities. Table 4-45 presents the site requirements for an Airport Maintenance Complex replacement site. The Airport Maintenance Complex has ample space for expansion if needed.

Table 4-45
AIRPORT MAINTENANCE COMPLEX REPLACEMENT REQUIREMENTS (ACRES)

Area	Existing	2012	PAL25	PAL33	PAL40
PPM & Vehicle Maintenance	2.47	2.50	2.50	3.00	3.00
Warehouse	3.86	4.00	4.00	4.50	4.50
Fuel Areas	1.08	1.10	1.10	1.10	1.10
Offices	0.51	0.55	0.55	0.75	0.75
Storage Sheds	0.48	0.50	0.50	0.75	0.75
Storage Yard	1.28	1.30	1.30	1.50	1.50
Employee Parking	6.00	6.00	6.00	8.00	8.00
Supplemental	4.70	4.79	4.79	5.88	5.88
Total Area	17.91	18.24	20.74	25.48	25.48

Sources: Houston Airport System, LeighFisher, February 2013.

4.5.6 HAS Administrative Offices

HAS, with responsibility to operate IAH, maintains facilities for staff required to fulfill these responsibilities. Staff offices are operated in three areas described in the following subsections.

4.5.6.1 Main Administration Building

The main administration building area provides a campus of buildings to accommodate senior management and key HAS Department staff. The site is located on an 8.7 acre site on JFK Boulevard. The main administration building consists of three interconnected buildings providing approximately 75,000 square feet of office, conference and support spaces for Finance, Properties, Planning, Engineering, Marketing, IT, Human Resources and related departments. A supplemental building totaling 9,250 square feet of support space houses Graphic Services.

Expansion of the administration buildings has been considered in the past. The expansion would increase the existing site by 3.2 acres, including addition of 48,400 square feet of building space and 3.6 acres of parking.

4.5.6.2 Terminal

Some Airport operations staff are housed within approximately 45,000 square feet of the terminal facilities. The majority of the HAS operations offices are located in Terminal A, but additional space is located in other terminals. In Terminal A, HAS maintains management offices on the mezzanine level. On the Baggage Level, one of two Airport Security Badging offices along with RACOM, City FIDS and Facility Management are located on this level. On the South Concourse Apron Level, Security staff offices are used and on the North Concourse, offices for Facility Management are present.

In Terminal D, a common use facility managed by HAS, space is available for Terminal Management, Gate Management and International Services. In the Central FIS, a second Airport Badging Office and a conference area with offices is used by HAS.

Some of these HAS spaces are in the terminal buildings for functional reasons and some are for convenience. About 20,000 SF is assumed to be located in the terminals for convenience. This area represents candidate spaces to be located in a potential new centralized Airport Operations Center (AOC), in the following sections.

4.5.6.3 Airport Operations

Airport Operations is located in a separate facility located along Will Clayton Parkway. This facility provides approximately 9,300 square feet in two buildings for offices, conference rooms and administrative space to support the IAH operations staff. Auto parking is provided for visitors, staff and pool vehicle parking. The site has adequate expansion area if retained.

The HAS is considering the development of an Airport Operations Center (AOC) that will centralize many of the HAS airport management functions currently spread throughout the terminal buildings. Preliminary space programming for an AOC includes a building with as much as 50,000 SF and associated auto parking. The total site area is estimated to be 8.0 acres.

4.5.7 Fuel Farm

The fuel farm is located west of Runway 15R. It encompasses an area of 22.25 acres, and currently has 10 storage tanks with a total capacity of 12,078,000 gallons. The four smaller tanks are older and are planned to be replaced in the near future. It is assumed that these four small tanks representing 2,100,000 gallons of storage capacity will be replaced with two larger tanks similar to the other large tanks with a capacity of 1,838,000 gallons. It is noteworthy that much of the fuel farm is aged and was constructed in the 1990s. Several of the larger tanks and pumping systems will require maintenance. Plans are in place to repair rather than replace these older systems.

The annual fuel flow history at IAH is shown in Table 4-46. As shown, annual fuel flow is correlated to annual commercial aircraft departures to define the average fuel up-lifted per departure. The trend in the average uplifted fuel per departure reflects in part the fleet mix operated and the routes operated, most notably by United.

