3 Demand/Capacity Analysis and Facility Requirements

The principal challenges facing the Nashville International Airport (BNA or "the Airport") are those of meeting the changes emerging in the aviation industry and the future development requirements these changes may create. Airport development is often costly, and since each project is typically planned to last many years, care must be taken to ensure that each development project will adequately accommodate airport activity.

This chapter analyzes the ability of BNA and its existing facilities to accommodate the current and anticipated levels of activity as described in Chapter 2, *Forecasts of Aviation Demand*. This analysis is used to identify any deficiencies and determine facility needs throughout the 20-year planning period that can be satisfied through planning and development activities. The facility requirements assessed in this chapter include:

- **Airfield Requirements** – Requirements related to the safe and efficient operation of aircraft during takeoff and landing, as well as movements on the runways, taxiways, and aprons.
- **Gate and Terminal Space Requirements** – Requirements of the passenger terminal building and other functional areas associated with arriving and departing commercial passenger activity.
- **Programmatic Requirements** – Requirements related to airline support functions, secure and non-secure public access areas, concessions, and non-public areas.
- **Support Facilities Requirements** – Requirements related to operations such as general aviation (GA), cargo, military, fueling, firefighting, aircraft storage, and other aviation facilities and activities.
- **Surface Transportation and Parking Requirements** – Requirements related to the landside transportation system including the terminal roadway infrastructure, ground transportation support, and rental car and parking facilities.

The analysis of various airside and landside functional areas was performed with the guidance of several Federal Aviation Administration (FAA) publications, including Advisory Circulars (AC) 150/5060-5, *Airport Capacity and Delay*, 150/5300-13, *Airport Design*, and Order 5090.3C, *Field Formulation of the National Plan of Integrated Airport Systems (NPIAS)*. These facility requirements, based on various forecast components, should be regarded as general planning tools with development tied to activity levels. Should the forecast prove conservative, the schedule for proposed developments should be advanced. Likewise, if traffic growth materializes at a slower rate than forecast, deferral of expansion would be practical.

3.1 Summary of Aviation Demand Forecasts

The aviation demand forecasts presented in Chapter 2 were developed by examining historic Airport trends, analyzing current and anticipated economic influences within the industry, and producing projections based on the collected data. However, since airport activity levels are highly dependent upon economic fluctuations and industry change, identifying recommended facility expansion or upgrade requirements based upon specific years can be challenging. Therefore, Planning Activity Levels (PALs) will be used to identify thresholds for facility enhancement projects rather than using calendar years, since PALs allow for variances from the projected forecast years. For planning purposes, the subsequent PALs (PAL 1, PAL 2, PAL 3, and PAL 4) correspond, respectively, to the forecast years (2016, 2021, 2026, and 2031) presented in Chapter 2.

Table 3-1 provides a summary of the forecasts presented in Chapter 2, and the PALs used to estimate when Airport activity levels will trigger the need for various improvements.

Table 3-1 – Forecast Summary

	Baseline (2011)	PAL 1 (2016)	PAL 2 (2021)	PAL 3 (2026)	PAL 4 (2031)
Passenger Enplanements	4,806,092	5,835,700	6,929,300	8,190,000	9,658,600
Air Carrier Operations	123,972	140,990	158,020	176,980	198,270
Air Cargo Operations	2,640	2,940	3,260	3,610	4,010
Air Cargo Volume (Tons)	45,000	49,950	55,430	61,500	68,230
General Aviation Operations	44,804	49,660	55,050	61,030	67,670
Military Operations	3,578	11,000	11,000	11,000	11,000
Total Airport Operations	174,994	204,590	227,330	252,620	280,950
Based Aircraft	111	134	152	174	201

Source: RW Armstrong, 2012.

3.2 Airfield Capacity Requirements

Airside capacity is a measure of the number of aircraft that can operate at an airport in a given timeframe. Capacity is most often expressed in hourly or annual measures. Hourly capacities are calculated for visual flight rules (VFR) and instrument flight rules (IFR) in order to identify any peak period issues. Annual Service Volume (ASV) measures an airport's ability to process existing and future demand levels, and is generally a determinant for capacity-enhancing capital projects.

The major components to be considered when determining an airport's capacity include runway orientation and configuration, runway length, and runway exit locations. Additionally, the capacity of any given airfield system is affected by operational characteristics such as fleet mix, climate, and air traffic control procedures. Each of these components has been examined as part of the airside capacity analysis.

The FAA defines total airport capacity as a reasonable estimate of an airport's annual capacity, which takes into account the differences in runway use, aircraft mix, weather conditions, etc., which would be encountered over a year's time. The parameters, assumptions, and calculations required for this analysis are discussed in the following sections.

3.2.1 Airfield Capacity Parameters and Assumptions

The generally accepted methodology for calculating airfield capacity is described in FAA AC 150/5060-5. The calculations are based on the runway utilizations that produce the highest sustainable capacity consistent with existing air traffic rules, practices, and guidelines. The criteria and values used in the Advisory Circular are typical of U.S. airports with similar runway configurations and are designed to enable calculation of airport capacity as accurately as possible. The parameters and assumptions identified in this section were used to calculate the Airport's airfield capacity.

3.2.1.1 Runway Utilization

The Airport has 4 bi-directional runways; 3 with a northeast-southwest alignment and one with a northwest-southeast alignment. The utilization rates and orientation of these runways (2R/20L, 2C/20C, 2L/20R, and 13/31) were evaluated to determine the capacity of the Airport, which is the sum of capacities determined for each operation. It is important to note that an operation is defined as either a takeoff or landing. The direction of each operation is highly influenced by wind, available instrument approaches, noise abatement procedures, airspace restrictions, and/or other operating parameters. The runway use configurations used for BNA capacity calculations considered runway orientations for Runways 2R/20L, 2C/20C, 2L/20R, and 13/31 in various combinations, including:

- South flow operations, where aircraft arrive and depart to and from Runways 20L, 20C, 20R, and depart from Runway 13 (approximately 50 percent of BNA's annual traffic use this flow pattern).
- North flow operations, where aircraft arrive and depart to and from Runways 2L, 2C, and 2R, and depart from Runway 31 (approximately 50 percent of BNA's annual traffic use this flow pattern).
- A crosswind operation with a northwest flow, which accounts for less than 1 percent of BNA's operations, where aircraft arrive and depart to and from Runway 31 is used during periods of strong northwest winds (less than 1 percent of BNA's annual traffic use this flow pattern).
- In the unlikely event of a crosswind operation with significant winds out of the east, aircraft could arrive and depart to and from Runway 13.

- Noise abatement procedures call for Runway 13 departures and Runway 31 arrivals between 10:00 P.M. and 7:00 A.M. local time.

Based on the availability of BNA instrument approaches, each of these operational patterns were evaluated for both VFR and IFR conditions. **Figure 3-1** graphically illustrates the operational flow patterns and their utilization rates.

3.2.1.2 Aircraft Mix Index

The FAA has developed a classification system for grouping aircraft, based on size, weight, and performance. **Table 3-2** illustrates the classification categories as they are presented in FAA AC 150/5060-5. This classification system is used to develop an aircraft mix, which is the relative percentage of operations conducted by each of the 4 classes of aircraft (A, B, C, and D). The aircraft mix is used to calculate a mix index, which is then used for airfield capacity studies. The FAA defines the mix index as a mathematical expression representing the percentage of Category C aircraft, plus 3 times the percentage of Category D aircraft (C+3D). The FAA has established mix index ranges for use in capacity calculations as listed below:

- 0 to 20
- 21 to 50
- 51 to 80
- 81 to 120
- 121 to 180

Table 3-2 – FAA Aircraft Classification

Aircraft Category	Max. Cert. Takeoff Weight (lbs.)	Number of Engines	Wake Turbulence Classification
A	12,500 or less	Single	Small (S)
B	12,500 or less	Multi	Small (S)
C	12,500 – 300,000	Multi	Large (L)
D	over 300,000	Multi	Heavy (H)

Source: FAA AC 150/5060-5, *Airport Capacity and Delay*.

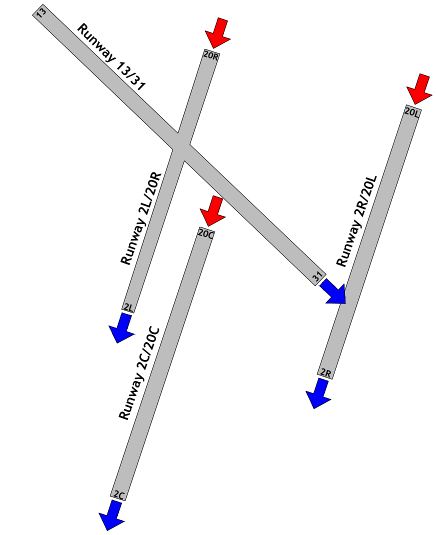
The current facilities at the Airport can accommodate all 4 aircraft classes. The following operations percentages for aircraft categories C and D were gathered from a review of base year operations:

- Class C = 74.86 percent of the Airport's operations
- Class D = 3.79 percent of the Airport's operations

As such, the base year aircraft mix index is 86.2 (74.86 + 3[3.79] = 86.23). While the actual mix index for the Airport is subject to vary given changes in air traffic operations, the likelihood of the Airport's mix index to grow beyond the fourth mix index grouping of 81-120 over the planning period is low.

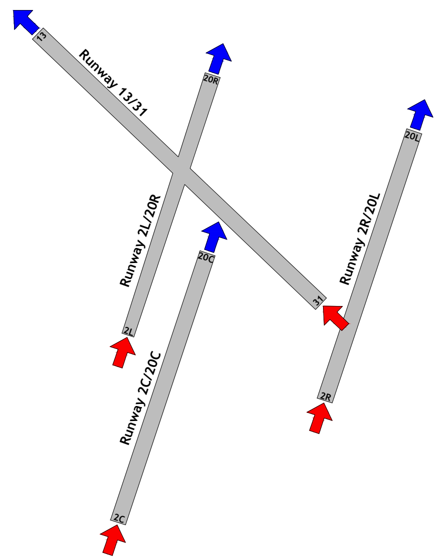
South Flow

Percent Utilized: 50%



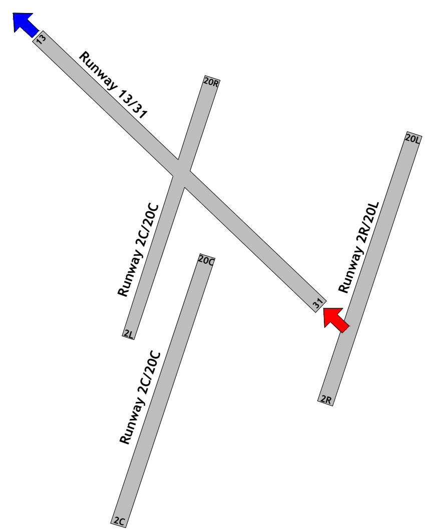
North Flow

Percent Utilized: 50%



NW Wind Condition

Percent Utilized: <1%



LEGEND

Arrivals

Departures

Figure 3-1
Runway Utilization

SOURCE: Atkins North America Inc., 2012.

RW ARMSTRONG.

Nashville International Airport℠

3.2.1.3 Arrivals Percentage

The percent of arrivals is the ratio of arrivals to total operations. It is typically safe to assume that total annual arrivals will equal total departures, and that average daily arrivals will equal average daily departures. Therefore, a factor of 50 percent arrivals will be used in the capacity calculations for the Airport.

3.2.1.4 Touch-and-Go Percentage

The touch-and-go percentage is the ratio of landings with an immediate takeoff to total operations. This type of operation is typically associated with flight training activity. Generally speaking, the percentage of touch-and-go operations at commercial service airports, such as BNA, is minimal. For that reason, touch-and-go operations were considered to be less than 1 percent annually for the purpose of BNA airfield capacity calculations.

3.2.1.5 Taxiway Factors

Taxiway entrance and exit locations are an important factor in determining the capacity of an airport's runway system. Runway capacities are highest when there are full-length, parallel taxiways, ample runway entrance and exit taxiways, and no active runway crossings. All of these components reduce the amount of time an aircraft remains on the runway. FAA AC 150/5060-5 identifies the criteria for determining taxiway exit factors. The criteria for exit factors are generally based on the mix index and the distance the taxiway exits are from the runway threshold and other taxiway connections. As the Airport's existing mix index was calculated to be between 81 and 120 over the planning period, only exit taxiways that are between 5,000 and 7,000 feet from the threshold and spaced at least 750 feet apart contribute to the taxiway exit factors. Taxiways that met these parameters were considered in completing the capacity calculations for all directions and all conditions.

3.2.2 Airfield Capacity Calculations

The airfield capacity calculations in this section were performed using the parameters and assumptions discussed previously. These calculations also use data from the aviation demand forecast, as presented in Chapter 2, for portions of the capacity calculations. The following sections outline the hourly capacities in VFR and IFR conditions, as well as the Airport's ASV.

3.2.2.1 Hourly VFR Capacity

The hourly VFR capacities for runways at BNA were calculated based on the guidance and procedures in FAA AC 150/5060-5. The runways were divided into 3 groups to account for the varying runway use configurations identified previously. The VFR capacity was calculated to be 147 operations per hour for south flow operations, 134 operations per hour for north flow operations, and 112 operations per hour when strong northwest winds allow for operations on Runway 31 only. The equations and calculations presented in **Table 3-3** show the step-by-step method used to calculate the hourly VFR capacities, based on the guidance provided in FAA AC 150/5060-5. The hourly VFR capacities will be used in the annual service volume calculations for the Airport.

Table 3-3 – Hourly VFR Equation

Hourly Capacity Base (C*) x Touch-and-Go Factor (T) x Exit Factor (E) = Hourly Capacity		
South Flow Operations	*North Flow Operations*	*Northwest Wind Condition*
C* x T x E = Hourly Capacity	C* x T x E = Hourly Capacity	C* x T x E = Hourly Capacity
155 x 1.00 x 0.95 = 147	142.5 x 1.00 x 0.94 = 134	58 x 1.00 x 0.94 = 112

Source: Atkins North America Inc., 2012.

It is important to note that during north flow operations, which occur approximately 50 percent of the time as shown on Figure 3-1, the crosswind runway is utilized for departures. This results in the south flow capacity being higher than the north flow capacity since this slows down operations on the parallel runways as operating aircraft may have to hold/wait for aircraft departing from the crosswind runway.

3.2.2.2 Hourly IFR Capacity

Hourly IFR capacities were calculated for the same runway use scenarios as described previously, and used similar assumptions to those used in the VFR hourly capacity calculations. However, maintaining greater separation between aircraft is generally required during IFR operations. Therefore, the hourly capacity base variable of the equation is lowered. This adjustment reduces the overall hourly capacity during IFR operations. The IFR capacity was calculated to be 114 operations per hour for south flow operations, 122 operations per hour for north flow operations, and 46 operations per hour when strong northwest winds are present. The hourly IFR capacity equation and calculations are shown in **Table 3-4**. The hourly IFR capacities will be used in the annual service volume calculations for the Airport. Although these operations occur during IFR flight conditions, aircraft instrumentation is not factored when calculating the equations.

Table 3-4 – Hourly IFR Equation

Hourly Capacity Base (C*) x Touch-and-Go Factor (T) x Exit Factor (E) = Hourly Capacity		
South Flow Operations	North Flow Operations	Northwest Wind Condition
C* x T x E = Hourly Capacity	C* x T x E = Hourly Capacity	C* x T x E = Hourly Capacity
115 x 1.00 x 0.99 = 114	132.6 x 1.00 x 0.92 = 122	50 x 1.00 x 0.92 = 46

Source: Atkins North America Inc., 2012.

3.2.2.3 Annual Service Volume

An airport's ASV is the maximum number of annual operations that can occur at the airport before an assumed maximum operational delay value is encountered. ASV is calculated based on the existing runway configuration, aircraft mix, and the parameters and assumptions identified herein, and incorporates the hourly VFR and IFR capacities calculated previously. The equation to calculate ASV is as follows:

- Weighted Hourly Capacity (Cw) x Annual/Daily Demand (D) x Daily/Hourly Demand (H) = ASV.

The Airport's existing conditions ASV was calculated to be 522,677 operations. It should be noted that the ASV represents the existing airfield capacity in its present configuration, with 3 parallel runways and a single crosswind runway.

The Airport's current aviation demand in number of aircraft operations for the base year (2011), as presented in Chapter 2, is 174,994 operations. This equals approximately 33.4 percent of the present ASV. Additionally, according to the FAA, the following guidelines should be used to determine necessary steps as demand reaches designated levels.

- **60 percent of ASV** – The threshold at which planning for capacity improvements should begin.
- **80 percent of ASV** – The threshold at which planning for improvements should be complete and construction should begin.
- **100 percent of ASV** – The airport has reached the total number of annual operations it can accommodate, and capacity-enhancing improvements should be made to avoid extensive delays.

Based on the forecast growth in aviation activity, BNA is not anticipated to exceed 60 percent of its total airfield capacity within the planning period, as indicated by **Table 3-5**.

Table 3-5 – Annual Service Volume vs. Annual Demand

PAL	Annual Operations	Annual Service Volume	Percent of Annual Service Volume
Baseline	174,994	522,677	33.50%
PAL 1	204,590	522,677	39.10%
PAL 2	227,330	522,677	43.50%
PAL 3	252,620	522,677	48.30%
PAL 4	280,950	522,677	53.80%

Source: FAA AC 150/5060-5, *Airport Capacity and Delay*; Atkins North America Inc., 2012.

3.2.2.4 Aircraft Delay

Although analysis has indicated that BNA's current and forecast level of aeronautical activity is not anticipated to exceed the airfield's calculated capacity, the potential for aircraft delay still exists due to ATC procedures, weather conditions, and aircraft maintenance issues. Hourly delay calculations, representing the aggregate hourly delay in minutes, were generated for each operational condition in effect at BNA (north flow, south flow, and northwest wind condition in both VFR and IFR conditions). The result of this analysis identifies hourly delays ranging from 3.375 minutes to 7.931 minutes depending on the operational condition, and a weighted hourly delay of 4.101 minutes. Guidance available from FAA AC 150/5070, *Airport Master Plans*, indicates that between 4 and 6 minutes of delay can be considered an acceptable level.

3.2.2.5 Future Service Volume

Currently, the runways at BNA are of sufficient length to support operations throughout the planning period. However, if higher growth scenarios prevail and longer-range cargo or international passenger operations materialize, a longer runway aligned with the area's prevailing winds could become necessary. The MNAA currently owns most of the land that would be necessary to extend Runway 2L, with the airspace for such an extension currently being preserved by its inclusion on the Airport Layout Plan (ALP). It is, therefore, recommended that the MNAA continue preserving the airspace that would be associated with a Runway 2L extension by continuing to include it on the ALP.

It is important to note that the addition of a fourth parallel runway would have a significant impact on the Airport's overall annual capacity. Using the metrics and methodology previously outlined, a future fourth parallel runway could increase BNA's ASV to as high as 870,650 operations; representing a 66.5 percent increase over the ASV calculated for the Airport's existing condition. While not needed during the planning period, the fourth parallel runway is included on the ALP in order to preserve the airspace associated with this future runway.

3.3 Airside Facility Requirements

Airfield improvements are planned and developed according to the established Airport Reference Code (ARC) for an airport, and then for each particular runway. According to FAA AC 150/5300-13, the ARC is a coding system used to relate airport design criteria to the operational and physical characteristics of the airplanes that operate or are projected to operate at an airport. An airport's ARC is determined by the critical aircraft (aircraft with the longest wingspan, highest tail, and fastest approach speeds) that makes "substantial use" of the Airport or a specific runway. FAA Order 5090.3C, *Field Formulation of the National Plan of Integrated Airport Systems (NPIAS)*, defines "substantial use" as 500 or more annual aircraft operations or commercial service use (an operation is either an arrival or departure).

The ARC is based on a combination of aircraft approach speed, wingspan, and tail height, as depicted in **Table 3-6**. The first character of the ARC (A, B, C, D, or E) represents the aircraft's approach speed. The second character of the ARC (I, II, III, IV, V, or VI) represents the aircraft's wingspan and tail height. Each character of the ARC is independent, and thus may represent a composite of 1 or more critical aircraft.

Table 3-6 – Airport Reference Code

Approach Category		
Approach Category	Airspeed (Knots)	Example Aircraft
A	<91 knots	Cessna 152, Beech Bonanza A36
B	91-<121 knots	Dassault Falcon 900 Gulfstream I
C	121-<141knots	Boeing 737, CRJ
D	141-<166 knots	Boeing 747, MD-11
E	166 knots or more	F-16

Airplane Design Group		
Design Group	Wingspan (Feet)	Example Aircraft
I	<49	Cessna 172, Cirrus SR-22
II	49-<79	ERJ, CRJ
III	79-<118	Boeing 737, Boeing MD 80
IV	118-<171	Boeing 757, MD 11
V	171-<214	Airbus A340, Boeing 747-400
VI	214-<262	Airbus A380, Antonov AN-124

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

Because BNA is a medium-hub airport supporting both commercial air carrier and air cargo operations, the type of aircraft operating at the Airport can vary from small general aviation aircraft to large turbine aircraft. As a result of previous Boeing 747 cargo operations, the design criteria for airside facilities vary between ARC D-IV and ARC D-V across the airfield system. However, as noted in the Inventory, BNA is currently an ARC D-IV airport supporting a Boeing 757 as its critical aircraft. Based on the forecast of aviation demand presented in the previous chapter, aircraft requiring such design criteria are anticipated to continue to make sufficient use of the airfield system throughout the planning period to retain this designation. It is recommended however, that those areas on the airfield that support Group V operations remain to accommodate Group V operations from air cargo or other carriers that require the separation.

3.3.1 Airside Design Criteria

As indicated, airfield dimensional standards are based on the ARC system, which relates physical airport design criteria to the operational and physical characteristics of aircraft that will operate at an airport. **Table 3-7** presents the geometrical design standards for BNA airfield infrastructure, **Table 3-8** presents the separation criteria required for runways and taxiways at the Airport, and **Table 3-9** identifies current taxiway fillet design criteria for the Airport.

Table 3-7 – Geometrical Design Standards

Geometrical Design Standards	ARC D-IV	ARC D-V	ARC D-VI
Runway Width	150	150	200
Runway Shoulder Width	25	35	40
Runway Blast Pad Width	200	220	280
Runway Blast Pad Length	200	400	400
Runway Safety Area Width	500	500	500
Runway Safety Area Length Beyond Runway End	1,000	1,000	1,000
Runway Obstacle-Free Zone Width	400	400	400
Obstacle Free Zone Length Beyond Runway End	200	200	200
Runway Object-Free Area Width	800	800	800
Object Free Area Length Beyond Runway End	1,000	1,000	1,000
Taxiway Width	75	75	82
Taxiway Shoulder Width	25	35	40
Taxiway Safety Area Width	171	214	262
Taxiway Object Free Area Width	259	320	386

Note: Numbers are in feet.
Source: FAA AC 150/5300-13, *Airport Design*.

