APPENDIX B

Purpose and Need and Alternatives

TECHNICAL MEMORANDUM – *Final*

Forecast
Technical Memorandum

Charlotte Douglas International Airport
Environmental Impact Statement

PREPARED FOR

FEDERAL AVIATION ADMINISTRATION

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Record of Changes/Version History

Change/ Version Number	Date of Change	Sections Changed	Description	Person Entering Change
1	11/10/2017	All	Original Draft	VHB/InterVISTAS
2	1/17/2018	1, Appendix	Additional data added to tables	VHB/InterVISTAS
3	03/27/2018	All	Response to FAA Comments	VHB/InterVISTAS
4	04/18/2018	None.	Finalized.	VHB

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1

Introduction

In accordance with FAA Order 1050.1F “Environmental Impacts: Policies and Procedures, an EIS requires a Purpose and Need section. In order to demonstrate part of the need for capacity-related components of the Project, a passenger and operations forecast (“EIS forecast”) has been completed for Charlotte Douglas International Airport (“the Airport” or “CLT”). This technical memorandum covers analysis of the historical traffic at CLT as well as the methodology and results of the long-term traffic forecast. This long-term annual forecast was used as the basis of derivative forecasts (busy day, peak hour, design day schedules), which served as inputs into the simulation modeling. Summary forecast results are shown below in **Table 1-1**. The most recent calendar year of data available as of the writing of this memorandum is 2016; therefore, 2016 was selected as the base year for this EIS.

In addition to showing the results of the EIS forecast, this memorandum also compares the EIS forecast to the Federal Aviation Administration’s (FAA) 2016 Terminal Area Forecast (TAF) and the forecast completed by the Charlotte Aviation Department (the Department) in 2014 for the CLT Master Plan (known as the Airport Capacity Enhancement Plan or ACEP).[1] The service and outlook for CLT is now updated to reflect changing conditions since completion of the ACEP.

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[1] The ACEP was released in February 2016; however, the latest full year of data shown in the report and used in the forecast is 2013.

Table 1-1 Summary of Charlotte Douglas International Airport Forecast

	Forecast				Compound Annual Growth Rates		
	Base Year 2016	Base Year+1 2017	Build Year 2028	Build Year +5 2033	Base Year+1 2017	Build Year 2028	Build Year +5 2033
Passenger Enplanements							
Air Carrier	15,640,736	15,850,803	19,824,450	21,720,151	1.3%	2.0%	2.0%
Commuter	6,533,011	6,895,699	8,068,898	8,578,173	5.6%	1.8%	1.6%
Total	**22,173,747**	**22,746,502**	**27,893,348**	**30,298,324**	**2.6%**	**1.9%**	**1.9%**
Aircraft Operations							
Air Carrier	400,819	409,357	482,269	513,764	2.1%	1.6%	1.5%
Air Taxi	117,378	118,994	129,351	133,460	1.4%	0.8%	0.8%
Subtotal	*518,197*	*528,351*	*611,620*	*647,224*	*2.0%*	*1.4%*	*1.3%*
General Aviation	24,869	24,935	25,487	25,742	0.3%	0.2%	0.2%
Military	2,676	2,676	2,676	2,676	0.0%	0.0%	0.0%
Total Operations	**545,742**	**555,962**	**639,783**	**675,643**	**1.9%**	**1.3%**	**1.3%**
Peak Hour Operations	114	116	134	146	1.8%	1.4%	1.5%
Cargo/Mail							
Enplaned and Deplaned Tons	154,477	169,152	235,242	261,000	9.5%	3.6%	3.1%
Operational Factors							
Average Aircraft Size (seats)							
Air Carrier	144	144	148	150	0.0%	0.2%	0.2%
Air Taxi	59	59	62	63	0.0%	0.4%	0.4%
Average Enplaning Load Factor							
Air Carrier	83.6%	83.7%	84.3%	84.6%			
Air Taxi	80.2%	80.3%	81.4%	81.4%			

Source: FAA Operations Network (OPSNET); InterVISTAS analysis for forecast.

Note: This summary table shows is based on a Build Year of 2028. A similar version of this table reflecting Base Year + 5, 10 and 15 years is shown in the Appendix.

Note: The forecast does not reallocate air taxi operations to air carrier as the seating capacity increases; therefore, the average aircraft size (seats) for air taxi goes above 60 seats.

2

Historical Traffic Analysis

This chapter presents background information on the Charlotte Douglas International Airport (“the Airport” or “CLT”), the economics of the surrounding catchment area, historical traffic growth, the relationship between local economics and airport traffic, as well as the Airport’s role as a hub in the network of the dominant air carrier American Airlines.

2.1 Catchment Area

The Airport serves the 20-county Charlotte-Gastonia-Salisbury economic area, which includes portions of both North Carolina and South Carolina (**Figure 2-1**).[2] Included in this economic area is the Charlotte-Concord Combined Statistical Area (CSA), which in turn covers the 10-county Charlotte-Concord-Gastonia Metropolitan Statistical Area (MSA) and two micropolitan areas (Albemarle and Shelby). The largest county, Mecklenburg County in North Carolina, includes the City of Charlotte and the Airport itself.

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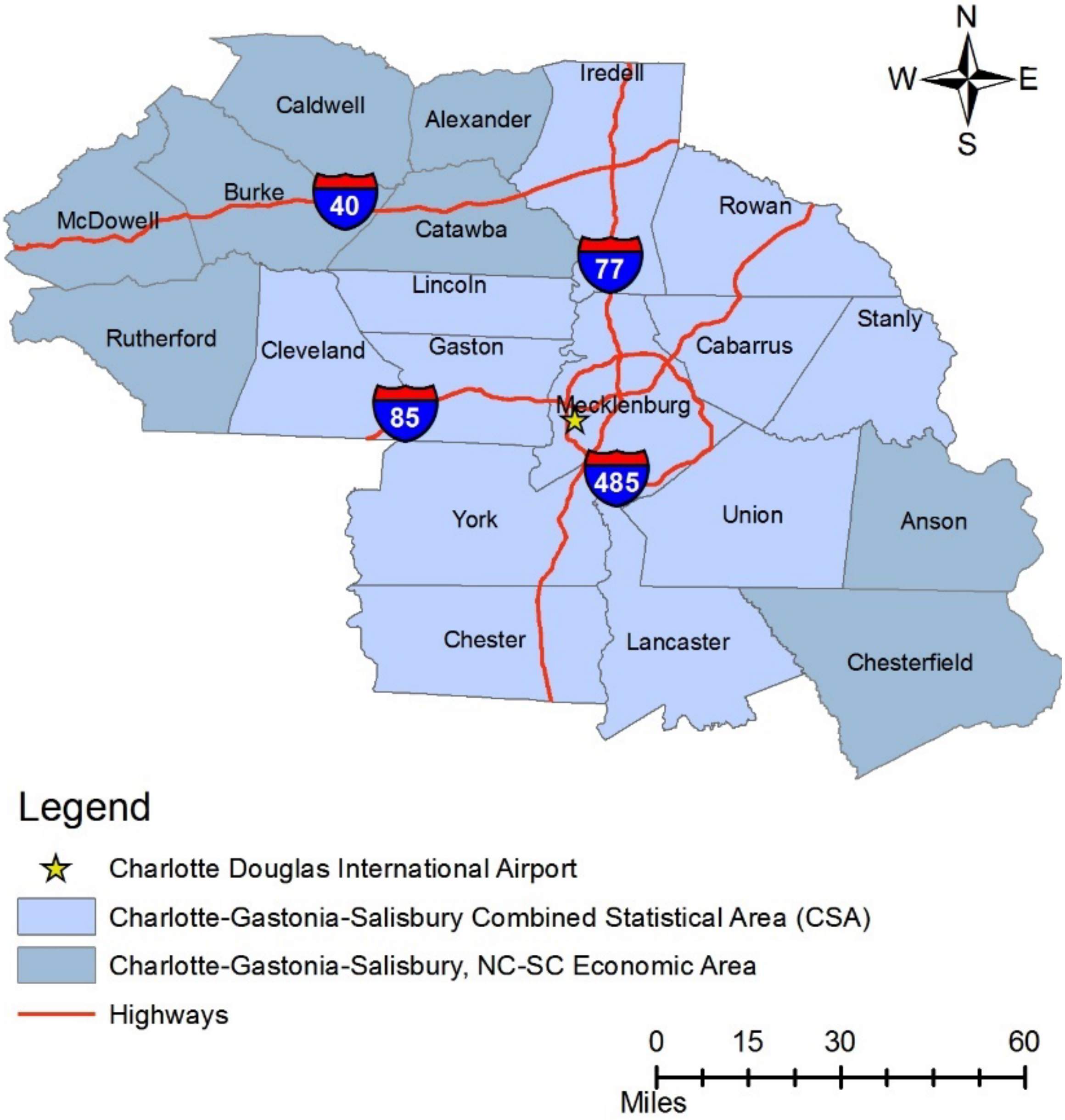
[2] City of Charlotte, Official Statement, Bond Series 2017 A-C, May 19, 2017.