Table 4-46
HISTORIC FUEL CONSUMPTION

Year	Annual fuel *(a)* (gallons)	Departures *(b)*	Fuel/Departure (gallons)
2002	494,413,426	229,324	2,156
2003	516,770,628	234,775	2,201
2004	537,655,306	256,844	2,093
2005	557,763,584	275,927	2,021
2006	566,482,368	298,508	1,898
2007	565,400,401	301,687	1,874
2008	552,890,921	297,063	1,861
2009	544,738,464	270,300	2,015
2010	576,856,376	265,768	2,171
2011	580,179,866	266,060	2,181

(a) Allied Fuel Services provided annual fuel consumption.
(b) FAA Terminal Area Forecast

Future requirements for fuel storage capacity are estimated in Table 4-47. As shown, average fuel per departure is shown to increase over the forecast period reflecting projected increases in fleet mix and route stage length.

Table 4-47
AVERAGE DAY FUEL STORAGE CAPACITY REQUIREMENTS

Level of demand	Forecast annual departures	Fuel per Departure (gallons)	Annual Fuel Consumption (gallons)	Average day uplifted fuel (gallons)	Average day required fuel supply (gallons) *(b)*
2012 *(a)*	258,703	2,200	569,145,500	1,559,303	1,949,128
PAL25	316,329	2,300	727,556,302	1,993,305	2,491,631
PAL33	375,990	2,400	902,374,955	2,472,260	3,090,325
PAL40	413,470	2,500	1,033,675,222	2,831,987	3,539,984

Source: LeighFisher, June 2013.

(a) 2012 represents the requirement at 2012 demand levels.
(b) Assumed to be 1.25 times average day uplifted fuel

The number of days' supply of fuel should be stored onsite in reserve is a business decision to be made by the airlines. The number and configuration of the tanks to be provided are ultimately determined by the airlines based on operating considerations, such as the tank filling and fuel settling process, as well as the reserve supply desired. Table 4-48 summarizes the gross storage volume and land area requirements for future fueling facilities.

Table 4-48
FUEL STORAGE REQUIREMENTS

	3-day supply		5-day supply		8-day supply	
Level of demand	Fuel storage requirement (gallons)	Land area requireme nt (acres)	Fuel storage requirement (gallons)	Land area requirement (acres)	Fuel storage requirement (gallons)	Land area requirement (acres)
2012 *(a)*	5,847,385	11	9,745,642	18	15,593,027	28
PAL25	7,474,893	14	12,458,155	23	19,933,049	36
PAL33	9,270,975	17	15,451,625	28	24,722,601	45
PAL40	10,619,950	19	17,699,918	32	28,319,869	52

Note: Assumes replacement of 4 older small tanks with 2 -1,838,000 tank by 2016.

(a) 2012 represents the requirement at 2012 demand levels.

Source: LeighFisher, June 2013.

As shown, the existing 12,078,000 gallons of jet fuel storage capacity, situated on approximately 22 acres of land, does not provide adequate storage capacity throughout the planning period considering a 5 or 8 day supply.