Table 3-8 – Airfield Separation Standards

Separation Standards	ARC D-IV	ARC D-V	ARC D-VI
Runway Centerline to Holdline[1]	250	280	280[2]
Runway Centerline to Parallel Taxiway/Taxilane Centerline[2,3]	400	400[4,5]	550
Runway Centerline to Aircraft Parking Area	500	500	500
Runway Centerline to Helicopter Touchdown Pad	700	700	700
Taxiway Centerline to Parallel Taxiway/Taxilane Centerline	215	267	324
Taxiway Centerline to Fixed of Moveable Object	129.5	160	193
Taxilane Centerline to Parallel Taxilane Centerline	198	245	298
Taxilane to Fixed of Moveable Object	112.5	138	167.5

Note: Numbers are in feet.
1 - This distance is increased 1 foot for each 100 feet above sea level for all design groups for approach category D aircraft. For BNA this represents a 6-foot increase.
2 - The taxiway/taxilane centerline separation standards are for sea level. At higher elevations an increase may be warranted to ensure an unobstructed OFZ.
3 - Existing taxiway/taxiline distance may be acceptable to support the existing runway service level (i.e. CAT I, II, III) when approved by the FAA Office of Airport Safety and Standards, Airport Engineering Division (AAS-100).
4 - For Airplane Design Group V, the standard runway centerline to parallel taxiway centerline distance is 400 feet for airports below 1,345 feet MSL.
5 - For approaches with visibility less than 1/2-statute mile, the separation distance increases to 500 feet, plus required OFZ elevation adjustment.
Source: FAA AC 150/5300-13, *Airport Design*; FAA AC 150/5390-2, *Heliport Design.*

Table 3-9 – Taxiway Fillet Dimensions

	Airplane Design Group (ADG)		
Item	**IV**	**V**	**VI**
Radius of Taxiway Turn	150	150	170
Length of Lead-in to Fillet	250	250	250
Fillet Radius for Tracking Centerline	85	85	85

Note: Numbers are in feet.
Source: FAA AC 150/5300-13, *Airport Design*.

3.3.2 Runway System

3.3.2.1 Runway Designations

The designations of a runway (runway end numbers and letters) are determined by the magnetic heading of each runway's direction along the runway's centerline. Those numbers are truncated and rounded to the nearest whole number between 01 and 36. Magnetic azimuth is determined by adjusting the geodetic azimuth associated with a runway to compensate for magnetic declination. Magnetic declination, also known as variation, is defined as the difference between true north and magnetic north. This value varies over time and is dependent on global location. Change in magnetic declination is a natural process which periodically requires re-designation of runways.

Current magnetic declination information was derived from the National Geophysical Data Center (NGDC) database in April 2012. Magnetic declination for the Nashville metropolitan area was calculated to be 03°25' West, changing by 0°5' West per year. The Airport's true bearings for each runway were identified through the most recent airport survey completed in accordance with the development of the Airport Layout Plan (ALP). **Table 3-10** depicts the calculated runway designations for the Airport.

Table 3-10 – Runway Designation Calculation

Runway	True Bearing	Magnetic Declination	Magnetic Bearing	Runway Designation Required
2L	18° 03' 02.09"	3° 24' West	21° 27' 02.09"	2L
2C	18° 22' 59.87"	3° 24' West	21° 46' 59.87"	2C
2R	18° 22' 11.15"	3° 24' West	21° 46' 11.15"	2R
20L	198° 22' 11.15"	3° 24' West	201° 46' 11.15"	20L
20C	198° 22' 59.87"	3° 24' West	201° 46' 59.87"	20C
20R	198° 03' 02.09"	3° 24' West	201° 27' 02.09"	20R
13	133° 42' 20.28"	3° 24' West	137° 06' 20.28"	14
31	313° 42' 20.28"	3° 24' West	317° 06' 20.28"	32

Source: Atkins North America Inc., 2012.

Based on the analysis of the magnetic bearing of each of BNA's 4 runways, re-designation of Runway 13/31 to Runway 14/32 is recommended in the future to avoid confusion for navigating pilots.

3.3.2.2 Runway Length Requirements

The length of a runway is a function of many factors, the most notable of which are the selection of a critical aircraft and the longest nonstop distance being flown by such aircraft from the airport of study (i.e., stage length). Guidance from FAA AC 150/5325-4B, *Runway Length Requirements for Airport Design*, recommends calculating the required runway lengths based on aircraft manufacturer performance specifications when the critical aircraft is in excess of 60,000 pounds at its maximum takeoff weight (MTOW). Since the Boeing 757 series aircraft has been identified as the critical aircraft for all of BNA's runways, Boeing's performance specifications for the 757 series were consulted to determine the runway length required for both takeoff and landing operations at the airfield. In addition, performance data for the 737-700, 737-800, and 747-400 aircraft were also included in the analysis. **Figure 3-2** depicts the calculated runway length requirement for takeoff operations, and **Figure 3-3** identifies the runway length required for landing.

As is evident by the runway length requirements analysis, the existing BNA runway configuration presents some limitations for the most demanding aircraft on hot days. Boeing 757 series aircraft are shown to incur weight penalties when operating on Runways 2L/20R, 2C/20C, and 2R/20L. Additionally, the majority of the B747 series aircraft studied would incur weight penalties when operating on any runway at BNA. It is important to note, however, that aircraft often do not takeoff (or land) at their maximum weight. Airlines and cargo operators fuel their aircraft to support their intended route and often do not carry a full load of passengers and/or cargo. The forecast presented in Chapter 2 indicates that commercial service operators (represented here by the B737 series aircraft) are anticipated to operate at a load factor near 80 percent throughout the planning period. Cargo operators (represented by the B757 series and potentially the B747 series aircraft) are likely to operate closer to a 90 percent load factor or higher.

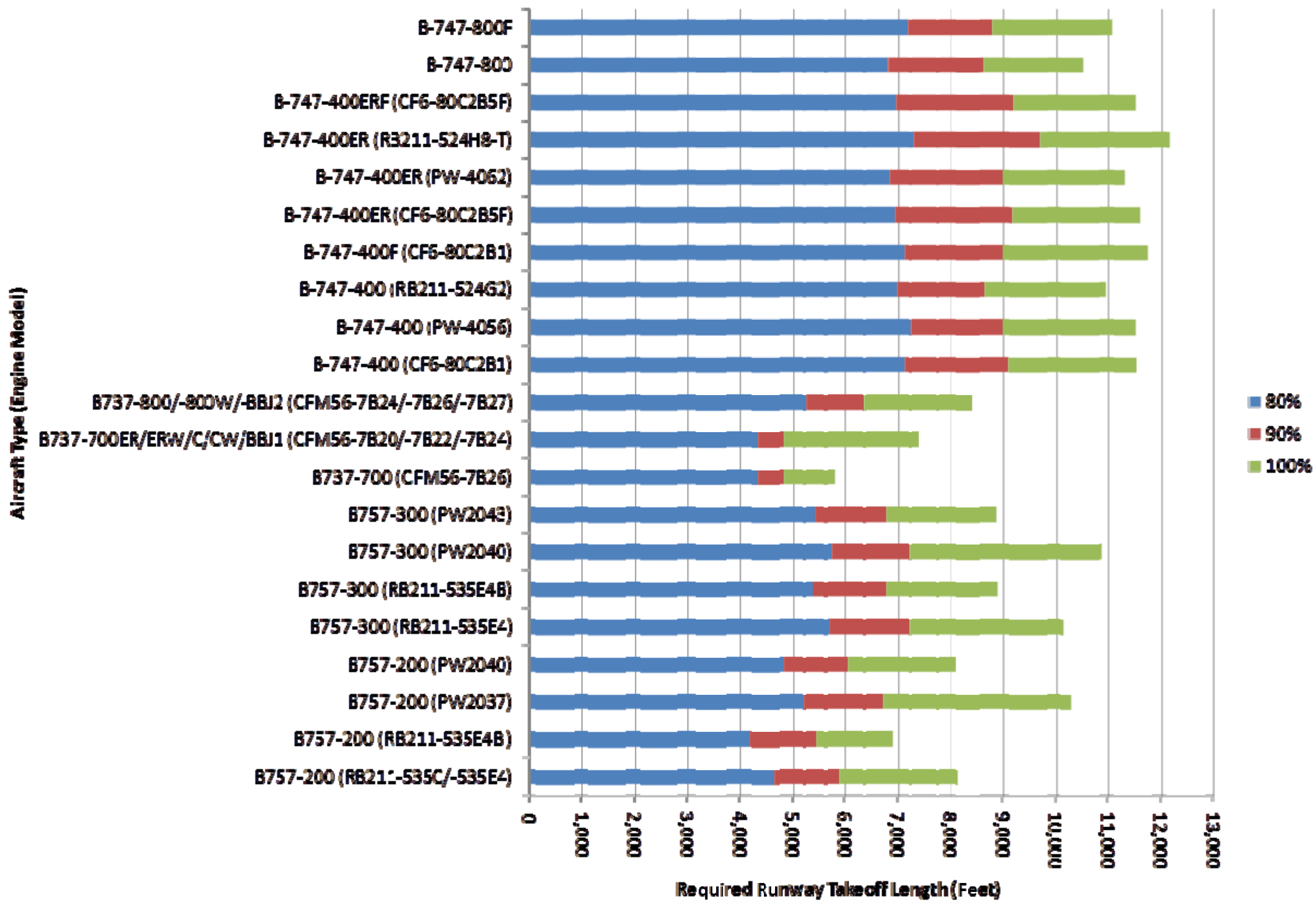
3.3.2.3 Runway Width

Runway width requirements are based on the critical aircraft associated with each particular runway. For ARC D-IV and D-V, the required runway width is 150 feet. Currently, all runways at BNA are 150 feet wide, thereby meeting this design requirement.

3.3.2.4 Runway Shoulders

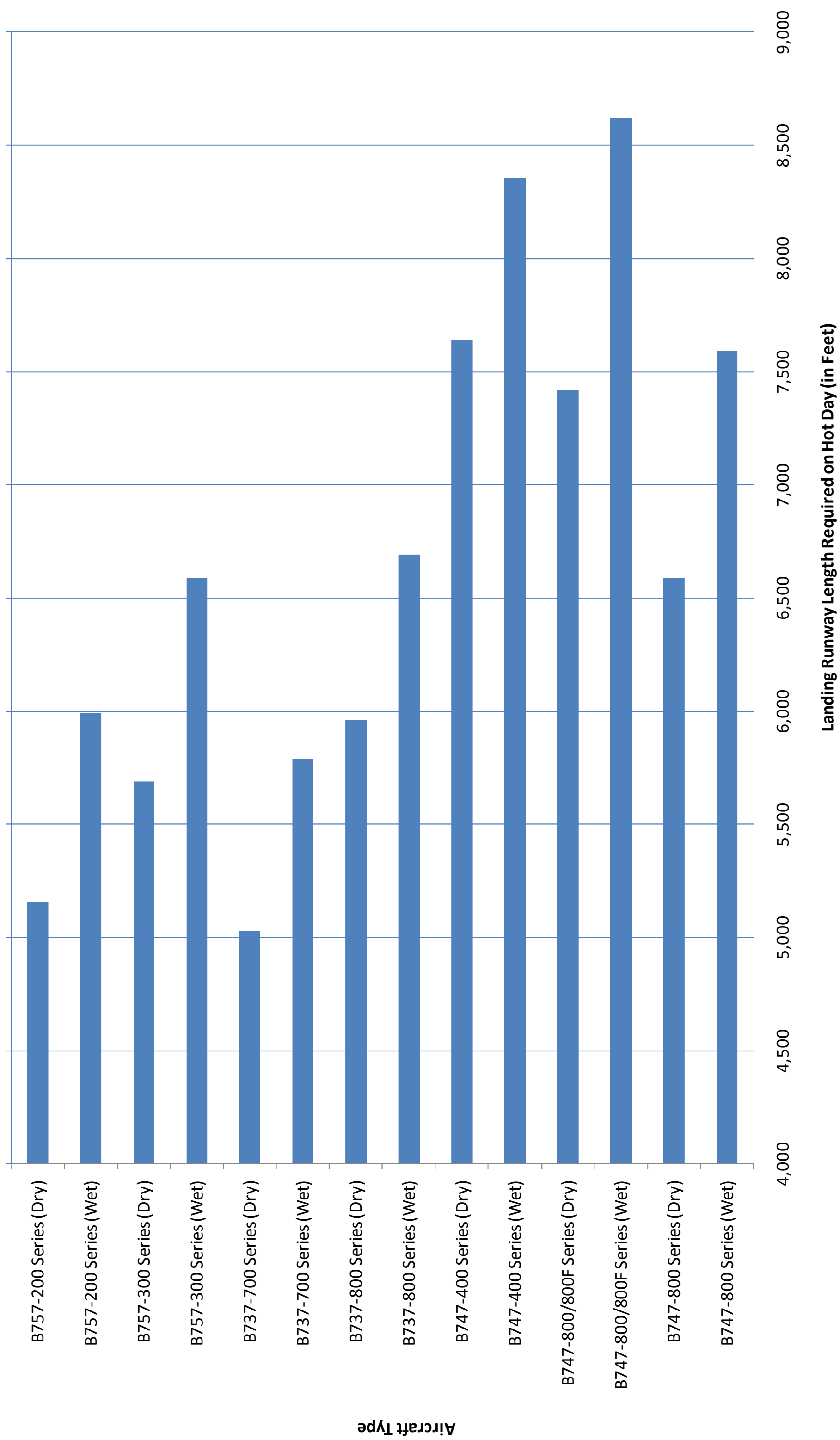
Runway shoulders provide resistance to blast erosion and accommodate the passage of maintenance and emergency equipment and the occasional passage of an airplane veering

Figure 3-2 – Runway Lengths Required for Takeoff



Note: Runway length requirements shown reflect hot day conditions (STD + 25°-31°F) when aircraft are operating at their maximum takeoff weight.
Source: Individual Aircraft Manufacturers, Atkins North America Inc., 2012.

Figure 3-3 – Runway Lengths Required for Landing



Note: Runway length requirements shown represent the maximum runway length needed for the aircraft series when operating with 30° of flaps.
Source: Individual Aircraft Manufacturers, Atkins North America Inc., 2012.

from the runway. Dense, well-rooted turf cover can minimize erosion. With the issuance of AC 150/5300-13A in September 2012, The FAA requires paved shoulders for runways accommodating Group IV aircraft and higher and also recommends paved shoulders for Group III aircraft. Since all four of the Airport's runways are intended to accommodate Group IV aircraft, the inclusion of paved shoulders will be required in conjunction with runway rehabilitation or reconstruction projects. FAA AC 150/5300-13A indicates the required shoulder width to be 25 feet on either side of an ARC D-IV runway and 35 feet on either side of an ARC D-V runway. Runway 2R/20L was built in the mid 1980's and runway 2C/20C was built in the mid 1990's. The requirement at that time was for a 25-foot shoulder that could consist of turf, if stable. The AC does recommend paved shoulders for runways accommodating ADG III aircraft and higher. Based on experience of stable turf shoulders in use at BNA prior to that time, it was determined that turf shoulders were appropriate. Operating mowing equipment around the runway edge lights was problematic; hence, a 12-foot wide paved 'non mow' strip was incorporated along the runway edge. This strip was not intended to function as a paved shoulder, but rather to help address the maintenance concerns. Therefore, Runway 2R/20L and Runway 2C/20C shoulders consist of 12-foot wide paved sections and 13-foot wide turf sections to make up the full 25-foot width. Both Runways 2L/20R and 13/31 are equipped with 35-foot-wide paved shoulders. Runway 13/31, however, only has shoulder pavement southeast of its intersection with Runway 2L/20R. To meet the runway shoulder width requirements for ARC D-IV runways, additional shoulder pavement should be added to Runway 2R/20L and Runway 2C/20C to bring each shoulder's width to the required 25 feet. Runway 13/31 should receive paved shoulders from the Runway 2L/20R intersection to the Runway 13 end. Runway 2L/20R exceeds the current shoulder width requirement and meets the more stringent requirement for ARC D-V runways.

3.3.2.5 Runway Blast Pads

Similar to runway shoulders, blast pads are intended to provide erosion protection at the runway end. Conformance to FAA design criteria requires that 200-foot-wide by 200-foot-long blast pads be placed symmetrically at the end of each ARC D-IV runway. At present, except for Runway 20R and Runway 2L, all BNA runways meet or exceed the design standards for ARC D-IV runways. The blast pad prior to the Runway 20R approach end is 150 feet square. This blast pad should be extended 50 feet and widened 25 feet on both sides to address its nonconformity to the standard. The blast pad prior to the approach end of Runway 2L is 216 feet long by 150 feet wide. This blast pad exceeds the length requirement, but should be widened 25 feet on both sides to meet its width requirements.

3.3.2.6 Pavement Design Aircraft Determination

Aircraft weight characteristics also affect the design of an airport's pavements, as pavement design of runways, taxiways, and aprons is based on a design aircraft. The design aircraft is different from the critical aircraft described previously. The design aircraft is determined by landing gear configuration (i.e., single-wheel, dual-wheel) and the known forecast number of aircraft operations with the heaviest maximum gross takeoff weights. **Table 3-11** identifies the load-bearing capacities of each runway and provides an example of aircraft for each gear configuration.

Table 3-11 – BNA Existing Pavement Strength/Load-Bearing Capacities

Gear Configuration	ACN[1]	RWY 13/31	RWY 2L/20R	RWY 2C/20C	RWY 2R/20L
Single-Wheel (DC3)	17(B)	75,000	75,000	75,000	75,000
Dual-Wheel (B737)	55(B)	210,000	210,000	210,000	210,000
Dual-Tandem-Wheel (B757)	49(B)	440,000	450,000	450,000	450,000
Double-Dual-Tandem-Wheel (B747)	70(B)	875,000	875,000	857,000	857,000
Pavement Classification Number (PCN)	N/A	71(B)	116(B)	86(B)	86(B)

1 – Aircraft classification number.
Note: Numbers are in pounds.
Source: Atkins North America Inc., 2012.

An analysis of the BNA pavement strengths was conducted in November of 2011 by Applied Research Associates (ARA) with the results published on June 4, 2012 in their report entitled *Pavement Condition Report*. In their analysis, ground taxi movements were developed in coordination with MNAA planning, operations and air traffic control personnel to summarize the typical traffic patterns based on runway utilization and total airside aircraft operations (see Chapter 4 of the ARA Report). This traffic modeling was used as a basis in determining the pavement strength characteristics utilizing the standardized methodology referred to as "Aircraft Classification Number – Pavement Classification Number (ACN-PCN)." Published on Form 5010 by the FAA, this methodology evaluates the specific aircraft number (as reported by all aircraft manufacturers) in comparison to the pavement strength. If the ACN is less than the PCN, then the aircraft can operate without restrictions. The results of the ACN-PCN analysis are presented in Chapter 4 and Table 21 of the ARA report where the PCN of each runway and taxiway pavement segment is listed. Although it was noted that the end portions of Runway 13/31 have a reduced strength capacity in relation to its middle sections, in summary, the study did not find significant weight-capacity concerns throughout the airside complex.

3.3.2.7 Runway Safety Areas

The Runway Safety Area (RSA) is a rectangular area bordering a runway that is intended to reduce the risk of damage to aircraft in the event of an undershoot, overrun, or excursion from the runway. The RSA is required to be cleared and graded such that it is void of potentially hazardous ruts, humps, depressions, or other surface variations. Additionally, the RSA must be drained by grading or storm sewers to prevent water accumulation, be capable of supporting snow removal and firefighting equipment, and be free of objects except those required because of their function.

The RSA for an ARC D-IV or D-V runway is required to be 500 feet wide and extend 1,000 feet beyond the runway end. The longitudinal grade from the end of the runway should be from 0 percent to -3 percent for the first 200 feet and no more than -5.0 percent for the remaining 800 feet of RSA. Transverse grades should be -1.5 percent to -3.0 percent away from the runway shoulder edge and beyond the runway ends.

The RSAs associated with each of BNA's runways meet the length and width requirements of ARC D-IV/V runways. However, declared distances and displaced thresholds are required on Runway 13/31 to ensure the appropriate length of the RSA is made available prior to, and beyond, each runway end. Additionally, the localizer equipment located north of the Runway 20C threshold and supporting the ILS precision approach available to Runway 2C is located within the RSA, but has been declared fixed by function.

3.3.2.8 Runway Object Free Areas

The Runway Object Free Area (ROFA) is a rectangular area bordering a runway intended to provide enhanced safety for aircraft operations by ensuring the area remains clear of parked aircraft or other equipment not required to support air navigation or the ground maneuvering of aircraft. The ROFA design standard for ARC D-IV and ARC D-V runways is 800 feet wide, centered about the runway centerline, and extends 1,000 feet beyond each runway end, though never beyond the limits of the RSA. As with the Runway 13/31 RSA, declared distances and displaced thresholds are required on Runway 13/31 to ensure the appropriate length of the ROFA is made available prior to, and beyond, each runway end. In addition, the localizer equipment located north of the Runway 20C threshold and supporting the ILS precision approach available to Runway 2C is located within the ROFA, but has been declared fixed by function.

At present, all BNA runways adhere to the prescribed ROFA geometry and are free of potentially hazardous objects non-essential to air navigation or aircraft ground movements.

3.3.2.9 Runway Obstacle Free Zone

The Obstacle Free Zone (OFZ) is an area of airspace centered above the runway that is required to be clear of all objects, except for frangible navigational aids that need to be in the OFZ because of their function. The OFZ provides clearance protection for aircraft landing or taking off from the runway. The OFZ design standard for ARC D-IV is 400 feet wide centered on the runway centerline and extending 200 feet beyond each runway end. The OFZ is the airspace above the surface with an elevation at any point that is the same as the elevation of the nearest point on the runway centerline.

The inner-approach OFZ is a volume of airspace centered on the approach area that applies only to runways equipped with approach lighting. At BNA, the inner-approach OFZ applies only to Runways 2L/20R, 2C, and 2R/20L. The inner-approach OFZ begins 200 feet from the runway threshold and extends 200 feet beyond the last unit in the approach lighting system. It has the same width as the runway OFZ and rises at a slope of 50:1 away from the runway end.

The inner-transitional OFZ is a volume of airspace along the sides of the runway. It applies only to runways with lower than ¾-mile approach visibility minimums. Runways 2L, 2C, 2R, and 20L are the runway ends subject to inner-transitional OFZ object clearance restrictions at BNA.

At present, all BNA runways adhere to the prescribed OFZ geometry and are free of objects not fixed by their function.

3.3.3 Taxiway System

Taxiway systems should provide safe and efficient routes for aircraft ground movement to and from the runways and apron areas that serve an airport's facilities. The type and location of taxiways in relation to a runway system have a significant impact on the capacity of an airfield. As traffic increases, the taxiway system can limit an airport's overall capacity, especially if the configuration results in frequent runway crossings by taxiing aircraft or does not provide sufficient access to airport facilities or bypass capability.

FAA guidance found in FAA AC 150/5300-13-A recommends that a taxiway system should provide each runway with a full-length parallel taxiway; have as many bypasses, multiple accesses, or connector taxiways as possible to each runway end; provide taxiway run-up areas for each runway end; have the most direct routes possible; have adequate curve and fillet radii; and avoid areas where ground congestion may occur.

The existing BNA taxiway system is sufficient to ensure that overall airport capacity is not affected. All runways are adequately served by full-length parallel taxiways and have an adequate number of entrance/exit taxiways spaced at appropriate distances from the runway thresholds to allow aircraft to exit the runway in a timely manner after landing, thereby maximizing overall airfield capacity.

While the existing BNA taxiway system meets width and spacing requirements, many of the fillets found at taxiway/runway and taxiway/taxiway intersections do not meet the current FAA design standard. Historically, a few methodologies for designing and constructing taxiway fillets were permitted by the FAA. However, with the most recent release of FAA 150/5300-13-A, the options have been reduced to a single standard that ensures all wheels of an aircraft tracking on the taxiway centerline will remain on taxiway pavement. This standard is more conservative than other fillet design methods previously used, and thus requires more pavement. The majority of taxiway/runway and taxiway/taxiway intersections at BNA have pavement deficiencies in light of this new standard. As a result, all airfield fillets should be reviewed in detail and improved where necessary as part of any runway or taxiway improvements. **Figure 3-4** depicts the fillet deficiencies (shown in red). A listing of all the non-compliant fillets is also presented in Section 3.10 of this chapter.