Figure 2-1 CLT Catchment Area



Source: County data from U.S. Census Bureau

Within the United States, Charlotte was the 17th largest city and the 21st largest CSA (**Table 2-1**) in 2016.

Table 2-1 Top 20 U.S. Cities Ranked by Population, CY 2016

Rank	City	State	Population
1	New York City	New York	8,537,673
2	Los Angeles	California	3,976,322
3	Chicago	Illinois	2,704,958
4	Houston	Texas	2,303,482
5	Phoenix	Arizona	1,615,017
6	Philadelphia	Pennsylvania	1,567,872
7	San Antonio	Texas	1,492,510
8	San Diego	California	1,406,630
9	Dallas	Texas	1,317,929
10	San Jose	California	1,025,350
11	Austin	Texas	947,890
12	Jacksonville	Florida	880,619
13	San Francisco	California	870,887
14	Columbus	Ohio	860,090
15	Indianapolis	Indiana	855,164
16	Fort Worth	Texas	854,113
17	**Charlotte**	**North Carolina**	**842,051**
18	Seattle	Washington	704,352
19	Denver	Colorado	693,060
20	El Paso	Texas	683,080

Source: United States Census Bureau, 2017.

While the Airport's entire catchment area represents approximately a two-hour drive time, the core of the Airport's catchment is the Charlotte-Concord CSA with a population of 2.6 million (**Table 2-2**).

Table 2-2 Population Comparison, CY 2016

Area	Counties	Population
City of Charlotte	n/a	842,051
Charlotte-Concord-Gastonia MSA	10	2,474,314
Charlotte-Concord CSA	**12**	**2,632,249**
Charlotte-Gastonia-Salisbury	20	3,179,393

Source: United States Census Bureau, 2017.

Historically, the population of the Charlotte-Concord CSA has grown at a rate higher than that of the United States (**Table 2-3)**. In addition, the CSA population is estimated to grow at an average annual rate of almost double that of the United States through 2050.

Table 2-3 Select Historical and Forecast Populations (in thousands)

Year	United States	10-Yr CAGR	North Carolina	10-Yr CAGR	South Carolina	10-Yr CAGR	Charlotte-Concord CSA	10-Yr CAGR
Historical								
2000	282,162		8,082		4,024		1,883	
2010	309,347	0.9%	9,559	1.7%	4,636	1.4%	2,382	2.4%
2016	324,161		10,169		4,951		2,626	
Forecast								
2020	336,383	0.8%	10,723	1.2%	5,192	1.1%	2,807	1.7%
2030	368,644	0.9%	12,215	1.3%	5,836	1.2%	3,3007	1.7%
2040	399,419	0.8%	13,732	1.2%	6,475	1.0%	3,839	1.5%
2050	428,119	0.7%	15,246	1.1%	7,096	0.9%	4,393	1.4%
CAGRs								
2000-2016	0.9%		1.4%		1.3%		2.1%	
2016-2020	0.9%		1.3%		1.2%		1.7%	
2016-2050	0.8%		1.2%		1.1%		1.5%	

Source: Complete Economic and Demographic Data Source (CEDDS), Woods & Poole Economics, Inc., 2017.
CAGR - Compound Annual Growth Rate

Real per capita income in the Charlotte-Concord CSA is expected to grow at 1.1 percent annually over the period of 2016-2050 (**Table 2-4**). Comparatively, the United States anticipates similar annual real growth in per capital income over the same period (1.2 percent).

Table 2-4 Select Historical and Projected Per Capita Income (in 2009 USD)

Year	United States	10-Yr CAGR	North Carolina	10-Yr CAGR	South Carolina	10-Yr CAGR	Charlotte-Concord CSA	10-Yr CAGR
Historical								
1990	29,082		25,370		23,376		26,531	
2000	36,833	2.4%	32,719	2.6%	29,840	2.5%	34,205	2.6%
2010	39,622	0.7%	34,757	0.6%	31,638	0.6%	36,846	0.7%
2016	44,637		37,884		35,477		41,295	
Forecast								
2020	47,378	1.8%	40,272	1.5%	37,757	1.8%	43,677	1.7%
2030	54,339	1.4%	46,262	1.4%	43,450	1.4%	49,564	1.3%
2040	60,336	1.1%	51,212	1.0%	48,040	1.0%	54,367	0.9%
2050	66,890	1.0%	56,621	1.0%	53,055	1.0%	59,481	0.9%
CAGRs								
2000-2016	1.2%		0.9%		1.1%		1.2%	
2016-2020	1.5%		1.5%		1.6%		1.4%	
2016-2050	1.2%		1.2%		1.2%		1.1%	

Source: Complete Economic and Demographic Data Source (CEDDS), Woods & Poole Economics, Inc., 2017.