4.5.8 United Airlines Support Facilities

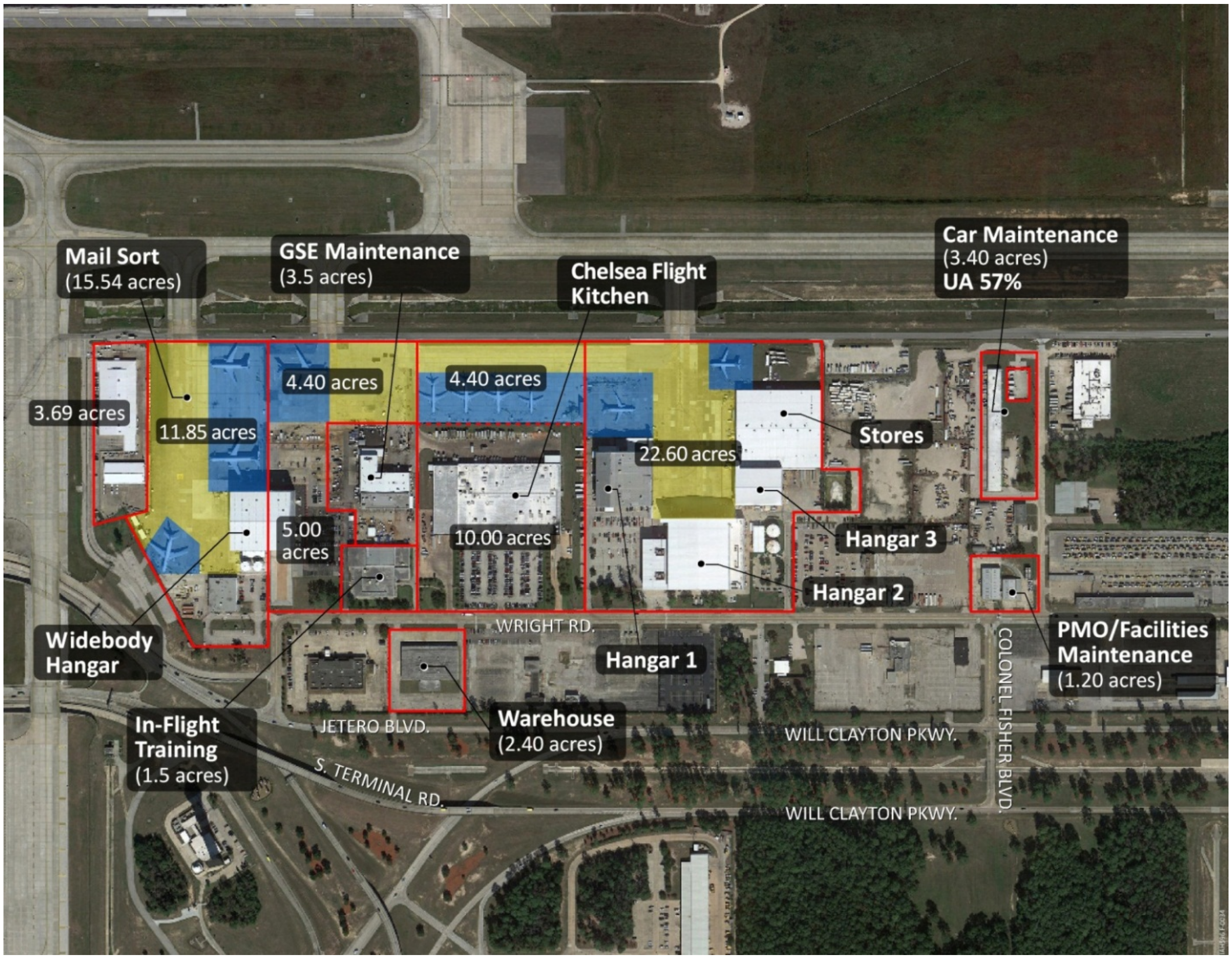
As a hub airline at IAH, United operates numerous buildings for functions needed to support and maintain the hub. The majority of these buildings and facilities are co-located in an area located north of Wright

Road, south of Taxiway NB and east of Taxiway SF, which is referred to as the United North Campus. Included are:

- Four hangar buildings
- Parts storage building
- Flight kitchen
- Mail sort facility
- In-flight training building
- GSE maintenance facility
- Auto maintenance facility
- Program management office
- Supplemental employee auto parking lot
- Supplemental warehouse building (catering)

Other facilities (including a flight simulator and cargo building) are located west of JFK Boulevard, adjacent to Runway 15L-33R. The United North Campus lease parcels and United Airlines facilities are shown on Figure 4-30.

Figure 4-30
UNITED AIRLINES NORTH CAMPUS FACILITIES



Source: LeighFisher, March 2013.

4.5.8.1 Hangar Maintenance

United Airlines operates four hangar buildings and a large parts storage building. In addition to the hangar facilities, United has apron spaces used largely for overnight line maintenance functions. The widebody maintenance area is the western most of the United Hangars. The hangar can accommodate one widebody aircraft at a time. Apron area for taxilane access from Taxiway NB along with aircraft parking for as many as six other widebody aircraft is available.