According to AC 150/5300-13A, "unprotected soils adjacent to taxiways are susceptible to erosion, which can result in engine ingestion problems for jet engines that overhang the edge of the taxiway pavement." Prior to September, 2012, paved taxiway shoulders were recommended by FAA airport design standards, though not required. However, introduction of the FAA's new AC 150/5300-13A presents the requirement that paved shoulders be provided on taxiways, taxilanes and aprons accommodating ADG-IV and higher aircraft. Some of the Airport's taxiways, taxilanes, and aprons are equipped with paved shoulders, however most are not. As such, the addition of paved shoulders is required on the Airport's taxi routes intended to be utilized by ADG-IV aircraft.

Further, Taxiway T3, which connects the Taxiway B/K intersection to the Taxiway L/T4 intersection, thereby crossing Runway 13/31 at a non-perpendicular angle, has been identified as a hot spot for runway incursions. Other identified hot spots for potential airfield incursions at BNA include Taxiway R3 at the Taxiway A/K intersection, and Taxiways S7 and S6 adjacent to the Runway 20C approach end. The utility and alignment of these taxiways should be reconsidered and potentially altered to minimize the risk of an unanticipated runway crossing or airfield incursion. Another improvement that would minimize the potential of runway crossings and airfield incursions would be to extend Taxiway K northwest to the Runway 13 end. This would remove the need for an aircraft to cross Runway 13/31 from Taxiway K to access the Runway 13 end.

3.3.3.1 Taxiway Safety Areas

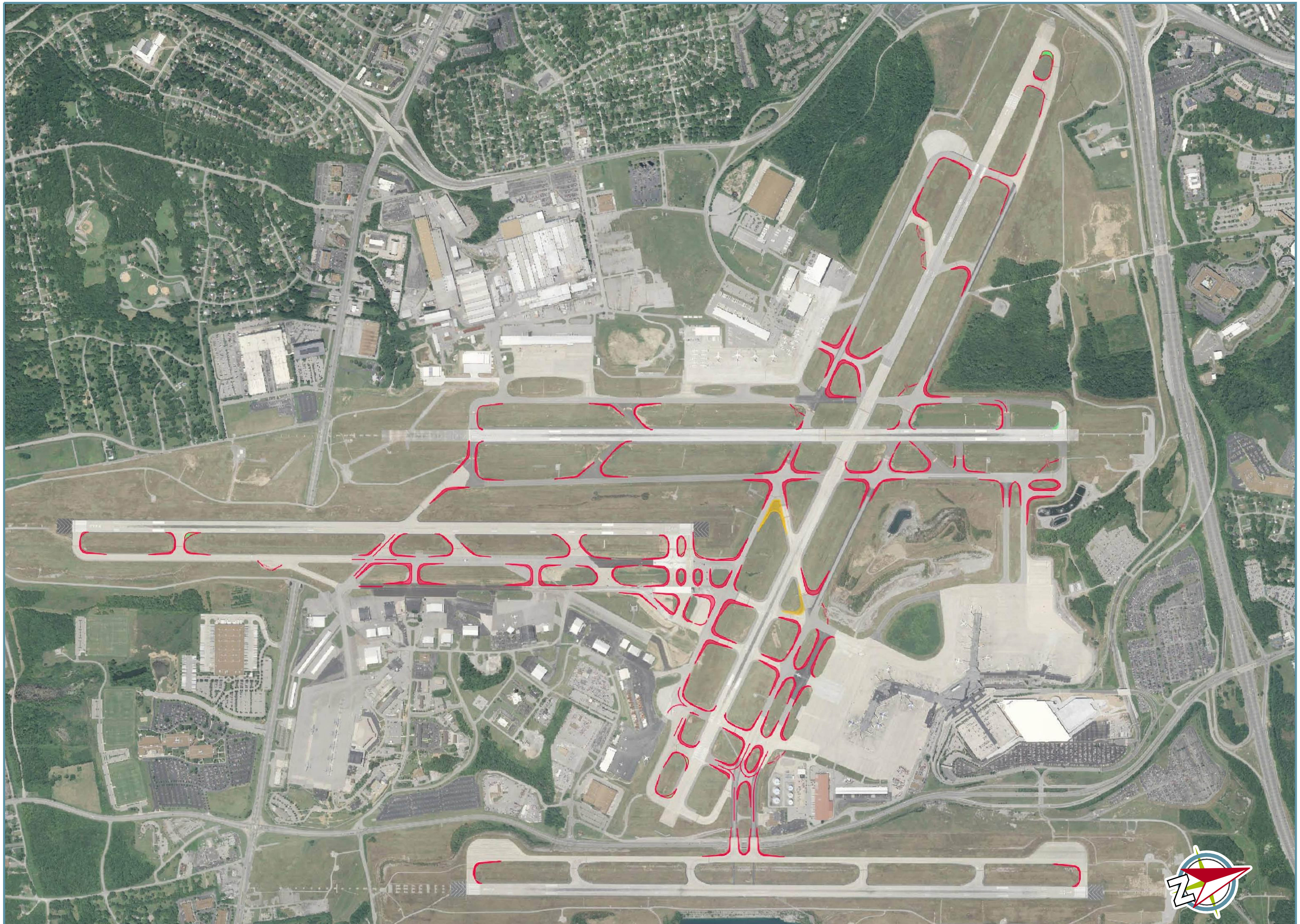
Similar to a Runway Safety Area, the Taxiway Safety Area (TSA) is intended to be cleared, graded, drained, and capable of supporting snow removal and firefighting equipment as well as the occasional passage of aircraft. The safety area for a taxiway serving Group IV aircraft is 171 feet wide along the length of the taxiway. Taxiways for Group V aircraft are required to have a minimum TSA width of 214 feet.

In general, taxiways at BNA meet the Group IV width requirement of 171 feet centered about the taxiway centerline. Exceptions include those along Taxiways A, B, H, K, and L where drainage swales were allowed in the safety area to minimize erosion on the steep side slopes that exist past the safety area. Once the drainage patterns have been addressed, these areas can be re-graded to meet the Group IV standards. In those instances where Group V aircraft are permitted (such as along Taxiways A and L), significant expansion of the safety area will be required since these were originally constructed under Group IV standards. Given the challenges and the occasional nature of the Group V traffic, it is recommended to focus on meeting the Group IV standards in lieu of the more stringent Group V standards.

3.3.3.2 Taxiway Object Free Area

The Taxiway Object Free Area (TOFA) is an area bordering the taxiway where standards prohibit service vehicle roads, parked airplanes, and above-ground objects, except those required for air navigation or ground maneuvering. The standard for a taxiway supporting, or intended to support, Group IV traffic is 259 feet wide centered about the taxiway centerline. For Group V taxiways, this width is increased to 320 feet.

THIS PAGE INTENTIONALLY LEFT BLANK



Nashville International Airport™

ARMSTRONG

LEGEND

Fillet Deficiency

Figure 3-4
Fillet Deficiencies

THIS PAGE INTENTIONALLY LEFT BLANK

Additionally, the hold-short markings on Taxiway U located just northeast of the Taxiway T4 and Taxiway U3 intersection are not positioned such that they would keep an aircraft holding on Taxiway U clear of the TOFA associated with Taxiway T4. Relocating this hold position marking approximately 125 feet farther back from the intersection (northeast of its current position) would preserve the Taxiway T4 TOFA.

3.4 Apron Requirements

Aircraft parking aprons provide space for aircraft parking and circulation. Section 1.1.6 identifies 4 aprons at BNA. These include the Terminal Apron, Cargo Apron, General Aviation Apron, and the Military Apron. Each of these apron spaces is discussed in detail in Section 13.1.6.

3.4.1 Commercial Terminal Apron

The commercial terminal apron space requirements are based upon the number of aircraft gates, parking positions, and maneuvering space required by the various aircraft using the available apron space. Several methodologies for estimating the number of required aircraft gate positions are identified in FAA AC 150/5360-13, *Planning and Design Guidelines for Airport Terminal Facilities*. The Airport's required number of commercial service aircraft gate positions was derived by using the annual enplanements per gate approach. This methodology assumes that the pattern of gate utilization will remain relatively stable over the forecast period. The existing apron adequately serves the Airport's 44-gate terminal.

However, apron expansions are typically required in conjunction with commercial terminal building expansions. Therefore, any future commercial apron expansions within the planning period are expected to be limited to requirements associated with the proposed replacement of the International Arrivals Building (IAB).

3.4.2 General Aviation Apron

BNA currently offers approximately 2.4 million square feet of apron pavement throughout the Airport. However, only approximately 927,000 square feet of that total apron is available for GA itinerant aircraft.

To determine existing and future GA itinerant aircraft parking requirements, it is important to first develop an understanding of how many aircraft are anticipated to use the apron during the peak period. For the purposes of this evaluation, a peak month-average day (PMAD) methodology was used to gauge the approximate number of GA aircraft parked on the apron during an average day of the peak month. The following is a description of the PMAD aircraft parking metric shown in **Table 3-12**:

- GA Itinerant Operations – According to the BNA TAF, itinerant GA operations account for approximately 99 percent of total GA operations.
- GA Peak Month Itinerant Operations – According to 2011 MNAA data, the month of August experienced the greatest number of GA operations (approximately 16 percent).
- GA PMAD Operations – The number of days in August (31) were divided by the GA peak month itinerant operations.
- GA Itinerant Arrivals – Since an operation is considered either a takeoff/departure or landing/arrival, the number of PMAD operations was reduced by half to derive the approximate number of GA itinerant arrivals requiring apron parking.
- GA Itinerant Aircraft Parked on the Apron – According to the FBOs, approximately 80 percent of the GA itinerant arrivals remain parked on the apron for an extended period during the day. Therefore, adequate parking space should be provided for the number of aircraft anticipated to use the apron during an average day of the peak month.

Table 3-12 – GA Itinerant Aircraft Parked on the Apron

	Baseline	PAL 1	PAL 2	PAL 3	PAL 4
GA Operations	44,804	49,660	55,050	61,030	67,670
GA Itinerant Operations	44,771	49,623	55,009	60,985	67,620
GA Peak Month Itinerant Operations	7,224	8,006	8,875	9,840	10,910
GA PMAD Operations	233	258	286	317	352
GA Itinerant Arrivals	117	129	143	159	176
GA Itinerant Aircraft Parked on the Apron	**93**	**103**	**115**	**127**	**141**

Source: RW Armstrong, 2012.

Once the approximate number of GA itinerant aircraft using the apron was determined, an aircraft parking fleet mix was generated to further understand each type of aircraft using the apron. This task was accomplished by applying the fleet mix percentage of GA aircraft operating at BNA with the aircraft fleet mix shown in **Table 3-13**.

Table 3-13 – GA Itinerant Aircraft Parking Fleet Mix

Aircraft Type	Baseline	PAL 1	PAL 2	PAL 3	PAL 4
Single-Engine Piston	9	10	11	12	13
Multi-Engine Piston	5	5	6	6	7
Turbo-Prop	37	41	45	50	56
Jet	41	46	50	57	63
Rotorcraft	1	2	2	2	2
Total	**93**	**103**	**115**	**127**	**141**

Source: RW Armstrong, 2012

Table 3-14 depicts the existing and projected parking space requirements for each aircraft type based on the aircraft parking fleet mix and FAA- and FBO-provided aircraft parking space requirements. As mentioned previously, approximately 927,000 square feet of apron is available for GA itinerant aircraft at BNA. As shown in the table, additional GA itinerant aircraft parking capacity may be required between PAL 1 and PAL 2.

Table 3-14 – GA Itinerant Aircraft Parking Space Requirements

Aircraft Type	Parking Space	Baseline	PAL 1	PAL 2	PAL 3	PAL 4
Single-Engine Piston	2,700	-	26,097	28,930	32,073	35,562
Multi-Engine Piston	3,000	-	15,355	17,021	18,870	20,923
Turbo-Prop	5,400	-	219,462	243,868	270,946	301,012
Jet	13,500	-	618,714	673,833	763,463	847,996
Rotorcraft	3,000	-	6,000	6,000	6,000	6,000
Total		**927,000**	**885,628**	**969,652**	**1,091,352**	**1,211,493**

Note: Numbers are in square feet.
Source: RW Armstrong, 2012.

3.4.3 Air Cargo Apron

As identified in Chapter 1, *Inventory of Existing Facilities and Conditions,* air cargo aircraft primarily operate on either the West Side Apron-North or the West Side Apron-South. The West Side Apron-North is made up of approximately 1.37 million square feet of full-strength pavement and is used for FedEx and Embraer operations. Approximately 270,600 square feet of the West Side Apron-North pavement is used for air cargo carrier parking while approximately 584,500 square feet is used for Embraer operations. The remaining pavement is used for aircraft circulation and taxi. At only 428,000 square feet, the West Side Apron-South is significantly smaller and supports cargo operations by ASTAR and BAX Global.

To determine future air cargo apron size requirements, individual aircraft apron needs were calculated for the projected air cargo fleet mix presented in Chapter 2. **Table 3-15** provides the required apron space for each air cargo aircraft type, based on the aircraft wingspan and length (footprint) with an additional 25-foot buffer added to allow for wingtip clearance, aircraft loading/unloading and ground service equipment movement.

Table 3-15 – Air Cargo Carrier Fleet Mix Requirements

Aircraft Type	Wingspan (Feet)	Length (Feet)	Footprint (Square Feet)	Apron Requirement (Square Feet)[1]
A300/310	147.1	177.5	26,110	**30,324**
B727	108.0	153.2	16,546	**19,967**
B737	94.9	109.7	10,411	**13,124**
B757	124.1	155.3	19,273	**22,921**
DC-8	148.1	187.4	27,754	**32,104**
DC-10	165.4	181.7	30,053	**34,548**
MD-10	155.4	182.3	28,329	**32,707**
MD-11	170.6	148.8	25,385	**29,534**
Cessna 208	52.1	41.7	2,173	**3,501**
ATR-72	89.1	88.6	7,894	**10,272**

1 - Includes 25-foot buffer area surrounding aircraft.
Source: Aircraft Manufacture Specifications, RW Armstrong, Atkins North America Inc., 2012.

Since many air cargo operations occur simultaneously, it is important to identify an approximate number of required air cargo aircraft parking positions for the peak period. To accomplish this, PMAD air cargo departures were calculated. **Table 3-16** provides a breakdown of the projected BNA air cargo operations and recommended air cargo aircraft parking positions.

Table 3-16 – BNA Air Cargo Carrier Apron Operations

	Baseline	PAL 1	PAL 2	PAL 3	PAL 4
Annual Operations	2,640	2,940	3,260	3,610	4,010
Annual Departures	1,320	1,470	1,630	1,805	2,005
Peak Month Departures	143	159	177	196	217
PMAD Departures	5	5	6	6	7
Aircraft Parking Positions	**5**	**5**	**6**	**6**	**7**

Source: RW Armstrong, 2012.

Using the air cargo carrier fleet mix and size requirements, the most demanding aircraft using each cargo apron was identified. The apron requirements for the identified aircraft were then multiplied by the recommended air cargo aircraft parking positions to calculate the maximum required cargo apron space (**Table 3-17**).

Table 3-17 – BNA Air Cargo Carrier PMAD Apron Space Requirements

	Baseline	PAL 1	PAL 2	PAL 3	PAL 4
West Side Apron-North[1]	159,370	177,480	196,790	217,920	242,070
West Side Apron-South[2]	148,090	164,920	182,870	202,510	224,940
Total	**307,460**	**342,400**	**379,660**	**420,430**	**467,010**

1 - The DC-10 was identified as the most demanding aircraft using the apron.

2 - The DC-8 was identified as the most demanding aircraft using the apron.

Note: Numbers are in square feet.

Source: RW Armstrong, 2012.

Currently, the West Side Apron-North and -South provide a total of approximately 698,600 square feet of air cargo parking. As shown, the current BNA air cargo apron space should remain adequate for existing and projected air cargo parking.

3.4.4 Military Apron

The Tennessee National Guard military apron is located between the GA apron and Murfreesboro Road along the Airport's southern border. This roughly 1.11 million square foot apron formerly allowed for simultaneous parking of 14 C-130s. The apron is sufficiently sized to facilitate the proposed change in based military aircraft discussed in Chapter 2. This change would include the relocation of Army aviation facilities, including a single twin-engine turbo-prop aircraft (C-12) and 19 rotorcraft (4 Lakotas and 15 Blackhawks). Based on the Department of Defense's Unified Facilities Criteria (UFC), such aircraft would require approximately 17,600 square feet each to allow for appropriate parking positions, clearances, and movement areas. Using this information, future military apron requirements at BNA are projected in **Table 3-18** throughout the planning period. Based on the analysis presented, the military Apron at BNA is of sufficient size to support its anticipated future operations and level of activity.

Table 3-18 – Military Apron Requirements

	Baseline[1]	PAL 2[2]	PAL 2[2]	PAL 3[2]	PAL 4[2]
Based aircraft parking apron	10	20	20	20	20
Apron Area Required	600,000	352,000	352,000	352,000	352,000
Apron Area Available	1,110,000	1,110,000	1,110,000	1,110,000	1,110,000

1 - C-130 Aircraft use.
2 - Future mission aircraft.
Note: Numbers are in square feet.
Source: Atkins North America Inc., 2012.

3.5 Navigation and Landing Aid Requirements

3.5.1 NAVAIDS

The inventory chapter alluded to the fact that the Airport is equipped with the most sophisticated navigational aids (NAVAIDS) currently approved for civilian use: Category III ILS, which enables aircraft to land during visibility conditions as low as 600 feet runway visual range (RVR). NAVAID deficiencies at the Airport are few. In fact, each runway end is equipped with systems supporting at least 1 non-precision GPS instrument approach procedure. Half of the runway ends are equipped with a visual approach slope guidance system by either a visual approach slope indicator (VASI) or precision approach path indicator (PAPI). However, visual approaches to the following runway ends could be enhanced by the addition of either a VASI or PAPI: Runways 2L, 2C, 20L, 31. According to the MNAA, the Runway 13 VASIs are in need of replacement and the Runway 2R PAPIs have been removed.

3.5.2 NextGen

The FAA's Next Generation Air Transportation System (NextGen) is an ongoing and comprehensive transformation of the current National Airspace System. The conversion to NextGen includes a complete overhaul of current and outdated ground-based technology systems associated with air traffic control and navigation technology in an effort to integrate new satellite-based technologies and enhance the airspace system across multiple fronts. One of the main benefits of NextGen will be its impact on aircraft navigation by converting all ground-based navigational equipment to satellite technology. Among other benefits, the NextGen system will update and enhance GPS technology, reduce congestion, increase airspace capacity, avoid delays, reduce fuel consumption, and increase the operational safety of flight.

3.6 Terminal Area Roadways

Below are the types of roadways that serve the purpose of providing access to/from and within an airport:

- Access Roadways – These roadways link the regional highway network with the airport terminal. Access roadways provide free flow of traffic and typically have a limited number of decision points.
- Curbside Roadways – These roadways are one-way thoroughfares located immediately in front of the terminal buildings for the loading and unloading of passengers and baggage. Curbside roadways typically consist of one inner lane, an adjacent maneuvering lane, and one or more through or bypass lanes.
- Circulation roadways – These roadways provide a variety of paths for movement of vehicles between the terminal, vehicle parking, and rental car facilities.
- Service Roads – These roadways link the airport access roadways with on-airport public facilities, employee parking areas, and other support facilities.

For the purposes of this master plan, the traffic analysis focused on the operations of the circulation roadway and the service roads where they merge or diverge from the circulation roadway for BNA. An analysis of access roadways, such as Donelson Pike, was not performed as part of this master plan effort. However, based on past studies, there appears to be sufficient justification for the realignment of Donelson Pike to improve mobility for regional traffic and provide improved access to BNA. Potential realignment options for Donelson Pike will be evaluated and presented in Chapter 5. In addition to the conclusions of the traffic

analysis for the service roads where they merge or diverge from the circulator road provided in this report, a potential service road to be located inside and adjacent to the airport operations area (AOA) fence throughout the property will be evaluated in subsequent tasks.

3.6.1 Terminal Access and Circulation Roadways

Level of Service (LOS) is a concept that has been formalized into industry-accepted standards and used by airports, as well as the Federal Highway Administration, state Department of Transportation offices, and municipalities nationwide. The defining component of LOS is based on existing system capacity and how well that facility can handle current and increased capacities at different periods. An analysis was completed to determine LOS for the traffic operations on the Airport loop road (i.e., circulator roadway) using a micro-simulation model called CORSIM. CORSIM is a probabilistic model that is designed to predict driver behavior and simulate travel patterns as they actually exist. Vehicle characteristics, such as speed and acceleration, are incorporated into the program, as well as driver characteristics such as aggressiveness and responsiveness. CORSIM produces performance measures, such as density and average speed, that are used to evaluate the traffic operations of freeway and multilane highway facilities. CORSIM also produces performance measures, such as delay, which are used to evaluate the traffic operations of at-grade intersections. The density values provided by CORSIM were used to determine the LOS of the weave and merge/diverge segments on the Airport loop road. The delay values provided by CORSIM were used to determine the LOS of the un-signalized, at-grade intersection located on the Airport loop road at the intersection with the consolidated rental car facility (CONRAC) access driveway. **Figure 3-5** depicts the weave segments of the Airport loop road.

The terminal area roadways LOS measures traffic operations and outputs a letter grade ranging from A to F. **Table 3-19** illustrates and describes each LOS and lists the criteria used to determine LOS for freeway and multilane highway facilities. **Table 3-20** illustrates and describes each LOS and lists the criteria used to determine LOS for at-grade intersections. The LOS criteria used in this analysis are based on the 2010 update to the Highway Capacity Manual published by the Transportation Research Board (TRB). For highway studies, traffic movements that operate at LOS A through D are considered acceptable, which is a typical threshold used for urban areas. Therefore, traffic movements that operate at LOS E or F will be considered deficient.