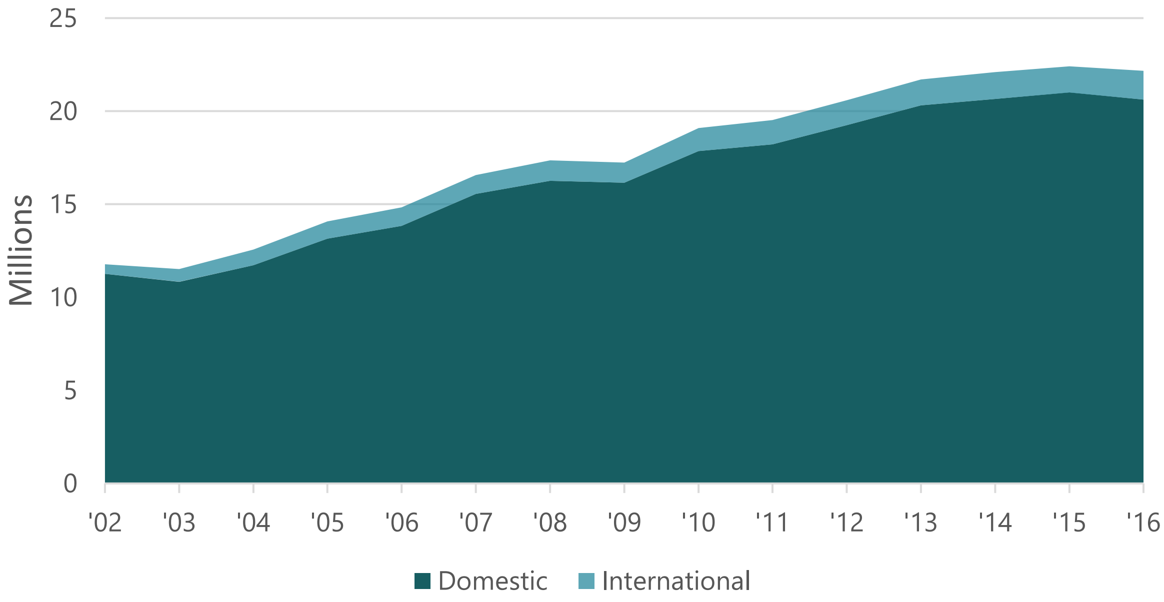
2.2 Background and Historical Passenger Traffic

One of the most important inputs into a traffic forecast is the historical traffic. This section shows historical data for enplaned passengers (including both Origin and Destination (O&D) passengers and connecting passengers) as well as discusses CLT's role as a hub for American Airlines.

2.2.1 Enplaned Passengers

Since 2002, the Airport has grown 4.6 percent annually on average in terms of enplaned passengers, reaching 22.2 million in 2016. During this period, average international growth (8.1 percent) almost doubled that of domestic growth (4.4 percent). As shown in **Figure 2-2** below, enplanements only dipped by 0.6 percent in 2009 following the 2008-2009 economic crisis – compared to a 7.2 percent drop in the United States as a whole.[3] Traffic rebounded in 2010 with a rate of 10.7 percent. In 2016, traffic declined by 1.1 percent, driven by a decrease in domestic connecting passengers (O&D passengers increased). However, in the first half of 2017, enplaned passenger traffic was three percent higher than the first six months of 2016; international enplaned passengers are 20 percent higher than the same period in 2016.

Figure 2-2 Historical Enplaned Passengers at CLT, 2002-2016



Source: CLT Monthly Activity Reports

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[3] FAA Aerospace Forecast, FY 2011-2031

Since 2002, domestic traffic has increased by an average of 4.4 percent annually and international traffic has increased by an average of 8.1 percent annually (**Table 2-5**).

Table 2-5 Compound Annual Growth Rates for Historical Enplaned Passengers at CLT

CAGRs	2002-06	2006-11	2011-16	2002-16
Domestic	5.3%	5.6%	2.5%	4.4%
International	17.7%	5.7%	3.5%	8.1%
Total	**5.9%**	**5.6%**	**2.6%**	**4.6%**

Source: CLT Monthly Activity Reports
CAGR - Compound Annual Growth Rate

Among the 30 large hub airports in the United States, CLT accounts for the 10th most enplaned passengers (see **Table 2-6** below).

Table 2-6 Enplaned Passengers at Top 30 U.S. Airports, CY 2016

Rank	Airport	Enplaned Passengers (millions)
1	Atlanta Hartsfield – Jackson International	50.5
2	Los Angeles International	39.6
3	Chicago O'Hare International	37.6
4	Dallas-Fort Worth International	31.3
5	NYC John F. Kennedy International	29.2
6	Denver International	28.3
7	San Francisco International	25.7
8	Las Vegas McCarran International	22.8
9	Seattle-Tacoma International	21.9
10	Charlotte/Douglas International	**21.5**
11	Phoenix Sky Harbor International	20.9
12	Miami International	20.9
13	Orlando International	20.3
14	Houston George Bush Intercontinental	20.1
15	Newark Liberty International	19.9
16	Minneapolis-St Paul International	18.1
17	Boston Logan International	17.8
18	Detroit Metropolitan Wayne County	16.8
19	NYC LaGuardia	14.8
20	Philadelphia International	14.6
21	Fort Lauderdale/Hollywood International	14.3
22	Baltimore/Washington International Thurgood Marshall	12.3
23	Ronald Reagan Washington National	11.5
24	Salt Lake City International	11.1
25	Chicago Midway International	11.0
26	Washington Dulles International	10.6
27	San Diego International	10.3
28	Honolulu Daniel K Inouye International	9.7
29	Tampa International	9.2
30	Portland International	9.1

Source: FAA, Enplanements at All Commercial Service Airports (by Rank), October 10, 2017.

The ACEP was released in February 2016; however, the latest full year of data shown in the report is from 2013. In 2013, CLT accounted for the 8th most enplaned passengers in the U.S. airport;[4] it has since been surpassed in the rankings by Las Vegas McCarran International Airport and Seattle-Tacoma International Airport.

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[4] ACI, 2012 World Annual Traffic Report as shown in the ACEP

2.2.2 Current Service and Role as Hub

Passenger traffic at CLT comprises of O&D traffic (travel to and from Charlotte) and connecting traffic (passengers making connections at CLT) as illustrated below. As can be seen in **Table 2-7**, connecting traffic comprises 71 percent of passenger movements and consists mostly of domestic connections.

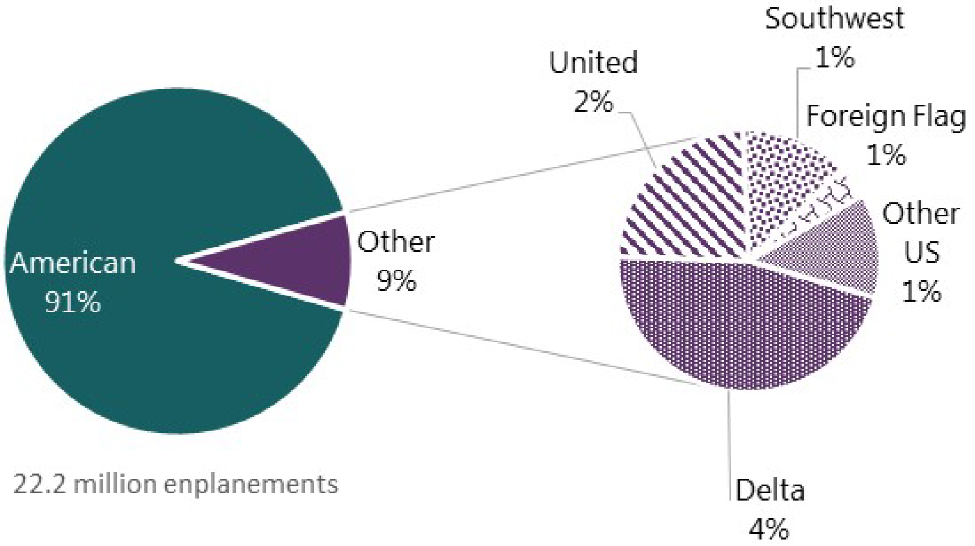
Table 2-7 Charlotte Passenger Traffic CY 2016

Traffic Type	Share
Domestic O&D	25.6%
International O&D	3.2%
Domestic Connecting	67.5%
International Connecting	3.7%
Total	**100.0%**

Source: U.S. DOT O&D and T100 data, via Flight Global's Diio Mi database.