Further to the east, three narrowbody aircraft hangars are configured in a common cul-de-sac configuration. The hangar floor space can accommodate as many as five narrowbody aircraft. Along the north side of the United North Campus Area an apron has been constructed for overnight narrowbody aircraft line maintenance. As many as seven narrow body aircraft can occupy the narrowbody maintenance apron areas.

United Airlines operates a narrow body aircraft maintenance hangar at William P. Hobby Airport. Within the past 10 years, United contemplated relocating this facility to IAH. United has no flight operations at Hobby Airport and relocation of the maintenance functions of this facility to IAH would require the construction of an additional narrow body hangar.

In the long-term, it is expected the construction of an additional narrow body hangar at IAH will be needed and be constructed to accommodate a growing number of larger narrow body aircraft (B737-800/ B737-900) expected to enter the United's operational fleet at IAH over time. In addition, an expansion of the overnight line maintenance apron is a possibility. While United has no current definitive plans for hangar facility or maintenance apron expansion at IAH, it is recommended for planning purposes that a 15 acre site be identified and preserved for future aircraft maintenance expansion. This area would include one new narrow body hangar and apron space for an additional six overnight line maintenance positions.

4.5.8.2 Mail Sort Facility

United and other airlines hold contracts with the US Postal Service to carry the mail to destinations served to/from Houston. The United Airlines Mail Sort Facility was built in 1999 and is located east of Taxiway SF and adjacent to the United Widebody Aircraft Maintenance Hangar. The Mail Sort building is approximately 43,560 SF on a site of approximately 3.7 acres. The site has both airside and landside access. The existing facility uses a simple flat plate race track conveyor to sort mail for manual transfer to carts and transfer to/from aircraft. This facility is approaching its functional capacity due in part to the labor intensive manual sort process.

A forecast of future air mail was not made as it is a small percent of total Air Cargo and Freight and was included in this forecast value. Historical trends in mail show a declining volume of mail in total, reflecting national trends.

An improved mail sort process is likely needed in the near future for United to effectively compete for mail contracts. A mechanized sort system is likely needed to accommodate both higher volumes and more economical handling. As a future requirement, a site with an area of at least 5.0 acres is defined to accommodate a facility with greater sort automation as well as flight/destination cart staging areas. A 76,000 SF building, as well as auto parking, truck docks and cart storage areas, is estimated to be needed to meet future site requirements.

4.5.8.3 In-Flight Training

A facility is provided for in-flight training of flight attendants. This building is located east of the widebody hangar along Wright Road. The site for this facility occupies approximately 1.5 acres. This facility is expected to remain adequate throughout the forecast period. However, it should be noted that United has indicated there may be an opportunity to consolidate training currently dispersed across several airports to IAH. A property reserve will be considered for this potential, based on United's input, during preparation of the Recommended Development Plan.

4.5.8.4 Flight Kitchen (Chelsea)

In-flight food services have changed in the past decade. The trend has been to provide less food on domestic flights. United (Continental) was one of the last airlines to eliminate traditional in-flight food services in economy/coach class. United food service is now comprised mostly of for purchase food in economy with meal services for first class passengers still provided. For mainline flights less than three hours and on most Express Jet flights, "snack boxes" are offered for purchase by economy/coach passengers. These are pre-packaged boxes containing an assortment of pre-packaged snacks. Hot items are offered for sale on domestic flights over three hours in economy/coach. United still provides in-flight meal services to first and business class domestic passengers and all passengers on international flights.

The Chelsea site was originally a part of a larger lease site. On or about 2000, the northern portion of the flight kitchen site was converted to a narrow body apron area for overnight aircraft maintenance. The site now utilized for the Chelsea Flight Kitchen is approximately 10.0 acres. The United flight kitchen functional site space use is presented in Table 4-49.

Table 4-49
CHELSEA FLIGHT KITCHEN

Item	Area (acres)
Building	
Processing	2.55
Receiving Storage	0.59
Receiving Truck Dock & Access	0.71
Other Receiving	0.33
Airside Truck/GSE Storage	1.44
Employee Parking	1.91
Supplemental	5.03
Total Area	10.00

Source: LeighFisher, March 2013.

United has leased a supplemental warehouse for flight kitchen receiving and storage located south of Wright Road and north of Will Clayton Parkway. This warehouse site is located on a 2.4 acre site. The warehouse building provides approximately 28,260 square feet of space.