THIS PAGE INTENTIONALLY LEFT BLANK

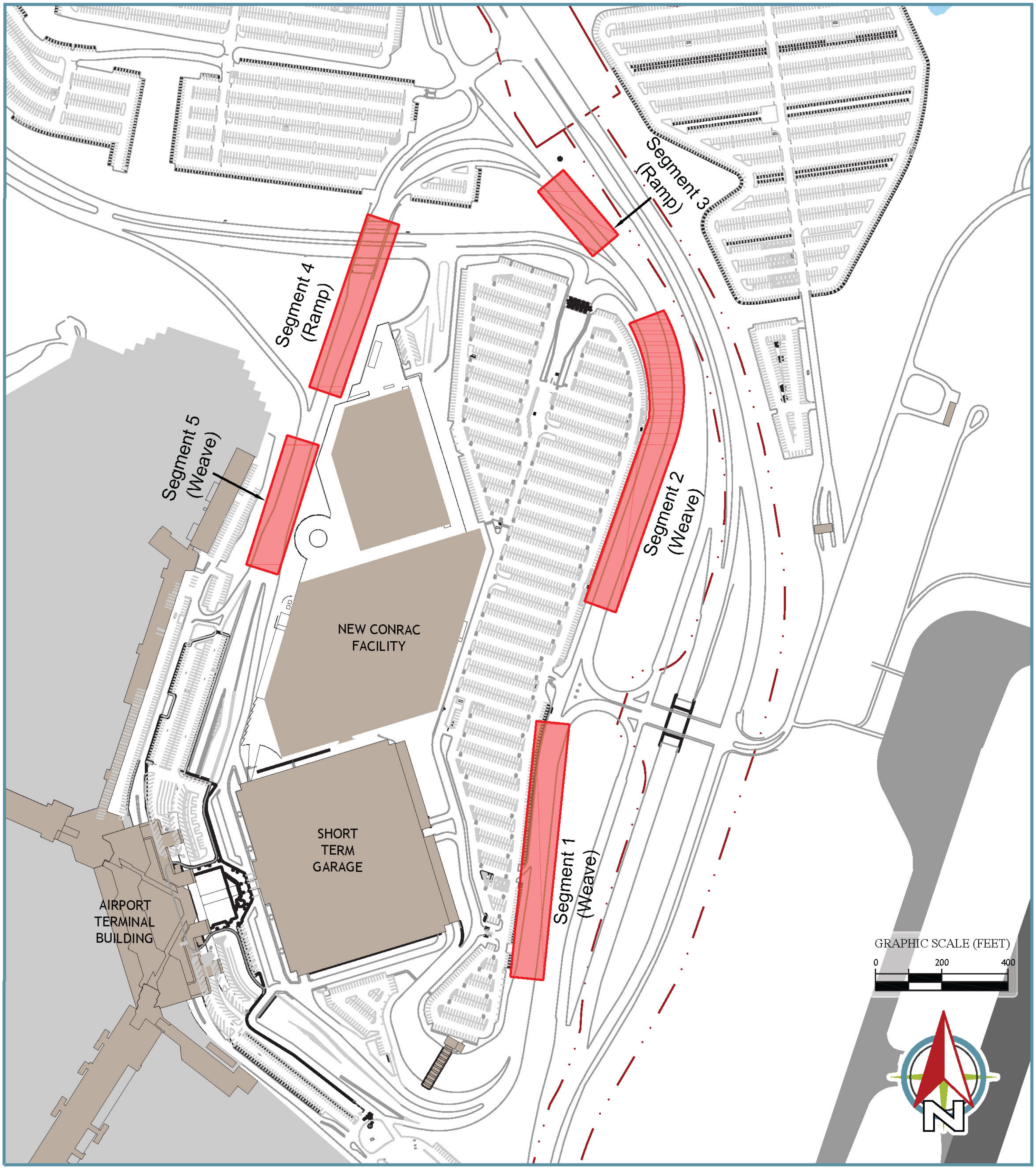


Figure 3-5
Airport Loop Road Traffic Analysis

Table 3-19 – Level of Service for Freeway and Multilane Highway Facilities

LOS	Basic Freeway Section Max. Density (pc/mi/ln)[1]	Freeway Ramp Section Max. Density (pc/mi/ln)[1]	Freeway Weaving Section Max. Density (pc/mi/ln)[1]	CD/Highway Weaving Section Max. Density (pc/mi/ln)[1]
A – Free Flow Operations	11	10	10	12
B – Reasonably Free Flow	18	20	20	24
C – Noticeable Congestion	26	28	28	32
D – Speeds Decline	35	35	35	36
E – At Capacity	45	37	43	40
F – Breakdown Conditions	>45	>37	>43	>40

1 - pc/mi/ln = passenger cars/mile/lane.
Source: Atkins North America Inc., 2012.

Table 3-20 – Level of Service for At-Grade Intersections

LOS	Signalized Intersection Max. Delay (In Seconds)	Un-Signalized Intersection Max. Delay (In Seconds)
A – Little or no Delay	10	10
B – Short Delays	20	15
C – Average Delays	35	25
D – Long Delays	55	35
E – Very Long Delays	80	50
F – Excessive Long Delays	>80	55

Source: Atkins North America Inc., 2012.

Table 3-21 provides a summary of the LOS analysis completed for the Airport loop road using the CORSIM model. As shown, all segments of the Airport loop road are anticipated to operate at LOS D or better through PAL 4. The un-signalized, at-grade intersection of the Airport loop road and the CONRAC access driveway are also anticipated to operate at LOS C through PAL 4. It must be noted that according to ACRP Report 40: *Airport Curbside and Terminal Area Roadway Operations*, typically on regional freeways and arterials, and in densely developed urban areas, LOS D is often considered acceptable. This is mainly due to the fact that motorists, traveling on regional roadway networks can select alternative travel paths should their preferred path be congested.

However, on airport roadways where only a single path is available (and the cost of delay to the traveler is great), LOS C is typically considered to be the minimum acceptable level of service because of the lack of alternative travel paths and the significant negative consequences resulting from travel delays (e.g., passengers missing their flights). All road segments reach LOS C during the planning period.

Table 3-21 – Airport Loop Road Peak Hour LOS

Airport Loop Road Segment Number/ Type	Description (from/to)	Baseline		PAL 1		PAL 2		PAL 3		PAL 4	
		Density (pc/mi /ln)[1]	LOS	Density (pc/mi/ln)[1]	LOS	Density (pc/mi/ln)[1]	LOS	Density (pc/mi/ln)[1]	LOS	Density (pc/mi/ln)[1]	LOS
1 (Weave)	Toll Plaza to Donelson Pike	14.3	B	17.4	B	21.2	B	26.0	C	27.6	C
2 (weave)	Donelson Pike to Discrete Access Rd	16.8	B	20.6	B	24.6	C	28.9	C	31.1	C
3 (Ramp)	Discrete Access Rd to Economy Parking	16.9	B	20.8	C	24.2	C	29.2	D	31.7	D
4 (Ramp)	Economy Parking to Discrete Access Rd	12.4	B	15.2	B	17.5	B	21.0	C	23.3	C
5 (Weave)	Discrete Access Rd to Terminal Facility	15.8	B	19.3	B	22.9	B	27.8	C	31.6	C

At-Grade Intersection	Description	Control Delay (sec/veh)	LOS	Control Delay (sec/veh)	LOS	Control Delay (sec/veh)	LOS	Control Delay (sec/veh)	LOS	Control Delay (sec/veh)	LOS
1 (Un-Signalized)	Loop Road WB LT at CONRAC Entrance	11.0	B	11.0	B	15.4	C	17.2	C	21.7	C

1 - pc/mi/ln = passenger cars/mile/lane.
Source: Atkins North America Inc., 2012.

In order for the MNAA to uphold its high level of customer service for passengers, tenants, employees, and the general public in accessing the terminal area, the following terminal area roadway improvements are recommended:

- Add additional lane capacity within the terminal area
- Expand decision-making distance
- Reduce or eliminate weaving
- Remove congestion at intersections

3.6.2 #Terminal Curbside Roadways

Airport curbsides have a number of lanes adjacent to the terminal. The innermost lane (closest to the terminal building) is essentially a short-term parking lane dedicated to vehicles stopping to drop-off/pick-up passengers. The adjacent outside lane is used by both double-parked vehicles and vehicles pulling in and out of the curbside. The third lane is a transition/weaving lane. The fourth lane is used by vehicles driving past the curb. Therefore, at minimum, the number of curbside lanes is recommended to be 4.

Curbside roadways work most efficiently if the lanes are divided to serve different vehicle types (e.g., passenger vehicles separated from commercial). Because of the very nature of curbside facilities, throughput per lane is greatly reduced compared to typical roadway facilities with the same number of lanes. There is a need to provide additional curbside lanes to handle peak loads and have enough capacity to handle maximum capacity volumes even if a through lane is blocked due to double/triple parking and maneuvering. According to FAA AC 150/5360-13, the inner most curbside lane is considered to have no throughput capacity and the adjacent outside lane should have the ability to handle 300 vehicles per hour. The additional 12-foot through lanes should provide a rate of 600 vehicles per lane per hour. Adjustments (or discounts) can be made to the previously mentioned capacity numbers to account for unique characteristics of the Airport and its passengers. In ACRP Report 40, it is suggested that the capacity of curb space located in a garage be discounted by 50 percent, and that the capacity of an outer curbside be discounted by 20 to 30 percent. These adjustments are applied to the following analysis.

The Ground Transportation level roadway provides for a taxi cab queue/through lane, valet vehicle drop-off/through lane, charter bus drop-off/through lane, and hotel/parking/limos drop-off, and 2 through lanes are provided in the short-term garage. The characteristics and operational nature of the commercial vehicles on the level impact throughput capacity as shuttles and buses take up more curbside and have longer dwell times. However, using the same criteria applied to other levels, the Ground Transportation level roadway provides a capacity of 1,290 vehicles per hour.

The Baggage Claim/Arrivals level roadway provides a total of 6 lanes with passenger pick-up parking. Applying the same criteria per FAA AC 150/5360-13 and ACRP Report 40, the configuration at BNA provides a capacity of 1,080 vehicles per hour for passenger vehicles. The designated lane for MNAA parking shuttles, the passenger pick-up lane (closest to terminal building) and the passenger pick-up parking were assumed to have no throughput capacity.

The Ticketing/Departures level roadway provides a total of 7 lanes with a pedestrian island between the vehicle travel lanes. The island separates the curb lanes into 2 traffic streams and enables the Airport to provide 2 parallel curbsides for pick-ups and drop-offs. The curbside traffic is separated into passenger vehicles and commercial vehicles. The inner curbside (closest to the terminal building) is designated for passenger vehicles with a total of 4 lanes while the outer curbside serves private vehicles with a total of 3 lanes. Crosswalks are provided between the terminal building and the pedestrian island. The Departures level configuration at BNA provides a capacity of 1,680 vehicles per hour.

Table 3-22 provides a comparison of terminal curbside capacity with peak period vehicles per hour demand. As shown, the terminal curbside roadways can accommodate peak period demand with the exception of the Baggage Claim/Arrivals and Ticketing/Departures levels. It is important to note that both the Baggage Claim/Arrivals and Ticketing/Departures levels experience periods of congestion and vehicle backup during peak periods. Evidence suggests that congestion occurs when flight schedules cause a surge in arrivals. Vehicle backup increases when vehicles double park in the throughput lanes or stop to wait for an angled, timed space to become available. These factors impede the flow of vehicles in the throughput lanes and decrease the capacity of the Baggage Claim/Arrivals level curbside. Alternatives to create additional capacity for the Baggage Claim/Arrivals level will be considered, and curbside management will be discussed in Chapter 5.

Table 3-22 – Terminal Curbside Roadway Requirements

	Peak Hour Vehicles[1]			Curbside Requirements	
PAL	**POV[2]**	**Commercial**	**Total**	**Curbside Lane Capacity (Vehicles/Hour)**	**Surplus/(Deficit) (Vehicles/Hour)**
			Ground Transportation Level		
Baseline	-	261	261	1,290	1,029
PAL 1	-	311	311	1,290	979
PAL 2	-	371	371	1,290	919
PAL 3	-	454	454	1,290	836
PAL 4	-	563	563	1,290	727
			Baggage Claim/Arrivals Level		
Baseline	843	-	843	1,080	237
PAL 1	1,003	-	1,003	1,080	77
PAL 2	1,200	-	1,200	1,080	(120)
PAL 3	1,465	-	1,465	1,080	(385)
PAL 4	1,926	-	1,926	1,080	(846)
			Ticketing/Departures Level		
Baseline	796	107	903	1,680	777
PAL 1	947	142	1,089	1,680	591
PAL 2	1,131	154	1,285	1,680	395
PAL 3	1,382	188	1,570	1,680	110
PAL 4	1,620	220	1,840	1,680	(160)

1 - Peak hour vehicles take from Table 3-36 - Curbside Demand Requirements.
2 - Private operating vehicle
Source: Atkins North America Inc., 2012.

3.6.3 Terminal Service Roadways

Service roadways associated with on-Airport public facilities, employee parking areas, and other support facilities were considered in the analysis of the access and circulation roadways. Other Airport service roads for non-passenger related activities such as freight loading/unloading, Airport maintenance, Airport rescue and firefighting, etc. tend to have low traffic volume and low vehicle operation speeds. FAA AC 150/5360-13 recommends that service roads be 2-way and have 12-foot lane widths. These roads have an hourly lane capacity of between 600 and 1,200 vehicles. An examination of data acquired by the MNAA's traffic counting system indicates that during the peak month, peak hour counts totaled 1,090 vehicles, which accounts for 10.44 percent of the average daily vehicle count of 10,441. The average daily vehicle count is 0.16 percent of the 6,704,835 total annual vehicles. Utilizing the terminal curb annual vehicle traffic forecast, the forecast of service roadway vehicles is presented in **Table 3-23**. As shown, the hourly service forecast exceeds the 1,200 hourly capacity starting in PAL 1.

Table 3-23 – Terminal Service Roadway Requirements

PAL	Annual Total Vehicles Forecast	Annual Service Vehicles Forecast	Hourly Service Vehicles Forecast
Baseline	6,704,835	10,441	1,090
PAL 1	8,141,200	13,026	1,359
PAL 2	9,666,900	15,467	1,615
PAL 3	11,425,600	18,281	1,909
PAL 4	13,474,400	21,559	2,251

Sources: MNAA, RW Armstrong, Atkins North America Inc., 2012.

3.7 Gate and Terminal Space Requirements

A detailed terminal planning study for BNA was undertaken to establish PALs for annual passenger enplanements. Each PAL was based on projections of annual passenger enplanements, aircraft operations, aircraft fleet mix, and forecast peak hour operations. The PALs are primary indicators in determining the need for future modifications and/or facility expansions at the Airport. Projected growth of enplaned passenger traffic is the key factor in determining the levels of future demand. For each planning period, 3 forecast scenarios were developed: base-passenger forecast, low-growth forecast, and high-growth forecast. Additionally, international off-peak and international on-peak scenarios were developed for each forecast.

International off-peak represents international service that occurs during domestic off-peak periods of activity with minimal facility impacts. International on-peak represents international service that occurs simultaneously with domestic peak periods of activity with a more significant demand placed on the facility requiring modifications and/or expansion.

The baseline passenger forecast was calculated by applying an annual growth rate of 3.6 percent throughout the planning period between the baseline planning period (2011) and PAL 4 (2031). By comparison, the high-growth scenario considered accelerated passenger traffic growth, driven by the expansion of low-fare carriers or the expansion of existing carrier service. Annual passenger volumes for the high-growth scenario were calculated based on 3.8 percent growth per year over the same planning period.

3.7.1 Terminal Programming Methodologies

Peak hour passenger activity levels from the baseline and low- and high-growth scenarios were used to forecast demand activity level impacts to the terminal for each planning period. These forecast activity levels were used to classify terminal space programs and establish detailed requirements for terminal development. The various terminal programs were compared against existing terminal facilities documented by area in Chapter 1, *Inventory of Existing Facilities and Conditions*.

The terminal facility demands, quantified by area square footages, were compared to existing terminal areas. These requirements for the respective PALs were generated by applying FAA and International Air Transport Association industry standards and guidelines, and including established terminal planning criteria. Comparing the spatial requirements for the PALs to the existing terminal facilities established the recommended terminal facilities required to meet projected future passenger activity traffic levels.

3.7.2 Terminal Facilities Programming Assumptions

Current industry trends and technologies have lasting effects on the size and use of the terminal facility by passengers. The emergence of self-service equipment for passengers to check-in and print boarding passes, either on- or off-airport property, has reduced occupied ticket agent positions. These considerations have been accounted for in the various program periods.

In the near-term, ticket counters, self-service kiosks, and personal computers are assumed to comprise 50 percent of all passenger check-ins. The remaining 50 percent use hand-held mobile devices. Long-term planning scenarios anticipate a higher percentage (more than 70 percent) of check-in procedures will occur with handheld devices.

For baggage check-in activities, near-term assumptions are that 100 percent of all baggage check-ins occur either inside the ticket lobby, including agent assist and self-bag tagging, or at curbside check-in positions. Long-term programming assumptions incorporate some off-airport check-in positions and baggage drop-off locations, such as hotels or rental car facilities, resulting in adjusted percentages of checked-baggage locations.

These critical factors in the programming requirements of the BNA terminal facility have been applied. The location and percentage of passenger ticketing and baggage check-ins are critical drivers for determining the spatial requirements for the terminal, both landside and airside.

3.7.3 Selected Terminal Planning Aircraft

Using projected aircraft fleet mix information (i.e., regional and narrow body aircraft) contained in Chapter 2, a "terminal planning aircraft" was selected for each terminal program calculation. The terminal planning aircraft is based on the most dominant aircraft types operating at the Airport during peak hour operations for both regional and narrow body aircraft. Peak hour operations for both regional and narrow body aircraft have been utilized to determine the forecast fleet mix. For planning purposes, the dominant regional and narrow body aircraft types were selected for each planning period, allowing for maximized flexibility of gate utilization. **Table 3-24** provides a summary of the selected terminal planning aircraft for the baseline passenger forecast scenarios for each planning period.

Table 3-24 – Selected Design Aircraft Summary

Aircraft Type	PAL 1	PAL 2	PAL 3	PAL 4
Regional Aircraft	**5**	**6**	**9**	**10**
RJ-200	1	-	-	-
RJ-700[1]	2	3	4	5
RJ-900	2	2	3	3
RJ-1000	-	1	2	2
Narrow body Aircraft	**17**	**19**	**19**	**21**
A318/A319	2	3	3	3
A320/A321	1	1	1	2
B737-300	2	-	-	-
B737-700[1]	10	12	12	13
B737-800	2	3	3	3

1-Selected terminal planning aircraft.
Source: Chapter 2, *Forecasts of Aviation Demand,* R.W. Armstrong 2012, Gresham, Smith and Partners, 2012.

3.7.4 Terminal Facility Requirements

Table 3-25 summarizes the annual enplanement forecast scenarios used for each critical planning period. Each scenario was further separated into passenger peak hour activity levels.

Table 3-25 – Passenger Activity Levels

PAL	Annual Enplanements	Peak Hour Enplanements
Baseline	4,806,092	1,434
PAL 1	5,835,700	1,706
PAL 2	6,929,300	2,040
PAL 3	8,190,000	2,492
PAL 4	9,658,600	3,092

Source: RW Armstrong, 2012.

The key factors in establishing terminal facility demand are the peak hour enplaned/deplaned passenger traffic for both domestic and international passenger activities, the peak hour operations for domestic/international flights, and the associated aircraft fleet mix.

For each critical planning period, corresponding PALs based on annual enplaned passenger growth were used to establish "milestone triggers." These triggers were used to signify when future terminal development is needed to support the increase in enplaned passenger activity, as well as to provide detailed requirements for terminal development. **Table 3-26** depicts the PALs that have been utilized for determining when future terminal development is recommended, based on when these PAL milestone "triggers" have been reached.

Table 3-26 – Terminal Development PALs

Forecast Scenario	PAL 1	PAL 2	PAL 3	PAL 4
Baseline – Annual Enplanements	5,800,000	6,900,000	8,200,000	9,700,000
High Growth – Annual Enplanement	6,400,000	7,500,000	8,700,000	10,200,000

Note: PALs are in number of annual passenger enplanements.
Source: Gresham, Smith & Partners, Inc., 2012.

Tables 3-27 through **3-33** provide a summary of the primary terminal space demand requirements for the baseline passenger forecast scenarios for each PAL, and highlights when terminal facility development is recommended. It is important to note that although forecast passenger growth throughout the planning period shows significant growth, it does not necessarily translate to additional growth of the existing facility. Taking into consideration that the original terminal facility was designed as a hub, the current function as an origin and destination (O&D) facility does not fully utilize the existing square foot area of the terminal. The current use of the facility, as well as evolving technologies and increased passenger reliance on self-service functions, indicate that efficient redevelopment and space re-purposing within the existing facility should be emphasized before considering facility expansion. One exception to redevelopment of existing space is at the Baggage Claim Level, where programmed space for additional circulation and the need for an additional baggage claim device at PAL 4 would require facility growth outside the limits of the existing facility.

The functional areas of the terminal facility have been divided into the following categories represented in **Tables 3-27** through **3-33:** Airline, Baggage Claim, Public, Concessions, Agencies and Terminal Services. For each category, the baseline area and/or actual element numbers have been represented for comparison to the facility requirements at each PAL to determine if action is necessary

For planning purposes, PAL 4 represents the final facility requirements at the conclusion of the planning period, while PALs 1 through 3 represent the incremental facility requirements to address increased passenger activity levels throughout the planning period. The differences between each PAL determine the specific requirements to be addressed, if necessary.

- Methodology:
  - Final facility requirements = PAL 4 - Baseline:
    - For example, hold room requirements = 118,686 square feet - 93,955 square feet = 24,731 square feet of additional hold room space is required.
  - Incremental facility requirements = PAL 2 through PAL 1:
    - Incremental hold room requirements = 93,677 square feet - 83,260 square feet = 10,417 square feet of additional hold room space required to address PAL 2 requirements.

3.7.4.1 Airline Space

Airline space requirements represent the areas of the terminal facility directly related to and utilized for airline operations. These areas include ticket counter agent positions, baggage check-in positions, self-service kiosks, boarding gates, gate hold rooms, and airline clubs.

Table 3-27 – Airline Space Requirements

Terminal Area Function	Baseline	Unit	PAL 1	PAL 2	PAL 3	PAL 4
Airline Space						
Curbside Positions	15	No.	8	10	11	14
Agent Assist Positions	41	No.	14	11	10	9
Bag Check Positions	7	No.	20	24	29	36
Ticket Kiosks - Self Service	48	No.	19	18	17	16
Ticket Counter/Bag Check	5,250	SF	5,100	5,250	5,400	6,750
Ticket Kiosks - Self Service	-	SF	646	612	578	476
Gates	44	No.	34	38	43	47
Holdrooms	93,955	SF	83,260	93,677	101,962	118,686
Airline Clubs	11,368	SF	9,400	9,400	9,400	9,400

Note: Numbers represented in square feet or actual number requirements.
Source: Gresham, Smith & Partners, Inc., 2012.

Ticket Counters and Positions

- Assumptions:
    - Transaction time for checking in at a kiosk is 2.5 minutes.
    - Transaction time for agent assistance is 3.0 minutes.
    - Transaction time for checking a bag is 1.7 minutes.
    - Ticket counter area assumes 5 linear feet per position, 15 feet depth for counter work area and 15 foot depth for queue space in front of the counter.
    - Kiosk area, assuming free standing kiosks not integral to counter, are 9 square feet per kiosk with 25 square feet of circulation space.
    - Airline/Airport Club spaces assumes 1 primary club at 7,000 square feet and 2 smaller airport clubs at 1,200 square feet each.
    - Throughout the planning period:
        - The quantity of curbside positions increases incrementally.
        - The quantity of agent assist positions decreases incrementally.
        - The quantity of baggage check positions increases incrementally.
        - The quantity of passenger self-service kiosks within the terminal facility decreases incrementally.
- Methodology:
    - Number of required curbside positions = Peak hour passenger enplanements × percent of passengers utilizing curbside kiosks × minutes per transaction time.
    - Number of required agent positions = Peak hour passenger enplanements × percent of passengers utilizing agent assistance × minutes per transaction time.
    - Number of required bag check positions = Peak hour passenger enplanements × percent of passengers utilizing agent assistance × minutes per transaction time.
    - Number of required kiosk positions = Peak hour passenger enplanements × percent of passengers utilizing terminal kiosks × minutes per transaction time.
- Ticket counter space is sufficient to accommodate the existing air carriers, as well as potential future carriers. This may involve relocation of current air carriers to improve operations or to create new counter locations.
- Throughout the planning periods, increased emphasis should be placed on curbside check-in processes to ensure passenger queuing and the check-in function do not affect curbside circulation.
- Currently, there are a total of 41 available agent assist ticket counter positions, although they are not all utilized. While the programming assumptions represent a decrease in agent assist positions across the planning period, there is an increase in the need for baggage check-in positions to accommodate passengers only needing to check a bag.

These passengers are assumed to have checked in for an outbound flight prior to entering the terminal facility.

- There are 48 existing self-service kiosk positions that are integrated into the ticket counters, where passengers can print boarding passes and check baggage, with access to agent assistance if necessary. The recommended number of self-service kiosks required across the planning period are suggested to decrease, but at a different rate than agent assist counter positions. This represents the direct correlation between passengers checking in for a flight remotely in the future, as opposed to utilizing a terminal self-service kiosk. To improve passenger processing times, it is recommended that the majority of self-service kiosks be strategically located throughout the ticket lobby and not integral to the ticket counters.