The high rate of connections at CLT reflects its role as a hub for American Airlines which accounted for 91 percent of seat capacity and passengers in CY 2016 (**Figure 2-3**).[5] Of the remaining nine percent of passengers, Delta Air Lines serves the largest share at four percent, followed by United Airlines at two percent.

Figure 2-3 Airline Share of CLT Enplanements, CY 2016



Source: U.S. DOT T100 via Airline Data, Inc.; CLT Monthly Traffic Reports.

Before the merger of American Airlines and US Airways in 2013,[6] Charlotte was the largest of US Airways' four hubs. Now, Charlotte is American Airlines' second largest hub after Dallas/Fort Worth, as illustrated in (**Table 2-8**) below. After carriers merge, it is typical for changes to be made

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[5] Innovata schedule data via Flight Global's Diio Mi database.

[6] Although the merger was announced in 2013, the two airlines did not begin operating under one Air Operator's Certificate (AOC) until 2015.

to the hub structure in order to optimize operations. As an example, the largest international connect flow was the U.S. Northeast-Caribbean market. Some of this traffic has since shifted to American Airlines' largest Caribbean gateway, Miami (**Figure 2-4**).

Table 2-8 Overview of Capacity at American Airlines Hubs, CY 2016

Seat Rank	Airport	Markets Served	Daily Departures	Daily Seats
1	Dallas/Fort Worth	202	749	95,927
2	Charlotte	158	660	71,170
3	Chicago O'Hare	133	481	49,938
4	Miami	129	333	48,061
5	Philadelphia	114	379	37,549
6	Phoenix	86	253	33,557
7	Los Angeles	70	202	27,723
8	Washington DCA	72	239	20,654
9	New York JFK	46	93	13,225

Source: Airport Records, U.S. DOT, O&D Survey, via Flight Global's Diio Mi database.

Figure 2-4 American Airlines Hub Locations

Source: Innovata schedule data via Flight Global's Diio Mi database, August 2017.

Flights from CLT reach 169 destinations; 135 of those in the United States (**Table 2-9**). These 135 destinations account for 95 percent of weekly departing flights. International service connects Charlotte to 34 airports with the 50 percent of those located in the Caribbean. American Airlines' focus at Charlotte is on domestic connections as it connects the United States to Latin American via its hub at Miami; Europe via its hub at New York JFK; and Asia from Los Angeles.

Table 2-9 Weekly Frequencies from CLT by Region, August 2017

Region	Weekly Departures	Weekly Departing Seats	Number of Destinations
Domestic	4,893	509,388	135
Europe	63	16,926	8
Caribbean	112	16,876	17
Mexico	30	5,048	4
Canada	46	2,984	2
Central America	7	882	3
Total	**5,150**	**552,104**	**169**

Source: Innovata Schedule Data via Flight Global's Diio Mi database, August 2017.

As noted above, the air service offerings at CLT has changed since the ACEP. In 2013, international flights accounted for 6.5 percent of total scheduled flights[7] whereas in August 2017 they accounted for 5 percent. Of these international flights, 65 percent were to Latin America in 2013;[8] this share has dropped to 57.8 percent in 2017.

Of the 5,150 weekly nonstop departures at CLT in August 2017, 67.8 percent are operated with narrowbody equipment **(Table 2-10**). Ten routes are operated with widebody aircraft.

Table 2-10 Weekly Frequency from CLT by Aircraft Type, August 2017

Aircraft Group	Weekly Departures	Weekly Departing Seats	Number of Destinations
Narrowbody	3,493	442,823	124
Regional Jet/Turboprop	1,584	89,985	90
Widebody	73	19,296	10
Total	**5,150**	**552,104**	**N/A**

Source: Innovata Schedule Data via Flight Global's Diio Mi database, August 2017

2.2.3 Origin and Destination (O&D) Passengers

While connections account for 71.2 percent of passengers at CLT, O&D passengers play an increasing role at the Airport. Over the last 20 years, O&D passengers have increased by 4.7 percent annually on average (**Table 2-11**), with slightly larger growth in the international segment (see **Figure 2-5)**. In 1996, international passengers accounted for 7.6 percent of total passengers; this share has increased to 11.1 percent in 2016. In 2016, both international and domestic O&D passengers grew, by 7.8 percent and 3.8 percent, respectively compared to 2015.

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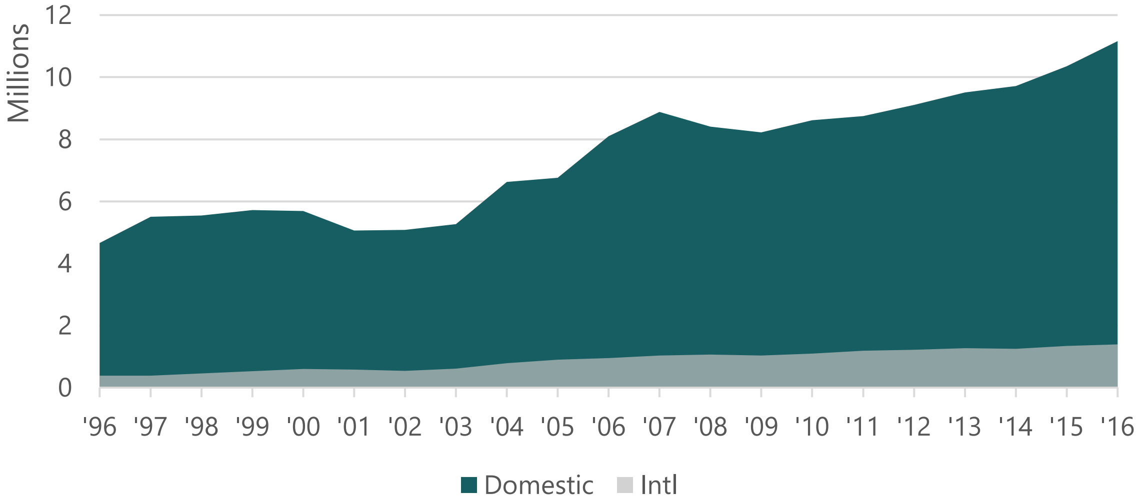
[7] OAG schedules as shown in the ACEP

[8] Ibid.

Figure 2-5 Historical O&D Passengers at CLT, 1996-2016



Source: U.S. DOT O&D Survey via Flight Global's Diio Mi database.

Table 2-11 Compound Annual Growth Rates for Historical O&D Passengers at CLT

CAGRs	1996-06	2006-16	1996-16
Domestic	5.7%	3.3%	4.5%
International	9.5%	3.9%	6.7%
Total	**6.0%**	**3.3%**	**4.7%**

Source: U.S. DOT O&D Survey via Flight Global's Diio Mi database.