The IAH flight kitchen currently produces 33,000 meals per day. Discussions with United Airlines management indicate that the existing flight kitchen facility is adequate for their current and foreseeable future needs.

An assessment of the flight kitchen demands was completed in order to have an independent check on long term facility adequacies. For this assessment, the future forecast of passenger enplanements were distributed between United and other airlines. It is assumed that United focuses primarily on their food service needs as well as for Express Jet and a limited number of Star Alliance Partners. In addition, future in-flight meal services are uncertain at this time. Industry trends may stay the same, increase or decrease over time. This assessment assumes that meal services will remain similar to those offered today. Since LSG is the only other flight kitchen operator at IAH, it is included in Table 4-50.

Table 4-50
ESTIMATED FLIGHT KITCHEN DEMAND/CAPACITY ANALYSIS

Level of demand	Annual enplaned passengers (millions)			Annual meals (millions)		Required meals per day		Percent of existing capacity	
				0.69	0.95				
	United	Other	Total	United	Other	Chelsea	LSG	Chelsea	LSG
2012*(a)*	17.4	2.8	20.3	12.0	2.7	32,922	7,379	55%	74%
PAL25	21.8	3.5	25.3	15.0	3.4	41,132	9,219	69	92
PAL33	28.6	4.7	33.3	19.8	4.4	54,138	12,134	90	121
PAL40	34.3	5.6	39.9	23.7	5.3	64,868	14,539	108	145

(a) 2012 represents the requirement at 2012 demand levels.

Sources: Chelsea Flight Kitchen, LSG, LeighFisher, March 2013.

Some facility growth or increases in production will be needed to accommodate additional demand for Chelsea by PAL40 and LSG by PAL33. The estimated future flight kitchen requirements are presented in Table 4-51.

Table 4-51
ESTIMATED FLIGHT KITCHEN REQUIREMENTS

Year	Building Area (SF)		Site Area (Acres)	
	Chelsea	LSG	Chelsea	LSG
2012*(a)*	108,989	25,457	5.6	1.3
PAL25	136,169	31,805	7.0	1.6
PAL33	179,226	41,862	9.1	2.1
PAL40	214,748	50,159	11.0	2.6

(a) 2012 represents the requirement at 2012 demand levels.

Source: Chelsea Flight Kitchen, LSG, LeighFisher, March 2013.

For United Airlines, a limited expansion might be needed in PAL40.

4.5.8.5 Pilot Training/Simulators

Both United Airlines and Express Jet have simulator buildings located on a common 11.5 acre lease site west of JFK Boulevard. These facilities house aircraft simulators and training rooms for recurrent pilot training. The lease area has ample area for the expansion of the United and the Express Jet facilities; therefore, no additional land areas are expected to be needed for this function (with the exception as previously noted that United may consolidate activity from other airports to IAH).

4.5.9 Other Support Facilities

Other support facilities include the LSG Flight Kitchen and the ExpressJet Hangar.

4.5.9.1 LSG Flight Kitchen

The LSG Flight Kitchen is located on a 2.0 acre site located south of Taxiway NB east of the United Airlines Support Facility complex north of Wright Road. LSG provides in-flight meal services to international and domestic airlines. LSG currently provides meal services to nine foreign flag airlines and three domestic airlines. LSG produces an average of 3,300 to 4,500 meals per day operating with a single shift. The capacity of the facility is estimated to be 10,000 meals per day. LSG prepares meals for flights to the Middle East which requires special meal processing to meet religious requirements. The LSG kitchen is a certified “halal” facility.

The existing facility is on a relatively small site. Inbound and outbound truck traffic is well managed, however employee parking and building storage space is inadequate. Therefore, expansion of the building and auto parking is currently being considered. For purposes of the Master Plan, an expansion of the site by 1.0 acre is assumed at PAL40.

4.5.9.2 Express Jet

Express Jet is a former subsidiary of Continental Airlines that is now an independent airline. Express Jet operates as a United Airlines commuter operator and has a fleet of EMB 135 and EMB 145 aircraft. These aircraft are maintained at IAH in a site located off of JFK Boulevard, east of Runway 15L. This site is adequate for Express Jet’s needs throughout the forecast period.