- As the existing self-service kiosks are currently integrally incorporated into the airline ticket counters, the area for circulation at these existing kiosks are included within the area of the ticket counters, and are therefore represented as zero square feet. Throughout the planning period, the area increase/decrease represented in the table for self-service kiosks, assumes the space required for kiosks that are positioned throughout the lobby in freestanding locations.

Passenger Ticketing

The increasing reliance on evolving technologies has changed and will continue to change passenger behavior with regard to the check-in process. Off-Airport and mobile check-in processes allows for increased levels of enplaned passengers without the need for increasing ticketing lobby area. These trends and assumptions pertaining to evolving technologies are represented in **Table 3-28**, and have been utilized in determining requirements for agent positions, baggage check positions and self-service kiosks. An example of how these trends impact program assumptions is an increase in passenger reliance on new technologies and streamlined check-in processes, such as off-airport ticketing, while the number of agent positions decreases across the planning period.

Table 3-28 – Passenger Check-In Location Summary

Check-In Function	PAL 1	PAL 2	PAL 3	PAL 4
Passenger Ticketing by Location				
Ticket Counter with Agent Assistance	15%	10%	7%	5%
Self-Service Kiosk Terminal Landside	25%	20%	15%	12%
Self-Service Kiosk Terminal Curbside	10%	10%	10%	10%
Self-Service Ticketing Off-Airport	50%	60%	65%	70%
Baggage Check Location				
Terminal Landside	60%	50%	45%	40%
Terminal Curbside	40%	45%	50%	50%
Off-Airport Location	-	5%	5%	10%

Source: Gresham, Smith & Partners, Inc., 2012.

- Assumptions: Passenger Check-in Location
    - It is assumed that throughout the planning period, the number of passengers requiring agent assistance with the check-in process decreases.
    - It is assumed that self-service kiosk use inside the terminal decreases gradually throughout the planning period.
    - It is assumed that the frequency of use for curbside kiosks remains constant throughout the planning period.
    - The reduction in use of check-in processes inside the terminal or at curbside has been offset by the increase in passengers checking in off-Airport.
- Assumptions: Baggage Check-in Location
    - 40 percent of passengers check baggage throughout the planning period.
    - The percentage of baggage checked inside the terminal decreases across the planning period.
    - The percentage of curbside checked baggage increases throughout the planning period, as the percentage inside the terminal decreases.
    - It is assumed that off-Airport checked baggage is introduced at PAL 2 and slowly increases through PAL 4.
- Throughout the planning period, the future locations and percentages of passenger ticketing and baggage check-in locations have been considered in the determination of facility requirements. As technology advancements create opportunities for increased self service functions, such as off-site check-in, self-tagging of checked baggage, and printing of boarding passes, the reliance on staffed ticket agent assistance decreases.
- Currently, there are a total of 41 available agent assist ticket counter positions, although they are not all utilized. While the programming assumptions represent a decrease in agent assist positions across the planning period, there is an increase in the need for baggage check-in positions to accommodate passengers only needing to check a bag. These passengers are assumed to have checked in for an outbound flight prior to entering the terminal facility.
- As each PAL is reached, consideration should be given to off-site self-service check-in functions, such as rental car facilities or off-site hotels, offering check-in positions for passengers and baggage. These functions present the Airport with opportunities to relocate a majority of the check-in in process outside of the limits of the Ticket Lobby, improving circulation and flow within the terminal. For off-site baggage check-in functions, consideration should be given to secure storage of off-site screened checked baggage as well as a means for conveyance of checked baggage from rental car facilities.

Airline Gates and Hold Rooms

- Assumptions:
  - There are 45 existing airline gates throughout the terminal facility, including 1 gate at the International Arrivals Building. Gate C-1 is not usable, which results in a total of 44 available gates.
  - Required gate quantities are based on the number of forecasted peak hour air carrier operations and gate positions.
  - The load factors utilized for the selected design aircraft are:
    - PAL 1 = 74 percent load factor.
    - PAL 2 = 75 percent load factor.
    - PAL 3 = 75 percent load factor.
    - PAL 4 = 82 percent load factor.
  - Load factor determines the number of passengers assumed to be present at each gate based on aircraft fleet mix and seating capacity.
  - It is assumed that 75 percent of the passengers present in a hold room are seated while 25 percent are standing.
  - Hold room sizing criteria take into account space requirements for circulation, seating, queuing, airline gate counters and implied dedicated access corridor area for deplaning passengers. Seated passengers are assumed to utilize 20 square feet per person while standing passengers utilize 13 square feet.
  - Hold room area for regional aircraft is based on an average of 1,650 square feet and for narrow body aircraft 2,700 square feet.
- Methodology:
  - Number of gates/hold rooms = Number of peak hour operations.
  - Number of passengers per hold room = Number of aircraft seats available per selected design aircraft × load factor.
  - Total hold room size requirements = Number of gates × hold room size.
- A 15 percent peak hour surge factor (1.5) has been applied to passenger load factors based on peak hour design aircraft fleet mix. This factor takes into account irregular operations, such as flight delays, where there is a potential for a higher concentration of passengers present in a hold room constraining the hold room space. The result of applying this surge factor is a larger hold room capacity at each gate that can accommodate these irregular operations.
- The programmatic requirements for total gates required to support the forecast design aircraft operations and schedules exceed the existing gate totals at PAL 4. Existing hold room layouts and areas should be reviewed for maximum efficiencies to ensure proper

sizing. Redistribution of hold room area should be considered to accommodate the PAL 4 recommended gate increase.

- With the evolving changes in the airline industry with regard to mergers and MNAA lease renewals in 2017, opportunities for existing air carrier relocation and introduction of new entrant air carriers throughout all concourses are a possibility and should be considered when reviewing future gate and hold room locations.

3.7.4.2 Baggage Facilities

Baggage facilities space requirements represent the areas of the terminal facility directly related to and utilized for checked baggage operations including both inbound claim and outbound baggage make-up areas utilized by the airlines. These areas include the bag claim lobby, bag claim loading area and baggage make-up areas. The bag claim area also takes into account the number of bag claim devices required, including the required linear footage of conveyor.

Table 3-29 – Baggage Claim Space Requirements

Terminal Area Function	Baseline	Unit	PAL 1	PAL 2	PAL 3	PAL 4
Baggage Claim						
Bag Claim Devices	8	No.	8	8	8	9
Carousel Length	1,214	LF	1,214	1,214	1,214	1,447
Baggage Claim Lobby	29,045	SF	40,000	40,000	40,000	45,000
Bag Claim Loading Area	12,000	SF	12,000	12,000	12,000	13,500
Baggage Make-up	44,533	SF	57,750	63,000	68,250	73,500

Note: Numbers represented in square feet or actual number requirements.
Source: Gresham, Smith & Partners, Inc., 2012.

Baggage Claim Lobby

- Assumptions:
  - 40 percent of the peak hour passengers check bags.
  - Each passenger is assumed to have checked an average of 0.9 bags.
  - Although the size of and space between each piece of baggage varies, for planning purposes each checked bag is assumed to be an average of 1.3 feet in length.
  - Assumes 175 linear foot average existing claim device capacity.
- Methodology:
  - Total linear feet of claim devices required = 40 percent of passenger enplanements × 0.9 bags × 1.3 feet.

- Number of required claim devices = Total linear feet ÷ 175 foot average existing claim device.
- Baggage claim lobby circulation area = 5,000 square feet per claim device.
- Baggage claim loading area = 1,500 square feet per claim device.

- The existing baggage claim lobby currently has 8 flat-plate baggage claim devices with sufficient capacity. This available capacity is sufficient for the first 3 PALs; however, once the PAL 4 "trigger" is reached, consideration should be given to the addition of one new baggage claim device. Emphasis should be placed on the linear footage (frontage) of baggage claim devices to determine the expansion needs for Baggage Claim.

- The addition of a new flat plate baggage claim device will require the expansion of the existing facility to the northeast. This expansion will also provide additional public circulation space, larger public restrooms, and increased area for airline baggage service offices.

- Passenger, meeter/greeter activity, and circulation needs increase throughout the planning period. Consideration should be given to the reconfiguration and area increase of the baggage claim lobby area when PAL 3 is approached to accommodate increased general circulation needs and passengers claiming checked baggage.

- While the emphasis on the location for meeter/greeter areas is at the Ticketing Level, area for this function should also be considered at the Baggage Claim Level.

- There is sufficient loading area for the claim devices through PAL 3. Additional area should be provided at PAL 4 to support the recommended addition of the ninth claim device.

Baggage Make-Up

- Assumptions: Based on forecast peak hour departures
  - Regional aircraft departures can stage 3 departing flights (tiers) simultaneously from 1 baggage make-up device.
  - Narrow bodied aircraft departures can stage 2 departing flights (tiers) simultaneously from 1 baggage make-up device.

- Methodology:
  - Number of baggage make-up devices = Number of peak hour departures (based on aircraft type) ÷ number of tiers.
  - Area for baggage make-up = 5,000 square feet per make-up device.
  - Area for cart circulation = Total required baggage make-up area × 5 percent.

- Throughout the planning period, forecast passenger activity levels are anticipated to increase. As industry trends and technologies will influence where the passenger check-in process occurs, these trends will also tend to "push" the check-in process to locations outside of the terminal ticket lobby, to such places as rental car facilities and off-site hotel locations. Checked baggage quantities increase proportionally as well, regardless of where the check-in process occurs. Consideration should be given to increasing the existing baggage make-up areas for the processing of outbound checked baggage.
- The 2011 CBIS project was designed to accommodate forecast checked baggage loads throughout the planning period for both the Concourse C and Main Terminal. The Concourse C make-up carousels for both Southwest and American Airlines were designed to accommodate the outbound baggage loads for Concourse C throughout the planning period. No additional space is required.
- At the Main Concourse, Delta Airlines currently utilizes the largest of the make-up rooms with a dedicated carousel. The remaining airlines that operate out of Concourse A and B have single, proprietary make-up rooms with individual run-out conveyors for baggage delivery. As checked baggage loads increase or potential new entrant air carriers begin service, consideration should be given to re-utilization of the 2 existing bag make-up rooms and optimizing existing space before expanding the building footprint through PAL 1 and PAL 2. Once PAL 3 baggage load levels have been reached, a building expansion in the area adjacent to gate C-2 should be considered to provide adequate floor area.

3.7.4.3 Public Space

Public space requirements represent the areas of the terminal facility directly related to and utilized by the public for general concourse circulation, ticket lobby circulation, areas dedicated for meeters/greeters and restrooms.

Table 3-30 – Public Space Requirements

Terminal Area Function	Baseline	Unit	PAL 1	PAL 2	PAL 3	PAL 5
Public Space						
Concourse Circulation	113,961	SF	66,660	74,475	82,500	90,315
Ticket Lobby Circulation	24,689	SF	12,580	12,580	12,580	12,580
Meeter/Greeter Waiting	4,426	SF	4,275	5,100	6,225	7,725
Restrooms	22,300	SF	22,300	26,375	31,875	39,200

Note: Numbers represented in square feet or actual number requirements.
Source: Gresham, Smith & Partners, Inc., 2012.

Concourse Circulation

- Assumptions:
  - For planning purposes, average concourse circulation width requirements are 15 feet based on a single loaded concourse configuration, with a double loaded concourse being 30 feet wide. The existing concourse width is 25 feet.
  - Concourse length requirements are based on selected design aircraft wingspan dimension + wingtip clearance requirements between parked aircraft.
  - Concourse circulation requirements have been adjusted by a factor of 15 percent to be in alignment with peak hour operations.
- Methodology:
  - Concourse area = Number of aircraft positions × (design aircraft wingspan + wingtip clearance per gate) x 15-foot circulation width.
- General concourse circulation area within the existing facility begins to increase at PAL 2 and requirements for additional growth are reflected throughout the remainder of the planning period.

Ticket Lobby Circulation

- The area for circulation within the existing ticket lobby is capable of accommodating the projected passenger enplanement activity levels throughout the planning period.

Meeter/Greeter Area

- Assumptions:
  - Assumes number of meeter/greeters is based on a factor of 10 percent of peak hour arriving passengers.
  - Assumes 25 square feet of required space per meeter/greeter occupant.
- Methodology:
  - Number of meeter/greeters = Number of peak hour arriving passengers x 10 percent.
  - Meeter/greeter area = Number of meeter/greeters x 25 square feet.
- Additional functional area for meeters/greeters should be considered once PAL 2 is approached.

Restrooms

- For the purposes of determining restroom facility requirements, the pre-secure restrooms are sized assuming the peak hour passenger enplanements and deplanements occur at differing periods, while the post-secure restrooms are sized assuming the peak hour passengers enplanements and deplanements occur at the same time.
- Assumptions:
  - It is assumed the 15 percent of the people use the restroom facilities at an area factor of 25 square feet per person.
- Utilizing these restroom sizing factors, the existing restroom facilities are sufficient to address the PAL 1 forecast facility needs.
- At PAL 2, it will be necessary to provide an additional 4,075 square feet of restroom.
- At PAL 3, it will be necessary to provide an additional 5,500 square feet of restroom.
- At PAL 4, it will be necessary to provide an additional 7,325 square feet of restroom.
- The total additional square footage of restroom facilities throughout the planning period is 15,400 square feet.
- As the requirements for restroom area and fixture quantities are anticipated to incrementally increase throughout the planning period to address the increased passenger load, methodologies utilized for determining the sizing criteria for restrooms should be reviewed at each PAL. Current restroom capacities should be compared to local governing building and engineering codes, as well as passenger enplanement loads, to ensure fixture counts and restroom area comply with these codes.

3.7.4.4 Concessions

Concessions space requirements represent the areas of the terminal facility directly related to and utilized for concessions, both airside and landside including storage requirements. Each concession area requirement has been divided into specific concession type: Food and Beverage, News/Gifts/Specialty and Services such as advertising, information desks, banking etc. Areas for Rental Car and Ground Transportation counters have been represented as a separate Concession category.

Table 3-31 – Concessions Space Requirements

Terminal Area Function	Baseline	Unit	PAL 1	PAL 2	PAL 3	PAL 4
Pre-Secure Concessions						
Food and Beverage	5,134	SF	4,085	4,850	5,733	6,761
News, Gifts and Specialty	1,033	SF	1,167	1,386	1,638	1,932
Services	1,838	SF	2,183	2,591	3,063	3,612
Total	*8,005*	*SF*	*7,435*	*8,827*	*10,434*	*12,305*
Post-Secure Concessions						
Food and Beverage	35,890	SF	49,327	59,901	70,803	83,493
News, Gifts and Specialty	20,490	SF	22,176	26,330	31,122	36,700
Services	860	SF	1,027	1,220	1,441	1,700
Total	*57,240*	*SF*	*72,530*	*87,451*	*103,366*	*121,893*
Concessions Storage	12,269	SF	23,664	28,097	33,210	39,163
Total Concessions	**77,514**	**SF**	**103,629**	**124,376**	**147,011**	**173,361**
Rental Car/Ground Trans.	6,876	SF	6,300	6,300	6,300	6,300

Note: Numbers represented in square feet of requirements.
Source: SI Partners, Inc., 2012.

- Assumptions:
  - Sizing criteria are determined by a factor of 18 square feet of required concessions per every 1,000 passenger enplanements.
  - 9 percent programmed concessions square footage is allocated to Pre-Secure Concessions, distributed as follows:
    - Food and Beverage = 55 percent.
    - News, Gifts and Specialty = 17 percent.
    - Services = 28 percent.
  - 91 percent programmed concessions square footage is allocated to Post-Secure Concessions, distributed as follows:
    - Food and Beverage = 68 percent.
    - News, Gift and Specialty = 31 percent.
    - Services = 1 percent.
  - Storage is assumed to be a factor of 23 percent of the concessions area.

- Methodology:
  - Required concession area = Passenger enplanements ÷ 1,000 × 18 square feet.
  - Pre-Secure Concession Area = Required concessions area × 9 percent.
  - Post-Secure Concession Area = Required concessions area × 91 percent.
  - Total Concessions Area = Pre-Secure Concession area + Post-Secure Concession area + Concessions Storage.

Pre-Secure (Landside) Concessions

- Pre-secure concessions comprise 9 percent of the total programmed concessions requirements.

- Pre-secure concessions are shown to increase in area throughout the planning period. However, it is recommended that passenger and meeter/greeter behavior, as well as travel and security protocols, be evaluated at each PAL to determine the need and support for increased concessions offerings.
- At each PAL, potential locations for additional concessions should be considered at each of the 3 main terminal levels on the pre-secure side with an emphasis on the repurposing or reuse of existing space to create additional concessions offerings.

Post-Secure (Airside) Concessions

- Airside concessions comprise 91 percent of the total programmed concession requirements.
- As passenger enplanement demand increases throughout the planning period, the current airside concessions program needs are also anticipated to increase. Passenger behavior and technology may impact concessions offerings with regard to concession type and location(s). While each planning period reflects an increase in the concessions program, it is recommended that evaluation and consideration be given to each current and proposed concession location to maximize passenger satisfaction and Airport revenue-generating opportunities.
- At each PAL, potential locations for additional concessions should be considered at each concourse on the post-secure side. Consideration should be given to the repurposing or reuse of existing space, prior to any expansion consideration of the existing facility, to accommodate new or expanded concessions offerings. Emphasis should be placed on maintaining existing concourse circulation widths.
- Gate C-1 and its associated hold room should be considered for re-purposing to support an expanded concessions program. A building expansion in the area adjacent to gate C-2, immediately across from the exit lanes of the SSCP, would create a high exposure concessions area first accessed by passengers upon exit of the SSCP. This also presents opportunities to create an expanded seating area for passengers re-composing after being processed through the SSCP and opening up circulation between concourses. Space beneath this expanded area could be utilized for covered storage or additional baggage make-up area, while the structure above could be sized to support future MNAA office space

Rental Car Counters

- There is currently 6,876 square feet of existing rental car counter space representing 6 companies. Using a planning factor of 1,050 square feet per rental car company for offices and counters, a total of 6,300 square feet is required throughout the planning period, with no additional space required. This takes into account an average of 20 linear feet of counters, 20-foot deep offices and a 10-foot work space depth behind the counter.

3.7.4.5 Agency Space

Agency space requirements represent the areas of the terminal facility directly related to and utilized for the primary agencies that perform government security functions and processing of international travelers. The agency areas are divided into 3 functional areas. The first 2 pertain to the Transportation Security Administration areas dedicated to passenger and checked baggage screening, and the third pertains to the Federal Inspection Services areas utilized for processing arriving international travelers.

Table 3-32 – Agency Space Requirements

Terminal Functional Areas	Baseline	Unit	PAL 1	PAL 2	PAL 3	PAL 4
1 Security Checkpoint	17,544	SF	17,544	17,544	20,979	20,979
2 In-Line Baggage Screening	24,345	SF	12,240	12,240	12,240	15,840
3 CBP/International Arrivals	19,459	SF	28,909	28,909	28,909	28,909

Note: Numbers represented in square feet of requirements.
Source: Gresham, Smith & Partners, Inc., 2012.

Security Checkpoint

- Assumptions:
  - The current checkpoint configuration and allocated space is sufficient through the PAL 2 planning period.
  - It is anticipated that the checkpoint capacity may be restricted at PAL 3.
  - Prior to PAL 3 activity levels being reached, checkpoint throughput, performance, capacity and TSA protocol should be evaluated to determine if expansion is required to process the projected passenger levels.
- Throughout the planning period, the programmatic requirements reflect a consistent growth pattern of the security checkpoint functional area by using industry throughput and sizing criteria for planning factors.
- Using enhancements to the existing screening equipment layout and processes, as well as advanced scheduling of TSA screening personnel to accommodate peak month-average day passenger activity levels, the MNAA has efficiently and effectively managed the checkpoint size requirements to accommodate projected growth up to the PAL 3 planning period.

- Once PAL 3 has been reached, expansion and growth of the checkpoint functional area should be considered to accommodate an additional 2-1 screening lane configuration, comprised of one passenger screening portal and 2 carry-on x-ray table lanes.
- Throughout the planning period, screening technologies and protocols should be reviewed, as technical advancements in these areas may reduce the sizing requirements of the checkpoint and mitigate the need for further expansion.
- Improved screening processes, such as TSA "Pre-Check" and "Checkpoint of the Future," should be investigated at each PAL to determine industry-wide acceptance and how these processes can be applied to BNA to increase the efficiency of the checkpoint.

Checked Baggage Inspection System

- Assumptions:
  - Throughput of EDS machines is assumed to be 550 bags per hour per machine.
  - Area requirements per EDS machine is 2,400 square feet.
  - TSA area for office support is 25 percent of total screening area.
  - General circulation is assumed to be 20 percent of total screening area.
- Methodology:
  - Number of EDS machines = Peak hour checked baggage ÷ EDS processing rate.
  - Screening area = Number of EDS machines × 2,400 square feet per machine.
  - TSA office area = Screening area × 25 percent.
- Throughout the planning period, the existing area dedicated to baggage screening is sufficient. The current system was completed in 2010 and has the throughput capabilities to process the forecast checked baggage demand.
- Once each PAL is reached, consideration should be given to new, certified technologies and screening protocols, to compare the current system to the requirements for new technologies. Potential impacts from future technologies and protocols should be identified and the existing area modified, if necessary.

U.S. Customs and Border Protection

- Assumptions:
  - Sizing criteria for future Federal Inspection Service are based on 600 passengers per hour
  - The future facility sizing requirements remain unchanged throughout the planning period.

- The existing International Arrivals Building, which was originally constructed as a temporary facility, is approximately 19,460 square feet with 1 contact gate and is capable of processing 200 to 400 peak hour passengers.
- MNAA has stated future goals for increasing the level of international air carrier service to BNA. To accommodate the future processing demands for this increased service, the basis of design for all planning periods is representative of a facility capable of processing up to 600 passengers per hour, according to the U.S. Department of Homeland Security's *"Airport Technical Design Standards for Passenger Processing Facilities"* planning guidelines.
- The Federal Inspection Service (FIS) functional space requirements remain constant throughout the planning period. This facility will not only process up to 600 passengers per hour, but will also provide the additional contact gates to support diverted international flights from other airports, such as Hartsfield-Jackson Atlanta International Airport.
- Potential international scheduled service by Southwest-AirTran and international charter operations in the early planning periods will not immediately support a facility sized to accommodate the functional spaces for processing 600 passengers.
- Consideration should be given to the construction of a larger facility, sized to accommodate the functional requirements of increased processing capacity, but finished out to the sizing requirements necessary to support the current passenger rates. This allows for future facility expansion within the remaining shell space.
- Flexibility in international gating should be configured to function as "swing" gates, capable of serving domestic or international flights as need dictates. Through the use of sterile corridors in conjunction with access controlled boarding and hold room doors, "swing" gates can be configured to receive either domestic or international flights. This provides the most efficient use of an international gate, avoiding a dedicated international gate only being utilized for arriving international flights.

3.7.4.6 Terminal Services

Terminal Services space requirements represent the areas of the terminal facility directly related to non-public spaces, such as mechanical, electrical and storage rooms.

Table 3-33 – Terminal Service Space Requirements

Terminal Services	Baseline	Unit	PAL 1	PAL 2	PAL 3	PAL 4
Mechanical and Electrical	53,496	SF	37,092	41,071	45,991	52,262
Building Services	-	SF	7,400	7,400	7,400	7,400
Stairs/Elevators/Escalators	25,394	SF	21,820	24,029	26,793	30,415

Note: Numbers represented in square feet or actual number requirements.
Source: Gresham, Smith & Partners, Inc., 2012.