New York City (as represented by JFK, LaGuardia and Newark airports) is the largest O&D destination from CLT, followed by Chicago (O'Hare and Midway) (see **Table 2-12**).

Table 2-12 Top 10 O&D Destinations from CLT, CY 2016

Rank	City	O&D Passengers
1	New York City	1,514,506
2	Chicago	594,468
3	Boston	474,979
4	Dallas	422,592
5	Philadelphia	339,573
6	Orlando	281,049
7	Baltimore	274,187
8	Los Angeles	272,809
9	Washington D.C.	244,093
10	San Francisco	240,379

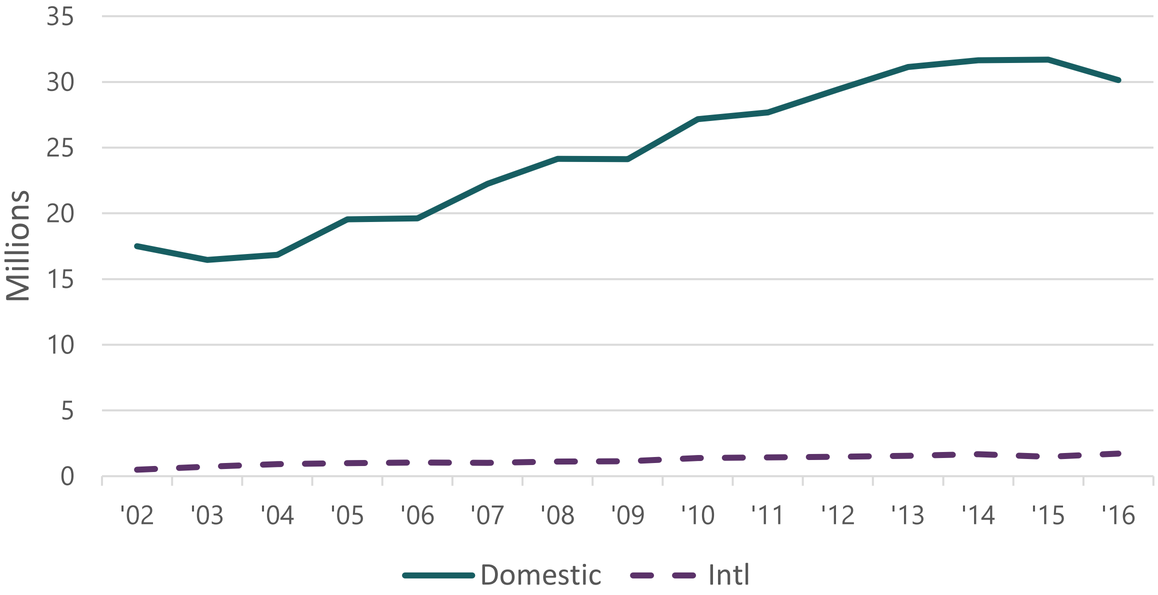
Source: U.S. DOT O&D Survey via Airline Data, Inc.
CAGR - Compound Annual Growth Rate

2.2.4 Connecting Passengers at CLT

Since 2002, the number of connecting passengers at CLT has increased by 4.2 percent annually on average (**Figure 2-6** and **Table 2-13**), reaching 31.9 million passengers in 2016. International connections, which include connections between domestic and international flights have increased at a faster rate than domestic-to-domestic connections, likely due to the increase in the number of international flights.

Connecting traffic is a function of air carrier hubbing and network decisions (primarily American Airlines at CLT). While underlying demand can grow connecting traffic, it is American Airlines decision to flow traffic through specific hubs that will ultimately affect traffic volumes at CLT.

Figure 2-6 Historical Connecting Passengers at CLT, 2002-2016



Source: U.S. DOT O&D Survey via Flight Global's Diio Mi database

Table 2-13 Compound Annual Growth Rates for Historical Connecting Passengers at CLT

CAGRs	2002-06	2006-11	2011-16	2002-16
Domestic	2.9%	7.1%	1.7%	4.0%
International	20.5%	6.6%	3.8%	9.3%
Total	**3.5%**	**7.1%**	**1.8%**	**4.2%**

Source: U.S. DOT O&D Survey via Flight Global's Diio Mi database

Table 2-14 below shows the major domestic connecting flows (domestic-to-domestic) and **Table 2-15** shows international connecting flows (domestic-to-international and international-to-international) at CLT in 2016. The major domestic-domestic flows tend to be north-to-south in nature, particularly on the eastern side of the country. CLT is geographically well-positioned to continue to handle these flows within America Airlines' network, compared with the Airline's other major hubs.

Table 2-14 Charlotte Domestic Connecting Flows, CY 2016

Domestic Connecting Flows	
Northeast-to-Southeast	16.7%
Florida-to-Northeast	14.1%
Northeast-to-Southwest	7.5%
Florida-to-Southeast	6.9%
Great Lakes-to-Southeast	6.8%
Florida-to-Great Lakes	6.0%
Northeast-to-Pacific	5.3%
Southeast-to-Southwest	5.0%
Other	31.7%
Total	**100.0%**

Source: U.S. DOT, O&D Database via Airline Data, Inc.

As shown in **Table 2-15**, for international, nearly two thirds of the flows are to the Caribbean and Mexico, which overlaps with American Airlines' Miami hub. Similarly, the flows to Europe overlap with Dallas and American Airlines' hubs in the Northeast.

Table 2-15 Charlotte International Connecting Flows, CY 2016

International Connecting Flows	
Domestic-to-Caribbean	50.8%
Domestic-to-Europe	23.6%
Domestic-to-Mexico	15.7%
Domestic-to-Canada	5.3%
Domestic-to-Other	2.9%
International-to-International	1.7%
Total	**100.0%**

Source: U.S. DOT, O&D Database via Airline Data, Inc.

In 2016, domestic connecting traffic at CLT accounted for 1.9 percent of total U.S. domestic passenger traffic, while international connecting traffic accounted for 1.5 percent of total U.S. international passenger traffic (see **Figure 2-7**).[9] Both the international and domestic connecting share of CLT compared to the national aviation market have been declining since 2013. This decline is due to an industry-wide trend towards more direct services as well as a consolidation of American Airlines' connecting traffic at other hubs such as Miami and Dallas. As discussed in the next chapter, this is a trend that is expected to continue, and it serves as one of the inputs into the long-term passenger forecast prepared for this EIS.