Mechanical and Services

- Assumptions:
    - Sizing criteria for mechanical and electrical services for each PAL assumes a factor of 7 percent of the total building gross area is dedicated to these services. This includes mechanical, electrical, and plumbing rooms, communication rooms, penthouses, utility chases/shafts, fire protection rooms, etc. The 7 percent gross building area factor takes into account incremental growth in both building occupant and concessions loads throughout the planning period compared to existing conditions. This does not directly translate into facility expansion, but build-out of space within the existing facility to accommodate growth.
    - Sizing criteria for terminal building services includes MNAA spaces necessary for operation of the terminal facility, including, but not limited to, maintenance offices, warehouse storage, break rooms, janitor closets, loading dock, delivery screening area, compactor/recycling area and storage for sweepers/lifts. Utilizing planning criteria from similar airports, the following assumptions have been made regarding space requirements for these functional areas:
        - Warehouse Storage Area – 1,000 square feet.
        - Employee Break Rooms/Lockers/Toilets – 1,000 square feet.
        - Terminal Maintenance Offices/Shops – 1,000 square feet.
        - Security Screening Area for Delivered Products – 1,200 square feet.
        - Truck Dock – 300 square feet.
        - Refuse Holding/Recycling Area – 500 square feet.
        - Sweeper/Lift/Janitorial Storage – 2,400 square feet.
- Methodology:
    - Mechanical/Electrical Services = Total Service Space Requirements - 7,400 square feet.
    - Building Services = 7,400 square feet.
- The areas considered for building services dedicated to the terminal facility include: area for mechanical and electrical systems, airport maintenance offices, warehouse storage, employee break areas, loading dock, screening area for deliveries, compactor/recycling

area, sweeper storage and lift storage. The MNAA is in the process locating a majority of these services outside of the terminal facility into the CSF Building or to the west side of the airfield. Consideration needs to be given to loading dock and delivery areas serving the terminal with regard to location and capacity. Direct terminal related services, such as lift and sweeper storage, loading docks and screening facilities should be planned for within the terminal facility.

Stairs/Elevators/Escalators

- Assumes areas dedicated to vertical circulation elements, such as stairs, elevators and escalators are based on a factor of 5 percent of the total building area. At each PAL, requirements for capacity and quantity of these elements should be compared against the existing elements to determine if action is necessary. Specific design action, such as adding new stairway capacity, elevators, escalator, etc., to ensure compliance with current governing code requirements relative to terminal facility growth.

3.7.5 Terminal Facility Curbside Requirements

BNA has 3 terminal curbsides. One curbside is located on the Ground Transportation level, one curbside is located on the Baggage Claim/Arrivals level, and one curbside is located on the Ticketing/Departures level. Departing passengers have the option to be processed at either the Ground Transportation or Ticketing/Departures level curbs, while arriving passengers have the option to be processed at either the Ground Transportation or Baggage Claim/Arrivals levels. Each terminal curbside has specific, restricted uses and defined access for specific vehicle types as well. The Ground Transportation level curbside primarily receives taxi cabs, limousines, shuttle busses and motor coach style buses. There is a valet parking operation that also utilizes this level for the drop-off and pick-up activities of privately owned vehicles (POVs) by passengers. This service is anticipated to increase, as well as supporting infrastructure requirements, as it increases in popularity. While most of the Baggage Claim/Arrivals level is limited to POVs for the picking up and loading of arriving passengers, the MNAA operates a parking shuttle service that utilizes this level for picking up arriving passengers. The Ticketing/Departures level curbside is utilized by POVs dropping off and unloading departing passengers, as well as by taxi cabs, limousines and off-airport shuttles, all of which are dropping off departing passengers. The MNAA utilizes this level for 2 different shuttle operations – the MNAA parking shuttle utilizes this level for dropping off departing passengers, and the MNAA employee shuttle drops off and picks up employees going back and forth to the employee parking lot.

The following provides a summary of each curbside level and the respective characteristics for each that were used to develop the curbside requirements.

- **Ground Transportation** – The Ground Transportation curbside capacity is comprised of 5 separate curbs: 3 located on the exterior curbside adjacent to the terminal and 2 located on the interior of the parking garage drive-through lane.

  Taxi Queue (Interior)- The first curbside adjacent to the terminal building is accessible to the right of the main through lane. It is reserved for the taxicab queue and no other vehicles are permitted to park at this curb.

  Shuttle Bus (Exterior) – The first curbside on the entrance end of the main through lanes is reserved for Airport based transportation Shuttle Buses. It is separated from the Taxi Queue by a raised curb and island.

  Charter Bus (Exterior) – The second curbside off of the main through lanes is adjacent to the valet parking services and is reserved for charter buses operated by off-airport touring companies and public transportation buses.

  Shuttle Bus (Inside Garage) – The first curbside encountered on the first level of the interior of the parking garage is reserved for shuttle buses operated by off-airport businesses, such as off-airport parking operators, off-airport rental car companies and Hotel/Motel operators.

  Limousine (Inside Garage) – The second curbside encountered on the first level of the interior of the garage is reserved for Limousine parking and is also used as additional parking for shuttle buses operated by off-airport businesses.

- **Baggage Claim/Arrivals** – The Baggage Claim/Arrivals level roadway provides a total of 6 lanes with 2 curb areas designated for passenger pick-up utilizing personal vehicles (POVs) parking and 1 curb dedicated for use by MNAA parking shuttles. Currently there are no commercial vehicles accessing this level for picking up passengers. The lanes for this level are currently configured as follows:

  Lane 1 – Lane 1 is adjacent to the terminal front and is utilized exclusively by the MNAA parking shuttles. It is a single lane framed by two raised concrete curbs. Support columns for the Baggage Claim/Arrivals level roadway are located between lanes 1 and 2, This curb cannot be removed to provide additional capacity for POV's. This lane provides no additional curbside parking capacity for vehicles.

  Lane 2 –Lane 2 is a parking lane adjacent to the curbside. This represents the first available parking for POV's to pick up passengers. This parking lane is adjacent to two through lanes for traffic (lanes 3 and 4). The assumed dwell time for passenger pick-up in Lane 2 is 3 minutes.

Lanes 3 and 4 –Lane 3 is immediately adjacent to Lane 2 curbside parking and is currently used for loading, maneuvering, and through traffic. Lane 3 cannot be utilized for double parking capacity without reducing roadside capacity and creating congestion. Lane 4 not only provides vehicle circulation, but also serves as the entry point for the angled timed parking spaces.

Angled Parking –Between Lanes 4 and 5 there are 20 angled parking spaces with 10 minute time limits for POV parking to facilitate passenger pickup. Once time expires, vehicles must vacate their spaces, thus allowing the opportunity for other vehicles to pick-up passengers. The 20 angled parking spaces provide the equivalent of 320 feet available for passenger pick-up, according to the following calculation, which was modified from Airport Cooperative Research Program (ACRP) Report 40: *Airport Curbside and Terminal Area Roadway Operations* (2010):

- Equivalent Curb Length of Angled Timed Parking = # of Parking Spaces × Stall Length × (1 – (% reduction for average dwell time))

A reduction factor is required to account for the difference in average dwell times between the angled timed parking at the curbside pick-up. Observation data indicates that the average dwell time in the angled timed parking is 2.5 to 3 times longer in duration than the dwell times of vehicles utilizing curbside pick-up. A reduction factor of 20% has been selected to represent this difference in dwell times. Therefore, the equivalent curb length of the angled timed parking is calculated as follows:

- Equivalent Curb Length of Angled timed Parking = 20 Parking Spaces × 20 feet × (1 – 0.20) = 320 feet

Lanes 5 and 6 – These lanes are utilized for through traffic circulation, with Lane 5 also being utilized as the exit lane for the angled, timed parking.

Baggage Claim/Arrivals Effective Curb Length - Total effective linear curb length capacity available for vehicle loading at the Baggage Claim/Arrivals Level, considering all existing curbs utilized for POV parking, is 963 linear feet.

- **Ticketing/Departures** – At this level, the continuous POV passenger unloading curb, which is 788 linear feet, is immediately adjacent to the terminal facility entrance/exit vestibules and air carrier curbside check-in positions. There are 3 drive-through lanes east of the curb. The outer curb, which is utilized for MNAA shuttles and employee shuttles and taxi cabs dropping off passengers, is 494 linear feet in length.

Table 3-34 represents the current BNA lengths for each curbside. These lengths are used as the baseline comparison for the planning periods and establish the curbside requirements for each period.

Table 3-34 – Existing Curbside Lengths

Ground Transportation Level	Linear Feet
Taxi Queue	135
Shuttle Bus (exterior)	189
Shuttle Bus (inside garage)	247
Charter Bus (interior)	195
Limo (inside garage)	245
Total	**1,011**

Baggage Claim/Arrivals Level	Linear Feet
Passenger Pick-Up Parking (20 angled spaces)	320
Passenger Pick-Up Curbside	643
Total	**963**

Departures/Ticketing Level	Linear Feet
Passenger Drop-Off Curbside (inner curb)	788
Shuttles/Taxis (outer curb)	494
Total	**1,282**

Source: MNAA, 2012.

3.7.5.1 Terminal Curbside Programming Assumptions

Utilizing ACRP Report 40: *Airport Curbside and Terminal Area Roadway Operations* (2010), which document industry accepted design criteria for terminal planning and design, curbside programming assumptions for a 1-hour peak planning period were used to determine the required curbside linear frontage and capacity for each of the 3 terminal roadway levels. The total vehicle quantity was then separated into vehicle type, including vehicle length and anticipated curb-level dwell time. These criteria were used to determine the curbside frontage requirements.

A more significant factor in determining required curbside length is the anticipated dwell time for each vehicle type at each specific curb. Using industry standards documented in ACRP Report 40, average vehicle dwell times were used and modified to accommodate vehicle behavior patterns specific to BNA. Standard dwell times have been adjusted to more accurately depict specific vehicle behavior, such as angled-timed POV spaces at Baggage Claim. While the dwell times for POVs picking up passengers can be 3.0 to 5.0 minutes, the timed spaces have a 10.0 minute maximum dwell time allowed; therefore, this factor was utilized for this outer curb in lieu of the recommended dwell time. **Table 3-35** represents the vehicle dwell time assumptions for the individual terminal curbsides. The following is an explanation for some of the variances in dwell times based on curbside use:

- **Ground Transportation Pick-Up** - Assumes a 4-minute average wait time to pick up deplaning passengers. Shuttle types considered present at this curbside level are off-Airport shuttle buses and charter motor coaches. Limousines also stage at this level for picking up deplaning passengers. Also assumes no POVs utilizing the curbside at this level, as these vehicle types are recirculating in traffic on the Airport roadway system.
- **Baggage Claim/Arrivals POV** – Observation data indicates that dwell times for POVs picking up passengers on the Baggage Claim/Arrivals Level curbside is approximately 2.0 minutes. The minimum allowable dwell time of 3.0 minutes per ACRP Report 40 requirements is used to calculate demand. **Ticketing/Departures POV** - As with factors considered for Baggage Claim/Arrivals, POVs are assumed to have a 3.0 minutedwell time, which is the minimum allowable for the calculations performed.
- **Ticketing/Departures Taxis** - Assumes 2.0 minute dwell time for unloading of passengers, including transaction time.
- **Ticketing/Departures Limousines** - Assumes 2.5-minute dwell time for unloading of passengers, including transaction time.

Table 3-35 – Vehicle Dwell Time by Level

Ground Transportation Level		
Type	**Minutes**	**Comment**
POV	3.0	Valet parking function not considered in curbside design demand
Taxi	2.0	Average for loading and wait time
Shuttle	4.0	Average for loading and wait time, including off-Airport shuttles and charter motor coach style buses
Limo	2.5	Average for loading and wait time
Baggage Claim/Arrivals Level		
Type	**Minutes**	**Comment**
POV	3.0	Minimum allowable assumed loading time
POV Park	10.0	Assumes 10-minute dwell time per each angled space (18 spaces total)
Shuttle	4.0	MNAA Parking Shuttle - Average for loading/unloading employee passengers
Ticketing/Departures Level		
Type	**Minutes**	**Comment**
POV	3.0	Minimum allowable assumed loading time
Taxi	2.0	Average for unloading including transaction time
Shuttle	4.0	Off-airport Shuttle - Average for unloading time
Shuttle	4.0	MNAA Parking Shuttle – Average for unloading time

Limo	2.5	Average for unloading time

Source: ACRP Report 40 (2010)

3.7.5.2 Future Curbside Requirements

Table 3-36 provides a summary of the terminal curbside demand requirements for the baseline passenger forecast scenarios. To determine curbside requirements, ACRP Report 40 takes into account a probabilistic factor added to the required stall dimensions, to determine the total design stall length, or curbside required. The design stall requirements take into account irregular curbside activities, such as longer than planned dwell times or varying vehicle mixes, by providing additional curbside capacity to address these irregular operations with minimal impacts to traffic flow.

The required curbside lengths for each roadway level have been determined utilizing the methodologies provided in ACRP Report 40. Where a deficit has been determined when compared to existing capacity, it is assumed that only single curb capacity is available.

Table 3-36 – Curbside Demand Requirements

	Peak Hour Vehicles		Curbside Requirement in Linear Feet			
PAL	**POV**	**Commercial**	**Existing (2011)**	**Required**	**Surplus/(Deficit)**	**UF**
			Ground Transportation Level			
Baseline	-	261	1,011	**619**	392	0.61
PAL 1	-	311	1,011	**733**	279	0.72
PAL 2	-	371	1,011	**878**	133	0.87
PAL 3	-	454	1,011	**1,079**	(68)	1.07
PAL 4	-	563	1,011	**1,335**	(324)	1.32
			Baggage/Arrivals Claim Level			
Baseline	843	-	963	**1,265**	(91)	1.09
PAL 1	1,003	-	963	**1,505**	(291)	1.30
PAL 2	1,200	-	963	**1,800**	(537)	1.56
PAL 3	1,465	-	963	**2,198**	(868)	1.90
PAL 4	1,926	-	963	**2,835**	(1,400)	2.45
			Ticketing/Departures Level			
Baseline	796	107	1,282	**1,550**	(268)	1.21
PAL 1	947	142	1,282	**1,847**	(565)	1.44
PAL 2	1,131	154	1,282	**2,209**	(927)	1.72
PAL 3	1,382	188	1,282	**2,699**	(1,417)	2.10
PAL 4	1,620	220	1,282	**3,163**	(1,881)	2.47

Source: Gresham, Smith & Partners, Inc., 2012.

The following assumptions and methodologies have been utilized to determine curbside requirements:

- Assumptions:
  - Vehicle Distribution by Level – The total peak hour vehicle quantities referenced in Chapter 2 have been divided and distributed by curbside levels as follows:
    - Ground Transportation: 13 percent of total peak hour vehicles.
    - Baggage Claim/Arrivals: 42 percent of total peak hour vehicles.
    - Ticketing/Departures: 45 percent of total peak hour vehicles.
  - Vehicle Type Distribution by Curbside Location – Using each peak hour vehicle total from individual curbsides, the vehicles have been divided by vehicle type: POV, taxi cab, limousine, shuttle vehicles and motor coaches.
    - Ground Transportation: POV = 0 percent, Commercial = 100 percent
      - Taxi Cab = 70 percent
      - Limousine = 5 percent
      - Shuttles/Motor Coaches = 25 percent
    - Baggage Claim/Arrivals: POV = 100 percent, Commercial = 0 percent
    - Ticketing/Departures: POV = 88 percent, Commercial = 12 percent
      - Taxi Cab = 70 percent of commercial vehicle total
      - Limousine = 5 percent of commercial vehicle total
      - MNAA Parking Shuttle = 25 percent of commercial vehicle total
  - Stall Lengths Considered:
    - POV = 25 feet
    - Taxi = 25 feet
    - Limousine = 30 feet
    - Shuttles = 30 feet
    - Buses/Motor Coaches = 50 feet
- Methodology:
  - Required Curbside Capacity – Based on the 60-minute peak vehicle demand quantities.
- Curbside linear length requirements: Peak Hour Vehicles x Dwell Time x Vehicle Stall LengthThis curbside capacity calculation is applied to each individual vehicle type per curbside level, with the total curbside requirement at each level being determined by the sum of each vehicles linear curbside requirement.

3.7.6 Future Ground Transportation Center

As noted in **Table 3-36**, deficiencies have been identified in all 3 curbside levels with regard to the required linear frontage lengths. While the Ticketing Level curbside, and to some degree the Ground Transportation curbsides, have the ability for double-parking, effectively increasing the available curbside length to address future deficits, the Baggage Claim curbside is more limited in this capacity. The curbside congestion relative to the curb configurations and traffic patterns associated with POVs picking up arriving passengers, as well as MNAA parking shuttles, creates peak hour traffic congestion that impacts both the Ground Transportation Level vehicles accessing the lower roadway and Ticketing/Departures Level vehicles accessing the upper roadway.

As enplanements increase throughout the planning period, vehicle inventories and related curbside frontage demand requirements increase as well. In combination with creating additional usable curbside frontage, consideration should be given to the creation of a Ground Transportation Center, beginning with the current planning period. A Ground Transportation Center would create a centralized location for all commercial vehicles to either pick-up or drop-off passengers, removing these vehicle types from the various curbsides and roadways. In doing so, each curbside capacity would be dedicated to POV traffic, reducing commercial vehicle traffic related congestion and creating additional curbside access and capacity for POVs.

3.8 Support Facility Requirements

A review of existing and future support facilities is necessary to identify any additional facilities that would be needed over the 20-year planning period.

3.8.1 General Aviation Facilities

GA comprises all civil aviation activities except commercial airline service. GA includes a wide variety of activities such as recreational flying, flight training, sightseeing, aerial patrol, filming and photography, utility/construction support, electronic news gathering, law enforcement, aerial ambulance, and corporate flying. GA aircraft range from single- and multi-engine piston aircraft to corporate jets, helicopters, and other types of aircraft. GA has a strong presence at BNA, representing approximately 25 percent of total annual Airport operations. Most of the GA facilities at BNA, including hangars, office space, and fuel facilities, are operated by private companies. Based on the analysis completed in Chapter 2, GA operations are anticipated to reach approximately 67,670 by 2031. This accounts for an average annual growth rate of 2.1 percent.

3.8.1.1 Fixed Base Operators

There are currently 2 fixed-base operators (FBOs) at the Airport: Signature Flight Support and Atlantic Aviation. Both FBOs are located in the GA area. Airfield access to both FBOs is available via Taxiways T4, U, and K. Vehicle access is available via Hangar Lane. The FBOs and aviation support businesses in this area provide a wide range of GA services, including aircraft fueling, airframe and engine repair, ramp parking and tie downs, ground handling, aircraft storage hangars, pilot amenities, and avionics repair.

3.8.1.2 General Aviation Aircraft Storage Requirements

Aircraft storage demand is highly dependent upon the type of aviation activity an airport experiences. In addition to commercial service operations, BNA facilitates a high level of corporate and business GA activity. Therefore, conventional hangars capable of storing small- to medium-size jet aircraft comprise the majority of on-Airport aircraft storage.

Aircraft storage space requirements, based upon FBO-provided information, were applied to the based aircraft fleet mix presented in Chapter 2 to evaluate BNA GA aircraft storage demand. **Table 3-37** presents the forecast BNA based aircraft fleet mix. **Table 3-38** depicts existing and projected aircraft storage demand throughout the forecast period.

Table 3-37 – BNA-Based Aircraft Fleet Mix

	Baseline	PAL 1	PAL 2	PAL 3	PAL 4
Single-Engine Piston	18	18	19	20	22
Multi-Engine Piston	25	25	25	24	24
Turbo-Prop	15	17	18	20	23
Jet	41	52	67	86	108
Rotorcraft	2	2	3	3	4
Total	**101**	**114**	**132**	**153**	**181**

Note: Excludes based military aircraft.
Source: RW Armstrong, 2012.

Table 3-38 – BNA-Based Aircraft Storage Requirements

	Aircraft Hangar Space Requirement[1]	Baseline	PAL 1	PAL 2	PAL 3	PAL 4
Single-Engine Piston	1,600	-	28,800	30,400	32,000	35,200
Multi-Engine Piston	1,600	-	40,000	40,000	38,400	38,400
Turbo-Prop	3,800	-	64,600	68,400	76,000	87,400
Jet	7,400	-	384,800	495,800	636,400	799,200
Rotorcraft	1,600	-	3,200	4,800	4,800	6,400
Public Hangar Requirement		168,060	172,060	211,000	259,910	318,980
Private Hangar Requirement		335,220	349,340	428,400	527,690	647,620
Total		**503,280**	**521,400**	**639,400**	**787,600**	**966,600**

1 - Numbers are in square feet per aircraft.
Source: RW Armstrong, 2012

BNA currently has a total of approximately 503,280 square feet of aircraft storage hangar space on the Airport. Of that total, approximately 168,060 square feet (33 percent) consists of public hangar space, and approximately 335,220 square feet (67 percent) consists of private hangar space. According to MNAA, it is reasonable to assume that the ratio of public/private hangar space (33 percent and 67 percent, respectively) will remain fairly constant throughout the planning period. With this assumption, it is anticipated that additional hangar space, both public and private, will be required between the baseline year (existing conditions) and the end of PAL 1.

According to the FBOs, all hangars are currently operating at full capacity. In addition, the MNAA has indicated that occasional requests are received for the development of additional public/private hangar space. However, due to topographical constraints, developing vacant property in and around the Airport is very expensive. Nevertheless, additional public/private hangar space is recommended between the baseline year (existing conditions) and the end of PAL 1. Chapter 5 will present potential public/private hangar development locations, should developers decide to construct additional corporate hangar space at the Airport.

3.8.2 Air Cargo Facilities

BNA has processing facilities for air cargo arriving and departing via both passenger airline freight and all-cargo aircraft. The air freight facility (Building 4321) in the main terminal complex area is for passenger airline freight and is conveniently located for transporting air freight to and from passenger aircraft. The facility has approximately 39,960 square feet of enclosed space, although not all of it is currently used for freight-related purposes.

The primary all-cargo facilities (Air Cargo Terminals One and Two) are on the west side of the Airport. The Air Cargo Terminal One facility (Building 4106) is approximately 116,000 square feet and is located along the West Side Apron-South, which consists of approximately 428,000 square feet of pavement. The Air Cargo Terminal Two facility (Building 4143) is approximately 34,500 square feet and is located along the West Side Apron-North, which is made up of approximately 1.37 million total square feet of pavement. The West Side Apron-North is used by several additional facilities, including Building 4144 (approximately 90,000 square feet), which supports scheduled FedEx cargo service and Embraer’s hangars (Buildings 4140, 4141, and 4142). Of the 1.37 million square feet of apron, only about 332,000 square feet of the North Cargo Apron pavement is used for air cargo carrier parking, while the remaining pavement is used for Embraer operations (approximately 324,000 square feet) and aircraft movement.

3.8.2.1 Air Cargo Building Requirements

Air cargo building requirements are typically a function of projected cargo volume. The air cargo building must have sufficient space to accommodate consolidating outbound freight and breaking down, sorting and loading inbound freight onto individual trucks. These processes may require short-term storage of cargo while awaiting additional material for consolidation, aircraft arrival/departure, and truck arrival/departure.

In 2011, there were 2,640 all-cargo carrier operations at BNA. These all-cargo carrier operations, in conjunction with passenger carrier air-freight, moved 45,000 tons of cargo during the year. As noted in **Table 3-39**, both air cargo operations and total air cargo volume (enplaned and deplaned) is anticipated to increase nearly 52 percent during the planning period.

Cargo building utilization rate is generally a factor used in developing projected building space required for cargo operations. The cargo utilization rate is calculated by dividing cargo volume by the available cargo processing space. The resulting quotient is a measure of cargo tons per square foot. Utilization rates can fluctuate based on the amount of cargo volume processed and the addition or removal of available cargo processing space.

Table 3-39 – BNA Air Cargo Forecast Summary

PAL	Annual Operations	Total Cargo Volume (Tons)
Baseline	2,640	45,000
PAL 1	2,940	49,950
PAL 2	3,260	55,430
PAL 3	3,610	61,500
PAL 4	4,010	68,230
2011-2031 Growth	**51.9%**	**51.6%**

Source: RW Armstrong, 2012.

During historic peak cargo operations, BNA experienced cargo building utilization rates between 0.26 and 0.36 cargo tons per square foot. The current utilization rate, however, has declined to 0.16 tons per square foot. This drop in utilization is likely the result of a significant loss in processed cargo volume since China Airlines ceased BNA operations in 2009.[1]

Despite the current decline in cargo building utilization, BNA air cargo volume is anticipated to rebound to near historic levels by PAL 4. Therefore, the 2007 BNA cargo building utilization rate of 0.26 tons per square foot was used to calculate the amount of recommended future air cargo building space shown in **Table 3-40**. Additionally, anticipated cargo truck parking and circulation space was quantified using a planning factor of 50 percent of the projected air cargo building space.

[1] China Airlines transported an average of approximately 52 tons of cargo per operation at BNA.

Table 3-40 – BNA Air Cargo Building and Vehicle Circulation Requirements

	Baseline	PAL 1	PAL 2	PAL 3	PAL 4
Air Cargo Building Space	173,080	192,120	213,190	236,540	262,420
Cargo Truck Parking and Circulation	86,540	96,060	106,600	118,270	131,210
Total	**259,620**	**288,180**	**319,790**	**354,810**	**393,630**

Note: Numbers are in square feet.
Source: RW Armstrong, 2012.

Between the air freight facility (39,960 square feet), Air Cargo Terminal One (116,000 square feet), Air Cargo Terminal Two (34,500 square feet), and Building 4144 (90,000 square feet), the Airport has approximately 280,500 total square feet of air cargo processing space available. According to projected space requirements, BNA has sufficient building and apron space to accommodate future air cargo demand.

According to the MNAA, Air Cargo Terminal One was constructed in 1970. Therefore, this building may require maintenance and/or replacement as the cargo utilization rate increases throughout the planning period.

3.8.3 Military Facilities

The Tennessee Air National Guard’s 118th Airlift Wing is stationed at BNA along the south portion of the airfield. Facilities include the headquarters and administration building, operations building, civil engineering facility, aircraft maintenance hangars, recreational facilities, and engine shops.

The Tennessee Air National Guard recently announced that military facilities at BNA will begin supporting Tennessee Army National Guard operations. As a result of this change in mission, the fleet of C-130 aircraft currently based at BNA will be transferred to other military installations. The Tennessee Army National Guard, however, has indicated that one twin-engine turbo-prop (C-12) aircraft and 19 rotorcraft (4 Lakotas and 15 Blackhawks) will be based at BNA.

Ongoing discussions with both the Tennessee Air and Army National Guard, coupled with the *BNA Military Installation Plan* (2010), will seek to ensure that existing facilities remain sufficient for current and future military operations.

3.8.4 Aircraft Deicing Facilities

Aircraft icing, or frozen contaminants on an aircraft, can cause severe hazards due to uneven airflow over the leading edge of the control surfaces. To prevent icing, it is common practice to treat aircraft with a deicing agent, such as propylene glycol, prior to takeoff. Since most deicing agents used today can be toxic to the environment, airports are required to obtain stormwater discharge permits and ensure that deicing runoff is properly collected and treated prior to discharge.

3.8.4.1 Aircraft Deicing Areas

Aircraft deicing at BNA is generally conducted via the centralized aircraft deicing method. The centralized method typically occurs on designated aircraft deicing pads or aprons away from the terminal gates and generally requires less holdover time since the aircraft is closer to the departure area.[2] Decentralized aircraft deicing typically occurs at the terminal gates. Holdover time must be lengthened when performing decentralized deicing due to the taxi distance from the gate to the runway.

According to the *BNA Snow and Ice Control Plan* (2011 – 2012), there are 3 designated pavement areas capable of supporting centralized deicing: the Southwest Airlines remote deicing area (111,310 square feet), the American Airlines remote deicing area (68,600 square feet), and the terminal north apron area (129,850 square feet), totaling 309,760 square feet. Although the majority of aircraft deicing activities occur on the centralized deicing areas, there is approximately 1.3 million square feet of pavement surrounding the terminal building capable of supporting decentralized aircraft deicing.

This evaluation projected aircraft deicing operations/positions required to perform centralized deicing, along with total apron area requirements. Although aircraft deicing at BNA is a seasonal operation, peak hour departures were used to determine the maximum number of projected aircraft deicing operations within the planning period. **Table 3-41** shows the number of peak hour BNA departures by aircraft type.

Table 3-41 – BNA Peak Hour Departures by Aircraft Type

Aircraft Type	Baseline	PAL 1	PAL 2	PAL 3	PAL 4
Narrowbody	13	17	19	22	25
Large RJ (over 70 seats)	2	3	5	6	7
Medium RJ (70 seats)	1	4	6	5	6
Small RJ (under 70 seats)	8	3	-	-	-
Total Departures	**24**	**27**	**30**	**33**	**38**

Note: Includes air cargo operations.
Source: RW Armstrong, 2012.

It is important to note that in addition to commercial air carrier operations, the peak hour departures by aircraft type include air cargo operations requiring aircraft deicing. Although

[2] Deicing holdover time is the length of time an aircraft can remain on the ground before deicing agent must be reapplied prior to takeoff.

some GA aircraft also require deicing during seasonal periods, that percentage is considered a nominal value when evaluating peak hour deicing demand.

Using a planning factor of 20 minutes per deicing operation for narrowbody aircraft and 15 minutes per deicing operation for regional jet aircraft, it is assumed that a deicing throughput of 3 narrowbody aircraft or 4 regional jet aircraft can be processed within a one-hour timeframe per each deicing position. As shown in **Table 3-42**, it is projected that a maximum of 11 deicing operations/positions will occur/be required by PAL 4.

Table 3-42 – BNA Peak Hour Deicing Operations

Aircraft Type	Deicing Time (Min.)	Aircraft Deicing Throughput/ Hour	Baseline	PAL 1	PAL 2	PAL 3	PAL 4
Narrowbody	20	3	4	5	6	7	8
Large RJ (over 70 seats)	15	4	1	1	1	1	2
Medium RJ (70 seats)	15	4	1	1	1	1	1
Small RJ (under 70 seats)	15	4	2	1	-	-	-
Peak Hour Deicing Operations			**8**	**8**	**8**	**9**	**11**
Required Deicing Pavement (square feet)			**276,000**	**276,000**	**276,000**	**310,500**	**379,500**

Source: RW Armstrong, 2012.

Using an aircraft apron space requirement of 34,500 square feet,[3] it is anticipated that a total of 379,500 square feet of apron pavement will be required during the peak hour period for aircraft deicing by PAL 4.

As mentioned previously, a total of approximately 309,760 square feet of apron pavement is currently designated for centralized aircraft deicing. As the number of BNA aircraft operations increase throughout the planning period, centralized aircraft deicing will likely continue to remain the preferred method of deicing, as it reduces the length of time an aircraft must remain at the gate. Therefore, additional centralized deicing space is anticipated to be warranted by PAL 4.

Currently, aircraft deicing is prohibited on all pavement outside of the designated terminal areas. Therefore, all air cargo and GA aircraft requiring deicing must taxi to either the terminal north apron or the American Airlines deicing areas. Discussions with the MNAA have indicated the desire for aircraft deicing capability in the west side and GA areas. Therefore, it is recommended that additional aircraft deicing areas be constructed in the air cargo and/or GA apron areas.

[3] The aircraft apron space requirement of 34,500 square feet is based on the aircraft within the BNA fleet mix with the greatest wingspan and length (DC-10) plus a 25-foot buffer for movement of deicing equipment.

3.8.4.2 Aircraft Deicing Storage

Additionally, Chapter 1 lists the existing on-Airport aircraft deicing agent storage capacity. According to the MNAA, 33,000 gallons of aircraft deicing agent is stored in 6 different storage units on the Airport. For the purposes of evaluating future deicing agent storage requirements, it is assumed that a total of 1,000 gallons of deicing agent is dispensed per each aircraft deicing operation, resulting in a total dispense of 11,000 gallons of deicing agent per peak hour. Since the peak hour represents the maximum number of departures, it is assumed there are fewer departures throughout the remainder of the day; especially during night hours. Therefore, existing deicing storage capacity is anticipated to remain sufficient for the peak hour demand.

3.8.5 MNAA Maintenance Facilities

MNAA maintenance facilities are located throughout portions of the Airport terminal building, the Consolidated Service Facility (Building 4351), and on the west side of the Airport. Specifically, maintenance functions located on the west side include AFEL, Grounds, Mobile Equipment and Welding, Procurement, and Material Controls.

The MNAA Westside maintenance buildings are nearing their useful life and the MNAA maintenance areas located under the International Arrivals building are inefficient; therefore, it is recommended, where applicable, that MNAA maintenance functions be consolidated into the Consolidated Service Facility.

3.8.6 Aircraft Maintenance Facilities

Multiple aircraft maintenance facilities are located at the Airport. The FBOs provide maintenance service to GA aircraft in addition to several private maintenance providers. Embraer also provides maintenance services at its facilities (Buildings 4140 and 4141).

According to the MNAA, Embraer has indicated a desire for expansion to accommodate existing and future aircraft maintenance requirements and is currently working toward the construction of 2 temporary hangars located on the West Side Apron-North. Chapter 5 will further identify potential areas capable of accommodating this expansion.

3.8.7 Ground Support Equipment Facilities

BNA Ground Support Equipment (GSE) maintenance facilities are comprised of various areas dedicated to specific capacities including vehicle storage locations, offices, maintenance shops, and several storage centers for supplies and liquids/chemicals needed for day-to-day activities at the Airport.

The BNA GSE facilities are located in buildings dispersed throughout the terminal and airfield area. The largest GSE facility is a large multipurpose building south of the terminal building (Building 4323). This building largely houses airline-operated utility vehicles (i.e., aircraft tugs, baggage tugs/carts, deicers, etc.). Excess GSE equipment is stored in covered areas surrounding the terminal building. The airlines currently own and operate all GSE equipment for servicing aircraft. It is recommended this facility (Building 4323) be maintained throughout the planning period in order to accommodate the equipment.

3.8.8 Aviation Fueling Facilities

As described in Chapter 1, all fuel (both aviation and non-aviation) at the Airport is stored in several in-ground and above-ground fuel tanks. The terminal apron is equipped with an in-ground fuel hydrant system, which provides a direct connection between the hydrant pit valves and the aircraft fueling point through a vehicle or cart hydrant system. There are several fuel farms at the Airport with the collective capacity to hold more than 8,000,000 gallons of Jet-A and over 27,000 gallons of 100 Low-Lead aviation gas (AvGas).

It is important that on-Airport fuel reserves maintain sufficient capacity throughout the planning period. In order to determine future aircraft fueling requirements, the projected number of aircraft operations requiring Jet-A and Avgas were calculated using 2011 PMAD BNA operations data. As depicted in **Table 3-43** and **Table 3-44**, the projected number of Jet-A and AvGas operations were then multiplied to create a "gallons-per-operation" figure used to calculate a PMAD fuel consumption requirement and a 7-day fuel reserve requirement.

Table 3-43 – BNA Jet-A Fuel Requirements

	Unit	Baseline	PAL 1	PAL 2	PAL 3	PAL 4
Total Airport Operations	No.	174,994	204,590	227,330	252,620	280,950
Jet-A Operations	No.	168,270	197,140	219,070	243,460	270,780
Jet-A PMAD Operations	No.	490	570	630	700	780
Fuel per Jet-A Operation	Gal.	430	430	430	430	430
Fuel per PMAD Jet-A Operation	**Gal.**	**210,710**	**245,120**	**270,920**	**301,020**	**335,420**
Jet-A Fuel Reserve (Gallons)	**Gal.**	**1,474,970**	**1,715,840**	**1,896,440**	**2,107,140**	**2,347,940**

Source: RW Armstrong, 2012.

Table 3-44 – BNA AvGas (100LL) Fuel Requirements

	Unit	Baseline	PAL 1	PAL 2	PAL 3	PAL 4
Total Airport Operations	No.	174,994	204,590	227,330	252,620	280,950
AvGas Operations	No.	6,723	7,451	8,260	9,158	10,174
AvGas PMAD Operations	No.	19	23	25	28	31
Fuel per AvGas Operation	Gal.	14	14	14	14	14
Fuel per PMAD AvGas Operation	**Gal.**	**270**	**320**	**350**	**390**	**440**
AvGas Fuel Reserve	**Gal.**	**1,890**	**2,240**	**2,450**	**2,730**	**3,080**

Source: RW Armstrong, 2012.

As a general planning factor, a 7-day reserve fuel supply is assumed to be adequate during the course of the forecast period. Although routine maintenance may be required due to the age of the system, as noted on both fuel requirement tables, the existing BNA fuel capacity and storage are sufficient to supply the fuel demand throughout the forecast period.

3.8.9 Aircraft Rescue and Firefighting

As documented in Chapter 1, the Airport's required level of Aircraft Rescue and Firefighting (ARFF) service is currently Index C. This indexing provides a general assumption about the size of aircraft that could be involved in an incident and the number and capacity of firefighting agents that would be required of the response vehicles. Based on current and future passenger aircraft fleet mix composition projections, the Airport's existing ARFF Index of C is anticipated to remain sufficient throughout the planning period.

3.8.9.1 Aircraft Rescue and Firefighting Facilities

Federal Aviation Regulation (FAR) Part 139 requires a minimum response time of 3 minutes from the time of an alarm to the arrival of the first ARFF vehicle at the midpoint of the farthest runway serving air carrier aircraft, and 4 minutes for the remaining rescue vehicles.

The current Airport's ARFF facility (Building 4334) is located at the BNA Department of Public Safety (DPS) facility, south of the terminal area. This location allows all firefighting equipment and vehicles to access any airfield pavement within the required time. However, the construction of additional runway capacity, such as the extension of Runway 2L or construction of a fourth parallel runway, would require an additional ARFF facility to meet the required response time. It is important to note that BNA's airfield facilities currently meet demand capacity; therefore, additional airfield capacity is not anticipated to be required during the planning period.

3.8.10 Air Traffic Facilities

The Air Traffic Control Tower (ATCT) (Building 4216) is located at 515 Olen Taylor Boulevard. Constructed in 1982, the building is used for Air Traffic Control, and contains administrative support offices and the Terminal Radar Approach Control (TRACON) facility. The land is leased from the MNAA, but the FAA owns the 191-foot tall (above ground level or AGL) building. There are approximately 40 automobile parking spaces that serve the ATCT. The tower is attended 24 hours a day throughout the year, during which time its staff controls air traffic in accordance with federal regulations.

It is anticipated that the BNA ATCT will reach the end of its useful life within the planning period and require replacement. Potential candidate replacement sites will be further investigated within the development concepts presented in Chapter 5.

3.9 Surface Transportation and Parking Requirements

The number of required parking spaces at an airport is directly related to annual enplaned passenger traffic levels. The following is an analysis of the public, employee and rental car parking space requirements throughout the planning period. Vehicle access to these parking facilities was also evaluated.

Table 3-45 presents a breakdown of the parking supply at the Airport in 2012.

Table 3-45 – BNA Parking Supply

Public Lots	Actual	Effective
Long Term A	2,060	1,854
Long Term B	2,124	1,912
Economy	3,690	3,321
Overflow	1,416	1,274
Short Term	2,396	2,156
Valet	1,152	1,037
South Lot (Valet Staging)	173	156
Total	13,011	11,710
Employee[1]		
Total	1,885	1,697
RAC, CONRAC, Ready/Return Parking		
Total	2,400	2,160
Private Off-Airport		
Total	3,020	2,718
Grand Total	**20,316**	**18,284**

1 - Includes the FIS Building and MNAA maintenance.
Source: MNAA, 2012.

There is a total of 17,296 parking spaces at the Airport, of which, 13,011 (75 percent) were public parking spaces and 4,285 (25 percent) were designated nonpublic spaces (Rental Cars and Employees). The table also presents the effective supply. Effective supply is 90 percent of actual supply to account for parking contingencies, including vacancies resulting from improperly parked vehicles, maintenance work and parking spaces for circulating traffic.

In addition to the on-Airport parking supply, 4 private off-Airport operators offer approximately 3,020 parking spaces to the public.

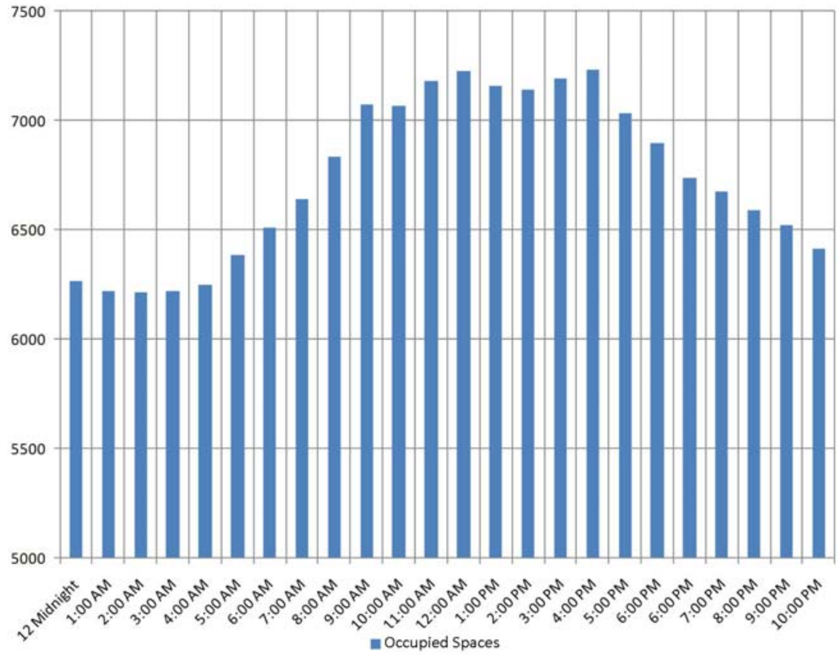
3.9.1 Public Parking Demand

Public parking demand is the number of spaces required during peak parking periods. Public parking demand at an airport is a direct function of airline passenger activity. Since 2006, the month of October has consistently had the highest number of occupied parking spaces. Furthermore, October 9, 2010, had the highest peak occupancy and, therefore, is the peak parking day for the peak month from which the subsequent parking demand ratio was developed. Although this day is not the absolute peak parking demand, it represents the number of occupied spaces on all but a few abnormally peak parking days.

It is important to note that even though connecting enplanements do not generate parking demand, the parking demand ratio is based on total annual enplanements rather than origin and destination enplanements, assuming the ratio of originating to connecting enplanements remains the same throughout the planning period. The forecast suggests that the percentage of connecting passengers will continue to be small and proportionally the same as the current percentage. Therefore, the parking demand ratio using total enplanements is considered valid for projecting future parking demand throughout the planning period.

Figure 3-6 illustrates the total number of occupied spaces on October 9, 2010 (excluding valet parking). The peak parking demand occurred at noon with 7,228 occupied self-park spaces. When valet parking demand is included, the total public parking demand is 8,228 spaces on the design day. In 2010, there were more than 4 million enplaned passengers. Based on the Airport parking demand of 8,228 spaces, the parking demand ratio is approximately 1.81 spaces per 1,000 annual enplanements. If private off-Airport parking demand is factored in, the public parking demand ratio is 2.27 spaces per thousand annual enplanements.

Figure 3-6 – Peak Parking Demand (October 9, 2010)



Source: MNAA, Albersman & Armstrong Ltd., 2012.

The future on-Airport parking demand will depend, in part, on the off-Airport parking supply component. The following is an analysis of 3 potential parking scenarios

3.9.2 Future Parking Demand

Table 3-46 presents an estimate of existing parking demand. This estimate includes both on- and off-Airport parking demand. Currently the on-Airport effective public parking supply is 11,710 spaces and the on-Airport public parking demand is 8,700 spaces.

Table 3-46 – On- and Off-Airport Parking Demand

On-Airport	
Ratio	1.81
Demand	8,700
Off-Airport	
Ratio	0.46
Demand	2,211
Total	
Ratio	2.27
Demand	10,911

Note: Ratio is 1.81 in 2011 and 2.27 spaces/1,000 enplanements thereafter.
Source: Albersman & Armstrong Ltd., 2012.

3.9.2.1 Parking Demand Scenario 1

In this scenario, the Airport aggressively competes with off-Airport parking resulting in an increase in demand for on-Airport parking. With these results presented in **Table 3-47**, the existing on-Airport parking supply is insufficient for the projected PAL 1 parking demand.

Table 3-47 – Parking Demand Scenario 1

PAL	Enplanements[1]	On-Airport[2]	Off-Airport[3]	Total
Baseline	4,806,092	8,700	2,211	**10,911**
PAL 1	5,835,700	13,247	-	**13,247**
PAL 2	6,929,300	15,730	-	**15,730**
PAL 3	8,190,000	18,591	-	**18,591**
PAL 4	9,658,600	21,925	-	**21,925**

1 - RW Armstrong, 2012.
2 - Based on 1.81 in 2011 and 2.27 spaces/1,000 enplanements thereafter.
3 - Based on .46 spaces/1,000 enplanements in 2011.
Source: Albersman & Armstrong Ltd., 2012.

3.9.2.2 Parking Demand Scenario 2

In this scenario, shown in **Table 3-48**, the Airport is successful in deterring the growth of off-Airport parking, which remains constant at 2,211 spaces.

Table 3-48 – Parking Demand Scenario 2

PAL	Enplanements[1]	On-Airport[2]	Off-Airport[3]	Total
Baseline	4,806,892	8,700	2,211	**10,911**
PAL 1	5,835,700	11,036	2,211	**13,247**
PAL 2	6,929,300	13,518	2,211	**15,729**
PAL 3	8,190,000	16,380	2,211	**18,591**
PAL 4	9,658,600	19,714	2,211	**21,925**

1 - RW Armstrong, 2012.
2 - Based on 1.81 in 2011 and 2.27 spaces/1,000 enplanements thereafter.
3 - Based on .46 spaces/1,000 enplanements in 2011.
Source: Albersman & Armstrong Ltd., 2012.3

3.9.2.3 Parking Demand Scenario 3

In this scenario, shown in **Table 3-49**, off-Airport parking demand grows at the same rate as overall parking demand.

Table 3-49 – Parking Demand Scenario 3

PAL	Enplanements[1]	On-Airport[2]	Off-Airport[3]	Total
Baseline	4,806,092	8,700	2,211	**10,911**
PAL 1	5,835,700	10,563	2,684	**13,247**
PAL 2	6,929,300	12,542	3,187	**15,730**
PAL 3	8,190,000	14,824	3,767	**18,591**
PAL 4	9,658,600	17,482	4,443	**21,925**

1 - RW Armstrong, 2012.
2 - Based on 1.81 in 2011 and 2.27 spaces/1,000 enplanements thereafter.
3 - Based on .46 spaces/1,000 enplanements in 2011.
Source: Albersman & Armstrong Ltd., 2012.

3.9.2.4 Preferred Parking Demand Scenario

It is unlikely that the Airport will completely capture all off-Airport business. However, it is plausible the Airport will realign the on-Airport parking system in a manner that stems the growth of off-Airport parking. Therefore, Scenario 2 (off-Airport parking remains stable) is the likely scenario and will be carried forward as the preferred scenario for this analysis.