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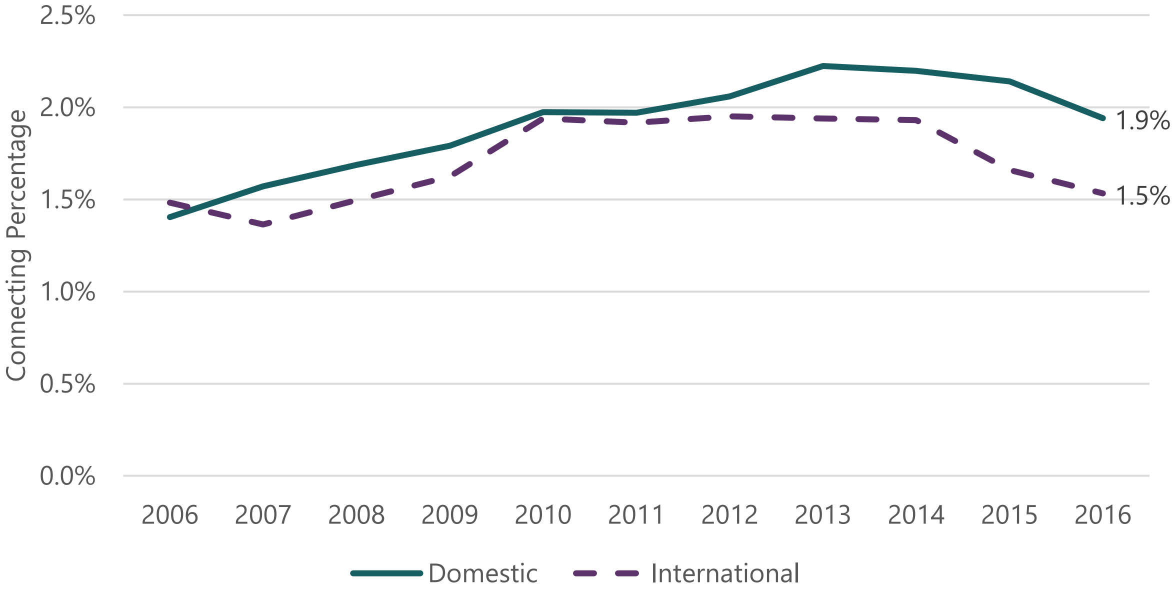
[9] "International" here includes U.S.-Transatlantic, U.S.-Latin American, and U.S.-Canadian markets

Figure 2-7 CLT Connecting Share of Total U.S. Traffic, 2006-2016



Source: U.S. DOT O&D Survey via Flight Global's Diio Mi database, FAA

2.3 Aircraft Operations

2.3.1 Types of Aircraft Operations

Aircraft operations can be divided into categories based on aircraft size or operation purpose. The following definitions are used in the FAA's annual TAF forecast and in this technical memorandum.

1. **Commercial operations** (those operated as a business) can be defined based on the size of the aircraft involved:
    a. **Air carrier** – "takeoffs or landings of commercial aircraft with seating capacity of more than 60 seats"[10]
    b. **Air taxi** includes**:**
        i. Commuter – itinerant operations performed by commercial aircraft with seating capacity of 60 seats or less on scheduled flights
        ii. On-demand – itinerant operations performed by commercial aircraft with seating capacity of 60 seats or less on non-scheduled or for-hire flights

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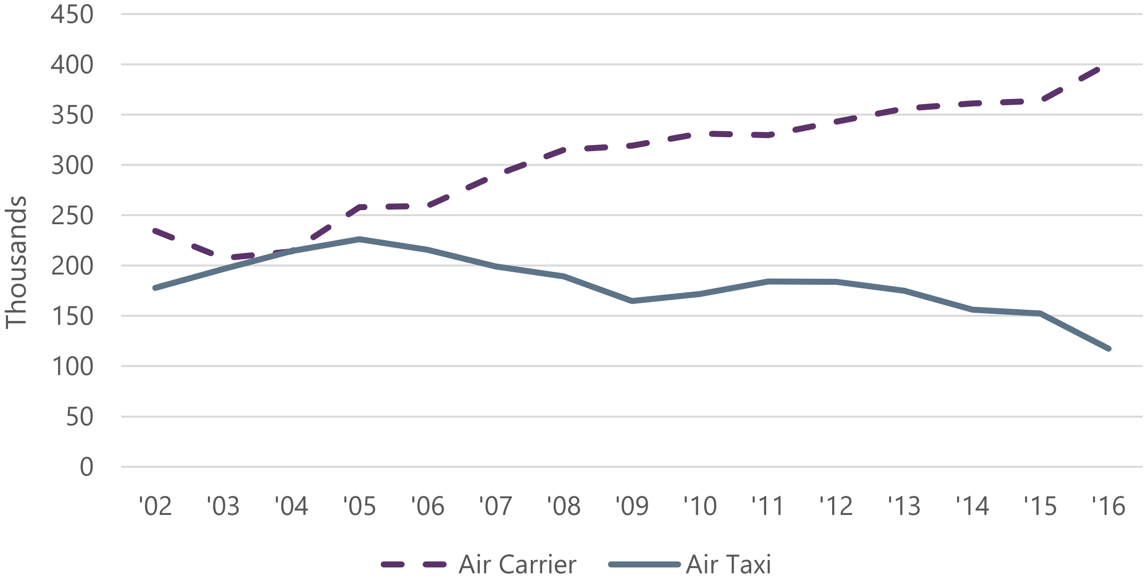
[10] FAA TAF, Appendix A: Description of Activity Measures, page 26.

2. **Non-commercial operations**
    a. **General Aviation (GA) – "**all civil aviation aircraft takeoffs and landings not classified as commercial or military"[11]
    b. **Military – "**takeoffs and landings by military aircraft"[12]

2.3.2 Historical Aircraft Operations at CLT

Overall commercial operations at CLT have increased by 1.7 percent on average annually since 2002, reaching 518,197 in 2016 (**Figure 2-8**).

Figure 2-8 Historical Commercial Operations at CLT, 2002-2016



Source: FAA OPSNET

This growth has been driven by increases in air carrier operations as air taxi operations have declined over this period by 2.9 percent per annum on average (**Table 2-16**). The number of both international and domestic air carrier operations have increased by 6.1 percent and 4.1 percent, respectively.[13]

Table 2-16 Compound Annual Growth Rates for Historical Commercial Operations at CLT

CAGRs	2002-06	2006-11	2011-16	2002-16
Air Carrier	2.6%	4.9%	4.0%	3.9%
Air Taxi	4.9%	-3.1%	-8.6%	-2.9%
Total Commercial	**3.6%**	**1.6%**	**0.2%**	**1.7%**

Source: CLT Monthly Activity Reports
CAGR - Compound Annual Growth Rates

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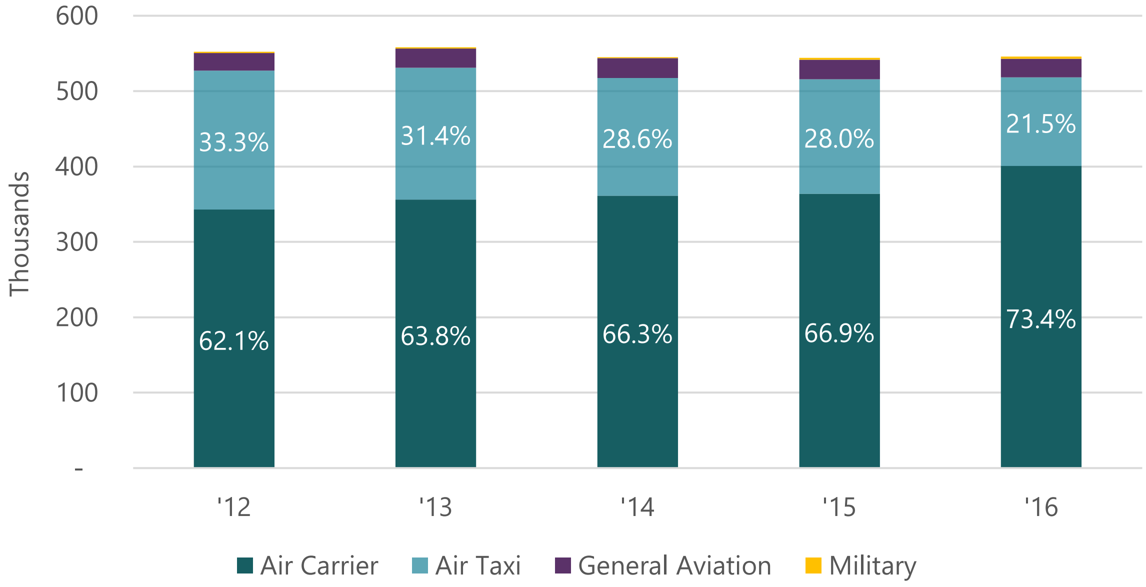
[11] FAA TAF, Appendix A: Description of Activity Measures, page 26.