3.9.3 Parking User Groups

There are typically 3 basic parking user groups at airports: short-term parkers, premium long-term parkers, and economy parkers.

3.9.3.1 Short-Term Parkers

Short-term parkers generally consist of meeters/greeters. This is the largest parking user group at the Airport, encompassing 63 percent of all parkers. Due to the relatively high turnover, the number of parking spaces required is typically 10 to 20 percent of the Airport's total parking spaces. Short-term parking demand was calculated based on the accumulation of parking data during the daytime hours of the design day compared to the overnight inventory. On the design day (2010), the peak occupancy was 7,229 while the overnight inventory was 6,219 (occupied spaces; see Figure 3-6). Additionally, there were 1,000 valet parkers. Assuming 25 percent of the valet parkers were also short-term parkers, the percent of total parking demand that can be attributed to short-term parking in 2010 was 15 percent, or 1,260 parkers.

3.9.3.2 Long-Term and Premium Long-Term Parkers

The remaining 83 percent of parking demand is associated with long-term parkers, which includes premium long-term parkers and economy parkers. Premium long-term parkers are those willing to pay more for the added convenience of parking near the terminal building (i.e., valet parking). In general, premium long-term parkers are often associated with business trips.

For the purposes of this evaluation, premium long-term parking is also considered parking that is within walking-distance of the terminal building.

Economy parkers are those willing to allow some inconvenience for cost savings. Economy parkers are the most likely parkers to be lured to less expensive private off-Airport parking facilities.

In order to estimate the split of long-term parkers and premium and economy parkers, it was assumed that all long-term parkers using long-term Lot A, the short-term parking garage, and those using valet parking are premium long-term parkers. The overnight inventory on the design day (2010) in the garage was approximately 576. The overnight inventory in long-term lot A was 1,282 spaces. It was further assumed that 750 of the 1,000 valet spaces are part of the long-term parking demand. Therefore, the estimated premium long-term parking demand is 2,608, or 36 percent of total parking demand.

3.9.3.3 Economy Parkers

Economy parking demand was estimated by subtracting short-term and premium long-term parking demand from total parking demand. Based on this approach, the estimated economy parking demand in 2010 was 4,361 spaces, or 53 percent of total on-Airport parking demand.

3.9.3.4 Parking User Group Summary

Table 3-50 presents an analysis summary of the 3 primary user groups. Future parking alternatives will consider the configuration and size of facilities required to satisfy these parkers.

Table 3-50 – Parking User Group Summary

Lot	On-Airport Demand	Percent	Off-Airport Demand	Percent	Total	
Short-Term	1,305	15%	-	-	**1,309**	**12%**
Premium Long-Term[1]	2,784	32%	-	-	**2,728**	**25%**
Economy	4,611	53%	2,211	100%	**6,874**	**63%**
Total	**8,700**	**100%**	**2,211**	**100%**	**10,911**	**100%**

1 - Premium long-term parking is considered parking within short walking-distance of the terminal.
Source: Albersman & Armstrong Ltd., 2012.

3.9.3.5 Public Parking Supply and Demand Projections

Table 3-51 presents the results of the preferred analysis established in Scenario 2, which assumes the Airport will implement policies and procedures that will halt the growth of off-Airport parking and facilitate future growth of on-Airport parking demand. Such policies and procedures could include implementing a concession fee for off-Airport parking providers, improving on-Airport customer service, or adjusting parking rates to compete directly with off-Airport parking providers. Based on this approach, the existing parking supply has the capacity to satisfy parking demand through PAL 2, at which time additional parking is anticipated to be required.

Table 3-51 – Parking Supply and Demand

PAL	Enplanements[1]	On-Airport Demand[2]	Off-Airport Demand	Effective Supply[3]	Surplus/(Deficit)
Baseline	4,806,892	8,699	2,211	14,428	5,729
PAL 1	5,835,700	13,247	2,211	14,428	1,181
PAL 2	6,929,300	15,730	2,211	14,428	(1,302)
PAL 3	8,190,000	18,591	2,211	14,428	(4,163)
PAL 4	9,658,600	21,925	2,211	14,428	(7,497)

1 - RW Armstrong, 2012.
2 - Based on 2.27 spaces per 1,000 enplanements.
3 - 2012 Parking supply (includes on- and off-airport).
Source: Albersman & Armstrong Ltd., 2012.

3.9.4 Projected Employee Parking Demand

In 2011, the Airport provided 1,885 employee parking spaces for a total of 1,710 users. Of the employee parking spaces, 288 were reserved for commuters, 832 were reserved for airline employees, and 590 were reserved for concessionaires. Based on occupancy counts from aerial imagery dated August 1, 2011, the current employee parking demand, as shown in **Table 3-52**, is 953 spaces.

Table 3-52 – Employee Parking Supply and Occupancy

Lot	Supply	Demand
Employee Lot	1,189	**797**
R1 Lot	212	**140**
R2 Lot	73	**17**
Total	**1,474**	**953**

Source: Occupancy counts from Google Earth Pro – Imagery dated August 1, 2011, Albersman & Armstrong Ltd., 2012.

To account for increases during shift changes, holiday, and other peak periods, the demand number was increased by 20 percent. These numbers were then increased at the same rate as the projected enplanements to achieve the anticipated employee parking demand shown in **Table 3-53**.

Table 3-53 – Projected Employee Parking Demand

	Baseline	PAL 1	PAL 2	PAL 3	PAL 4
Annual Enplanements	4,806,092	5,835,700	6,929,300	8,190,000	9,658,600
Percent Increase	20%	21%	19%	18%	18%
Projected Employee Parking Demand	1,144	1,388	1,649	1,949	2,298
Employee Parking Adequacy – Surplus/(Deficit)	741	496	236	(64)	(414)

Source: Albersman & Armstrong Ltd., 2012.

The assessment of the projected employee parking demand shows a need for additional employee parking spaces by PAL 3.

3.9.5 Projected Rental Car Demand

3.9.5.1 Rental Car Facilities

The new CONRAC is located adjacent to the terminal, north of the parking garage, and contains 2,400 ready and return car spaces on 3 levels. The quick-turn-around (QTA) facility is at grade level, adjacent to, and north of the ready and return car parking. The QTA consists of 10 car wash bays, 54 fueling positions, and queuing for about 240 vehicles. One supported level over the QTA area is used for storage of about 600 rental cars. Additionally, there is 17.5 acres of storage in the remote service center sites, and additional storage located between Concourse D and the air freight facility.

The existing QTA facilities have the capacity to service the entire ready and return parking facility within a day (e.g., 2,400 cars could be washed within 8 hours and serviced within 9 hours). Therefore the existing QTA, like the ready and return car parking, will likely satisfy the needs of the rental car market through the planning period. **Table 3-54** depicts the QTA's vehicle processing capability.

Table 3-54 – QTA Vehicle Processing

QTA Facility	Number of Facilities	Vehicle Processing Rate / Hour	Hourly Vehicle Capacity
Car Washes	10	30	300
Fueling Positions	54	5	270

Source: Albersman & Armstrong Ltd., 2012.

3.9.5.2 Ready and Return Car Parking

The demand for rental cars grows as a function of enplanements. As airline traffic increases, the area required to park rental cars also increases. However, the size of the ready and return car parking area does not necessarily increase correspondingly. As rental car demand increases, the rental car agencies will increase shuttling between the service center sites and the ready and return car area. Because of this dynamic, the range in the size of ready and return car parking areas varies significantly from airport to airport.

As an example, John Wayne-Orange County Airport (SNA) in Orange County, California has a slightly larger rental car market, but has a ready and return car parking area half the size of the ready and return car area at BNA. The ready and return area at the Minneapolis-St. Paul International Airport (MSP) is 27 percent smaller than BNA, but its market is 50 percent larger (**Table 3-55**). Note that those airports with rental car markets more than double the BNA market have recently opened consolidated rental car facilities that are sized to accommodate future growth for an additional 10 to 20 years.

It is anticipated that the BNA ready and return car parking area could satisfy the needs of the rental car market through the planning period. Furthermore, it may be possible to convert the vehicle storage (4 to 5 acres) above the QTA to ready and return car parking in order to expand the ready and return car parking at a future date.

Table 3-55 – Ready and Return Car Parking Comparison

Airport	% of BNA Market	Ready / Return Acres
Cleveland-Hopkins International (CLE)	69%	18
Sacramento International (SMF)	83%	7
Kansas City International (MCI)	85%	NA
Nashville International (BNA)	**100%**	**22**
John Wayne-Orange County (SNA)	106%	11
Raleigh-Durham International (RDU)	114%	N/A
Metropolitan Oakland International (OAK)	118%	11
Southwest Florida International (RSW)	132%	11
Minneapolis-St. Paul International (MSP)	151%	15
Baltimore/Washington International (BWI)	183%	27
Fort Lauderdale/Hollywood International (FLL)	229%	30
McCarran International (LAS)	231%	26

Source: Rental Car News, Albersman & Armstrong Ltd., 2012.

3.9.5.3 Total Rental Car Area

The total rental car area requirements include the area required for ready and return car parking, as well as vehicle storage, the QTA, the customer service building, and associated vehicle circulation. During the planning period, during which time passenger enplanements at BNA are projected to approximately double to 9,658,600 annual enplaned passengers, it is possible that the total area required for rental cars at the Airport will also double because of the increase in fleet size required to satisfy the rental car market. Based on airports with markets approximately twice that of BNA, it is anticipated that the total area required would increase from 45 acres to approximately 80 acres by the PAL 4, as shown in **Table 3-56**.

Table 3-56 – Rental Car Area Facility Requirements

Airport	% of BNA Market	Total Rental Car Acres
Cleveland-Hopkins International (CLE)	69%	42
Sacramento International (SMF)	83%	41
Kansas City International (MCI)	85%	66
Nashville International (BNA)	**100%**	**45**
Raleigh-Durham International (RDU)	114%	34
Metropolitan Oakland International (OAK)	118%	25
Southwest Florida International (RSW)	132%	59
Minneapolis-St. Paul International (MSP)	151%	47
Baltimore-Washington International (BWI)	183%	85
Fort Lauderdale/Hollywood International (FLL)	229%	80
McCarran International (LAS)	231%	87

Source: Rental Car News, Albersman & Armstrong, Ltd., 2012.

Table 3-57 summarizes the total space requirements. It is assumed that the deficits would be satisfied by increasing the size of the remote service and storage facilities. Development concepts presented in Chapter 5 will include this projected increase in size.

Table 3-57 – Rental Car Parking Demand Summary

PAL	Enplanements	Demand Acres	Supply Acres	Surplus/(Deficit) Acres
Baseline	4,806,092	45	45	-
PAL 1	5,835,700	52	45	(7)
PAL 2	6,929,300	60	45	(15)
PAL 3	8,190,000	69	45	(24)
PAL 4	9,658,600	80	45	(35)

Source: Albersman & Armstrong, Ltd., 2012.

Parking efficiency is defined as the number of square feet required per car. Parking efficiency for the various components of the BNA rental car facility varies significantly with function. Therefore, area requirements are expressed in acres rather than vehicle spaces. For example, the parking efficiency for public parking is approximately 350 square feet per vehicle while the parking efficiency in the ready and return area is approximately 400 square feet per vehicle. As a result, expressing rental car requirements in vehicle spaces would not provide the best measure of space requirements.

3.9.6 Projected Taxi Queue Demand

Taxis currently pick up arriving passengers on the ground transportation level. Taxis for departing passengers share the bus and parking shuttle lane on the ticketing level. The taxi queue (storage) is on the north side of the economy lot and has a capacity of approximately 40 taxi vehicles.

To achieve a reasonable estimate of appropriate queue size, the existing taxi queue capacity was compared to other airports of similar size in terms of enplanements. As shown in **Table 3-58**, BNA provides a similar amount of taxi queue space as Memphis (MEM), Milwaukee (MKE), Raleigh-Durham (RDU), Sacramento (SMF), and Houston-Hobby (HOU). Consequently, it is assumed the existing taxi queue at the Nashville International Airport is currently sized appropriately.

Table 3-58 – Taxi Queue Comparison

Airport	Enplanements	Queue Capacity
Portland-Hillsboro (HIO)	6,582,227	80
Lambert-St. Louis International (STL)	6,044,760	80
Charles B. Wheeler Downtown (MKC)	4,946,173	120
Memphis International (MEM)	4,930,935	55
Nashville International (BNA)	**4,806,092**	**40**
General Mitchell International (MKE)	4,760,170	40
Raleigh-Durham International (RDU)	4,465,736	40
Sacramento International (SMF)	4,424,279	45
Houston-Hobby (HOU)	4,357,835	35
John Wayne-Orange County (SNA)	4,278,623	60
Luis Munoz Marin International (TJSJ)	4,243,475	70

Source: Google Earth Pro, Individual Airport Websites, Albersman & Armstrong, Ltd., 2012.

For the purpose of this analysis, it was assumed that all available taxi queue spaces are occupied during the peak passenger hour. The existing supply of 40 spaces was used and increased at the same rate as the projected enplanements to achieve the projected taxi queue demand, as shown in **Table 3-59**. The assessment of taxi queue area requirements projects a shortage of only 9 spaces during PAL 1; however, it will need to double in size by PAL 4. Taxi queue development concepts, such as a potential GTC, will be presented in Chapter 5.

Table 3-59 – Projected Taxi Queue Demand

	Baseline	PAL 1	PAL 2	PAL 3	PAL 4
Annual Enplanements	4,806,092	5,835,700	6,929,300	8,190,000	9,658,600
Percent Increase	-	21%	19%	18%	18%
Projected Taxi Queue Demand	40	49	58	69	81
Taxi Queue Adequacy – Surplus/(Deficit)	-	(9)	(18)	(29)	(41)

Source: Albersman & Armstrong, Ltd., 2012.

3.9.7 Projected Cell Phone Lot Demand

Many airports have instituted cell phone lot waiting areas to allow meeters/greeters to park near the airport terminal and wait for their arriving party to call when they are ready for pick-up. However, the requirements for meeters/greeters using the cell phone lot can vary from airport to airport. For instance, some airports require drivers to remain in their vehicles while waiting while other airports may apply parking time limits implying drivers may leave their vehicles for a short period while using the cell phone lot. The results presented in **Table 3-60** show the available cell phone parking at other airports of similar size. This information suggests there is no standard for sizing of this type of parking option.

Table 3-60 – Cell Phone Lot Comparison

Airport	Enplanements	Capacity	Time Limit
Portland-Hillsboro (HIO)	6,582,227	30	30 Minutes
Lambert-St. Louis International (STL)	6,044,760	156	None
Kansas City International (MCI)	4,946,173	1,319	2 Hours
Memphis International (MEM)	4,930,935	26	None
Nashville International (BNA)	**4,806,092**	**49**	**None**
General Mitchell International (MKE)	4,760,170	30	30 Minutes
Raleigh-Durham International (RDU)	4,465,736	50	None
Sacramento International (SMF)	4,424,279	48	None
Houston-Hobby (HOU)	4,357,835	60	None
John Wayne-Orange County (SNA)	4,278,623	-	N/A
Luis Munoz Marin International (TJSJ)	4,243,475	-	N/A

Source: Google Earth Pro, Individual Airport Web Sites, Albersman & Armstrong, Ltd., 2012.

According to the MNAA, the cell phone lot was originally opened in 1999 with 20 spaces. It was expanded in 2010 in the current configuration to 49 spaces. The cell phone lot occupancy has been operating at or near capacity. Therefore, future parking demand was projected based on the current demand of 49 spaces, and increased at the same rate as the growth in enplanements to achieve the projected cell phone lot demand shown in **Table 3-61**. The assessment of cell phone lot demand projects a shortage of only 10 spaces by PAL 1. However demand capacity is anticipated to double by the end of the forecast period. Development concepts presented in Chapter 5 will include expanded cell phone lot options.

Table 3-61 – Projected Cell Phone Lot Demand

	Baseline	PAL 1	PAL 2	PAL 3	PAL 4
Annual Enplanements	4,806,092	5,835,700	6,929,300	8,190,000	9,658,600
Percent Increase	-	21%	19%	18%	18%
Projected Cell Phone Lot Demand	49	59	70	83	98
Cell Lot Adequacy – Surplus/(Deficit)	-	(10)	(21)	(34)	(49)

Source: Albersman & Armstrong Ltd., 2012.

3.10 Summary of Facility Requirements

Using accepted FAA and facility planning methodologies, the analyses presented in this chapter were designed to evaluate existing BNA facilities and the ability for each facility or area to accommodate future demand. Although general airport planning methodologies were used, unique characteristics related to the Airport were incorporated into the metrics to ensure the results of each evaluation were specific to BNA.

The following is a summary of the BNA facility requirement recommendations discussed in this chapter.

Airfield Recommendations

- Preserve ARC D-V infrastructure throughout planning period.
- Re-designate Runway 13/31 numbering to 14/32.
- Add additional shoulder width to Runways 2R/20L and 2C/20C to bring widths to 25 feet according to ARC D-IV criteria.
- Add paved shoulders on Runway 13/31 from the Runway 2L/20R intersection to the Runway 13 end.
- Extend Runway 20R blast pad by 50 feet and widen by 25 feet on both sides according to ARC D-IV criteria.
- Widen Runway 2L blast pad by 25 feet on both sides according to ARC D-IV criteria.
- Due to hot spots for runway incursions, consider reconfiguration of:
    - Taxiway T3, which connects the Taxiway B/K intersection to the Taxiway L/T4 intersection.
    - Taxiway R3 at the Taxiway A/K intersection.
    - Taxiways S7 and S6 adjacent to the Runway 20C approach end.

- Extend Taxiway K northwest to the Runway 13 end to remove the need for an aircraft to cross Runway 13/31 from Taxiway K to access the Runway 13 end.
- Construct additional GA apron by PAL 2.
- Consider extension of Runway 2L.
- Address taxiway intersection fillets that do not meet current FAA design standards. See Figure 3-4 for a depiction of these areas.
    - A1
    - A2
    - A4
    - Intersection of A and K
    - Intersection of A and L
    - B1
    - B2
    - B3
    - B4
    - Intersection of B and K
    - Intersection of B and L
    - H1
    - H6
    - Intersection of H and J
    - Intersection of H and L
    - L1
    - L2
    - L3
    - L7
    - L8
    - Intersection of L and Runway 2L/20R
    - K2
    - K3
    - K4
    - M
    - Intersection of N and B
    - R4
    - Intersection of S and Runway 2C end
    - B5
    - S1
    - S3
    - S4
    - S5
    - S6
    - S7
    - S8
    - Intersection of S and T4
    - Intersection of S and N
    - T1
    - T2
    - T3
    - T5
    - T6

Terminal Roadway Recommendations

- Add lane capacity within terminal area.
- Expand decision-making distance.
- Reduce or eliminate weaving.
- Remove congestion at intersections.
- Realign Donelson Pike to improve access, roadway movements, and parking expansion.

Gate and Terminal Space Recommendations

- Airline Space:
    - Reduce the amount of required agent assisted check-in positions.
    - Increase the amount of baggage check positions/locations.
    - Decrease the amount of self-service check-in kiosks.
    - Considerations for self-tagging baggage check-in.
    - Consider off-airport check-in locations.
    - Strategically locate self-service kiosks throughout the ticket lobby in order to assist in improving passenger processing times.
- Airline Gate and Hold Rooms
    - Review existing hold room layouts and areas to ensure maximum efficiencies and proper sizing.
    - Consider redistribution of hold room area to accommodate the recommended gate increase at PAL 4.
    - Consider future gate and hold room locations to ensure cohesiveness with existing air carrier relocation potential opportunities and introduction of new entrant air carriers throughout all concourses.
- Baggage Claim:
    - Consider additional baggage claim device by PAL 4.
    - Consider reconfiguration and area increase of the baggage claim lobby area to accommodate increased general circulation needs, baggage claim needs, and meeter/greeters.
- Baggage Make-up:
    - Consider increasing the baggage make-up areas to accommodate the processing of forecasted volume of outbound checked baggage.

  - Consider expanding the northern most make-up room. Coordination with aircraft parking limitations should be conducted.
  - Consider a phased approach for relocation of the concessions storage area and ramp offices to provide southward baggage make-up expansion.
- Public Space:
  - Consider additional functional area for meeters/greeters by PAL 2.
  - Consider additional circulation and restroom capacity to accommodate increased activity levels.
- Pre-Secure (Landside) Concessions:
  - Evaluate passenger and meeter/greeter behavior, as well as travel and security protocols, at each PAL to determine the need for and ability to support increased concessions offerings.
  - On the pre-secure side, consider placing an emphasis on the repurposing or reuse of existing space to accommodate increased concessions offerings.
- Post-Secure (Airside) Concessions:
  - Consider each existing and proposed concession location to maximize passenger satisfaction and Airport revenue-generating opportunities.
  - Consider anticipated concessions expansion away from the concourse to maintain current concourse circulation widths.
  - Consider the repurposing or reuse of existing space to accommodate new or expanded concessions offerings. Emphasis should be placed on maintaining existing concourse circulation widths.
- Security Checkpoint:
  - Consider expansion and growth of the checkpoint functional area to accommodate an additional 2-1 screening lane configuration once PAL 3 has been reached.
  - Review screening technologies and protocols throughout the planning period as technical advancements in these areas may reduce the sizing requirements of the checkpoint and mitigate the need for further expansion.
  - Review improved screening processes, such as TSA “Pre-Check” and “Checkpoint of the Future,” at each PAL to determine industry wide acceptance and how these processes can be applied to increase the efficiency of the checkpoint.

- Checked Baggage Inspection System:
  - At each PAL, consider new, certified technologies and screening protocols, and identify potential impacts from future technologies and protocols. Consider modification of the existing area, if necessary.
- International Gates
  - Consider the construction of a larger FIS facility, sized to accommodate the functional requirements of the larger processing capacity, but finished out to the current size requirements to support the current passenger rates to allow for future facility expansion within the remaining shell space.
  - Construct new FIS with "swing gates" designed to accommodate domestic passenger service when international flights are not scheduled.
- Terminal Services:
  - Consider location and capacity of loading dock and delivery areas serving the terminal building.
  - Plan for direct terminal related services, such as lift and sweeper storage, loading docks and screening facilities within the terminal building.
  - At each PAL, requirements for capacity and quantity of vertical circulation elements, such as stairs, elevators and escalators should be compared against the existing elements to determine if action is necessary, such as egress stair widths, to accommodate increased passenger loads.

Support Facility Recommendations

- Consider additional GA apron between PALs 1 and 2.
- Consider additional aircraft hangar storage between baseline year (existing conditions) and PAL 1.
- Maintain existing air cargo facilities.
- Consider additional deicing areas; potentially in GA or air cargo areas.
- Consider additional ARFF support if extending Runway 2L or constructing fourth parallel runway.
- Continue to consolidate MNAA maintenance facilities into 1 consolidated facility.
- Maintain multipurpose building (Building 4323) for GSE storage.
- Consider reserving a site for a new ATCT.

Surface Transportation and Parking Recommendations

- Provide ability to expand parking.
- Institute policies and procedures that will deter the growth of off-Airport parking and facilitate future growth of on-Airport parking demand. Examples of policies and procedures include:
    - Implement a concession fee for off-Airport parking providers.
    - Improve on-Airport parking customer service.
    - Adjust parking rates to compete directly with off-Airport parking providers.
- Increase on-Airport public parking by PAL 2.
- Consider relocating rental car service sites.
- Add 9 taxi queue spaces by PAL 1, and 41 spaces by PAL 4.
- Add 10 cell phone spaces by PAL 1, and 49 spaces by PAL 4.