[12] Ibid.

[13] U.S. DOT T100 via Airline Data, Inc.

In 2016, 73.4 percent of total aircraft operations were air carrier. Almost 22 percent of operations were air taxis; 4.6 percent were General Aviation (GA); and 0.5 percent were military (**Figure 2-9**). General Aviation operations have been steadily falling and represent 60 percent of the level in 2002. Military operations have typically remained within a band of 1,700-2,500 per year, increasing slightly to 2,676 in 2016.

Figure 2-9 Operations by Category, 2012-2016

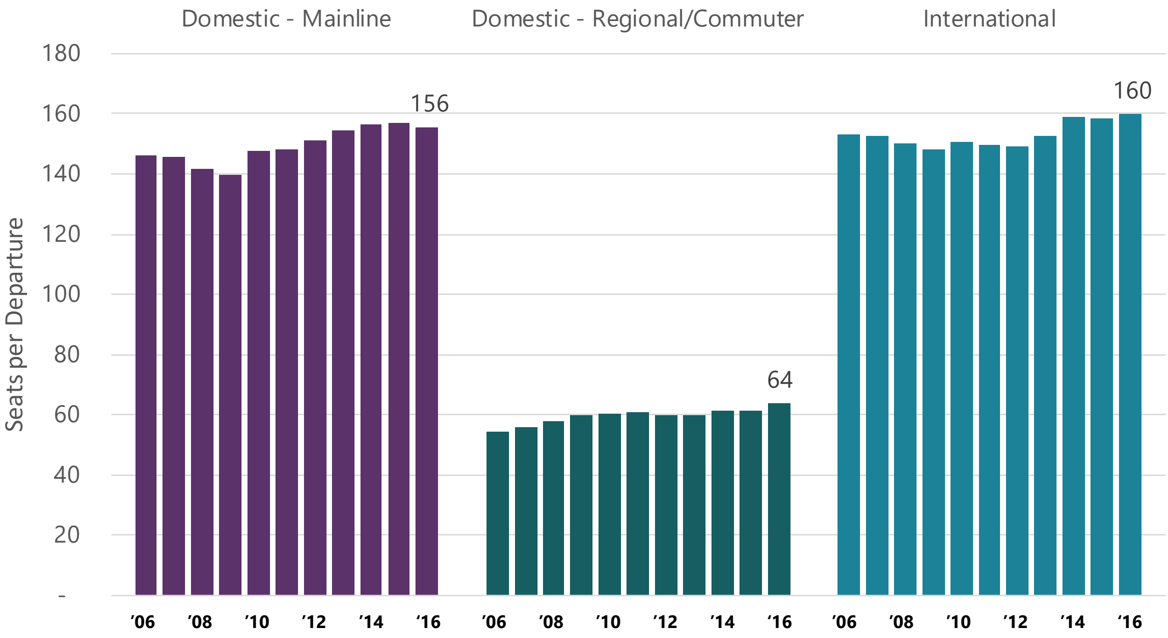


Source: FAA OPSNET

2.4 Aircraft Fleet Mix

As is the case nationwide, average aircraft size at CLT has been increasing (**Figure 2-10**). However, the growth rate of these larger aircraft in the CLT fleet has been faster than the national rate over the last 10 years. Since 2006, the average number of scheduled seats per departure at CLT has increased from 91 to 107, an average annual growth rate of 1.6 percent or 1.6 seats per year. For comparison, among U.S. commercial carriers over the same period, average annual growth was 1.1 percent. The reason for faster growth at Charlotte is the historically large share of CLT departures operated by smaller, regional/commuter aircraft. In 2006, over 60 percent of CLT's departures were operated on regional/commuter aircraft; in 2016, this share has dropped to 53.2 percent; at the same time, the regional carriers have started operating larger regional jets, such as the CRJ 700 and Embraer 170, which typically have a capacity between 65 and 90 seats. Both these factors have contributed to an increasing aircraft size at CLT.

Figure 2-10 Average Seats per Departure at CLT (Scheduled), 2006-2016

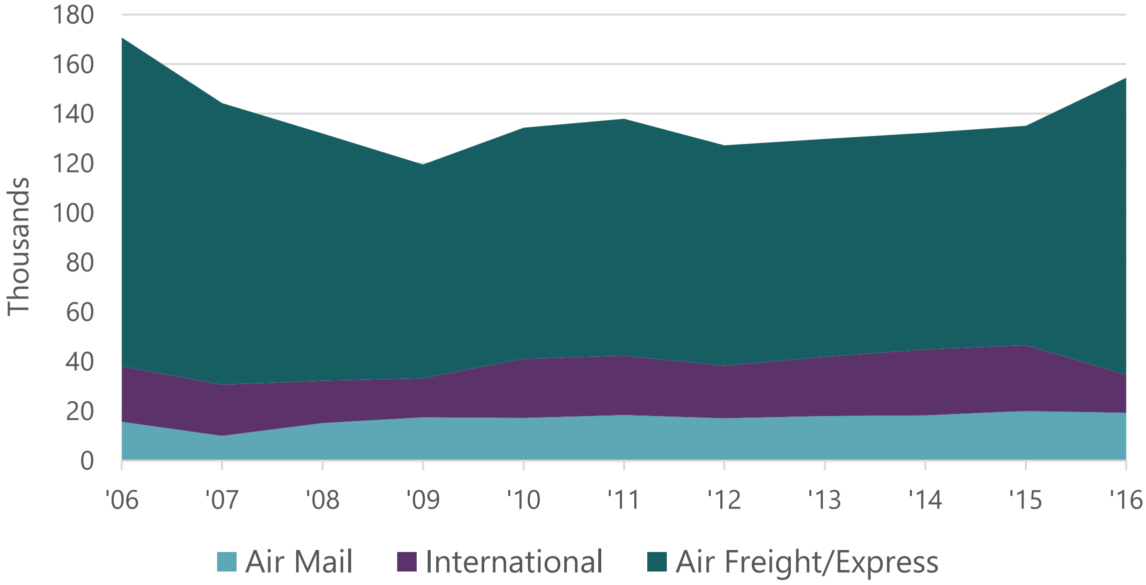


Source: Airline Schedules, via Airline Data, Inc.

2.5 Air Cargo

Air cargo tonnage has averaged 2.1 percent growth since the financial crisis (2009-15 growth). Domestic cargo accounts for 81 percent of total cargo enplaned and deplaned at CLT, while international makes up the remaining 19 percent. Historically, Charlotte has been served primarily by FedEx and UPS (which serve the air freight/express mail market), which together carried nearly 100 percent of cargo on scheduled cargo flights between 2012 and 2015. Belly cargo (cargo carried in the hold of commercial passenger aircraft) accounts for 33 percent of total cargo at CLT. Cargo volumes increased by 14.4 percent in 2016 to 154,000 tons (**Figure 2-11** and **Table 2-17**) much of which can be attributed to Amazon, which contracted services with both ABX Air and Air Transport for cargo operations in and out of Charlotte. In 2016, 77.5 percent of cargo served at CLT was air freight/express mail.[14]

Figure 2-11 Historical Cargo at CLT (tons), 2006-2016



Source: CLT Monthly Activity Reports

Table 2-17 Compound Annual Growth Rates for Historical Cargo at CLT

CAGRs	2006-11	2011-16	2006-16
Air Freight/Express	-6.3%	4.6%	-1.0%
Air Mail	3.1%	1.0%	2.1%
International	1.4%	-8.5%	-3.6%
Total	**-4.2%**	**2.3%**	**-1.0%**

Source: CLT Monthly Activity Reports

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[14] Air freight/express mail includes all cargo that is not international or regular mail.

3

Traffic Forecast

3.1 Introduction

In the process of conducting this EIS, it is necessary to update the long-term traffic forecast for the Charlotte Douglas International Airport ("the Airport" or "CLT"). This updated forecast will be used as an input into several subsequent analyses completed for the Environmental Impact Statement (EIS) including (among others): aircraft delay modeling, noise modeling, establishment of the design aircraft type, and determination of the optimal runway length. This chapter first presents the methodology and results for projecting passengers, operations and cargo. The most recent calendar year of data available as of the writing of this memorandum is 2016; therefore, 2016 was selected as the base year for this EIS forecast. The two benchmark years chosen for this study are 2028 (the "Build Year," when the Project is expected to open) and the Build Year plus five years (2033). Both the passenger and operations forecasts are compared to both the Airport Capacity Enhancement Plan (ACEP) and the FAA's Terminal Area Forecast (TAF) to determine consistency. Where the EIS forecast differs from either the ACEP or TAF forecasts, explanations are discussed. The forecasts presented in this chapter for CLT have been submitted to the FAA's Airport District Office (ADO) for approval for use in the EIS study.

3.2 Passenger Forecast Methodology

This section presents the separate approaches used to forecast Origin and Destination (O&D) and connecting traffic.

3.2.1 Origin-Destination Traffic Forecast Methodology

The long-term passenger forecasts prepared for this EIS are based on an econometric model for domestic, Canada, the Caribbean (including Mexico and Central America), South America, trans-Atlantic, and trans-Pacific origin-destination passengers. Separate outbound (Charlotte residents) and inbound (overseas residents) models were developed using data sourced from the U.S. DOT. Various models were tested to explain traffic volumes in terms of: relevant GDP measures, population, air fares and fuel prices. The most robust models, in terms of statistical fit (adjusted r-squared and parameter t-statistics), were found to be those based on measures of real GDP (as well as dummy variables in 2001 and 2002 to capture the impacts of the events of September 11, 2001). For the domestic and outbound international models, Charlotte Combined Statistical Area (CSA) gross domestic product (GDP) was found to be the most effective explanatory variable, while the real GDP of the international regions were used for the inbound markets. The dependent variables used in the econometric analysis were in natural log terms. The key results from the econometric analysis are summarized in Appendix 1.

As the markets mature, the responsiveness of demand to economic growth is expected to decline. To capture this, the GDP elasticities were gradually declined by 25 percent by 2035 - this of level decline is based on expert judgement and reflects the expected maturing of the market. To generate forecasts of O&D traffic, the parameters were applied to projections of real GDP sourced from Woods & Poole[15] for Charlotte GDP and the U.S. Department of Agriculture Economic Research Service.[16]

3.2.2 Connecting Traffic

Connecting traffic at CLT is primarily a function of air carrier decisions (primarily American Airlines). While underlying demand can grow connecting traffic, it is carriers' decisions regarding flow traffic through specific hubs that will ultimately affect traffic volumes.

Connecting traffic was modelled as a function of national demand for travel and CLT's share of that demand. In 2016, domestic connecting traffic at CLT accounted for 1.9 percent of total domestic passenger traffic. The FAA forecasts that in the U.S., domestic traffic will increase by 1.7 percent per annum up to 2035. It is assumed that CLT's share of this traffic will decline by 10 percent over the forecast period as new direct services reduce the need for connecting itineraries (CLT's share will decline to 1.7 percent). As noted in Section 2.2.4, CLT's share of domestic connecting traffic has been declining in recent years, and this trend is expected to continue. This trend of declining connecting share was broadly confirmed by interviews with American Airlines. As a result, domestic connecting traffic is forecast to increase by 1.2 percent per annum (forecast values are shown in the Appendix).

The forecasts of international connecting traffic were based on the FAA forecasts of traffic to/from Canada, Latin America and Trans-Atlantic. CLT's share of these total traffic flows is assumed to decline by 25 percent, due to the development of direct services and the increased concentration of connecting flows at other hubs. As with domestic connecting traffic, CLT's share of international connecting traffic has been declining and this trend is expected to continue. This results in average growth of 2.1 percent per annum over the forecast period (compared with 3.6 percent per annum growth in total demand). Forecast connecting passenger values are shown in the Appendix.

3.3 Passengers

The EIS passenger forecast projects passengers by route group (domestic and international) as well as type of passenger. The two types of passengers projected are O&D and connecting.

- **O&D passengers** at CLT are those beginning or ending their trip at CLT. An example of an O&D passenger would be someone traveling between Charlotte and New York City.
- **Connecting passengers** at CLT are those changing planes in the Airport on their way to another destination. An example of a connecting passenger would be someone flying from New York City to Charlotte and then to Dallas.

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[15] Complete Economic and Demographic Data Source (CEDDS), Woods & Poole Economics, Inc., 2017.

[16] U.S. Department of Agriculture Economic Research Service, https://www.ers.usda.gov/

3.3.1 Passenger Forecast Assumptions

The next three sections describe the different assumptions used to create the Base, High, and Low forecasts. Although the Base Case is that used for the majority of EIS analyses, it is important to have High and Low cases in order to test the range of possible outcomes.

3.3.1.1 Base Case

The following assumptions were made in creating the passenger forecast:

- The United States economy as well as Charlotte’s local economy will experience moderate and steady growth between 2016 and 2035 in line with current forecasts;
- No large demand shock, such as terrorism or war, will significantly affect demand for air travel in the U.S.;
- No significant change in airfares from Charlotte will dramatically affect demand for air travel;
- No large change in jet fuel prices will dramatically affect the airlines’ ability to serve Charlotte’s from their respective bases;
- The U.S. air traffic control system will be able to absorb incremental capacity throughout the forecast period;
- The airport’s facilities will not constrain demand; and,
- CLT's share of the U.S. industry domestic connects is forecast to decline from 1.9 percent to 1.7 percent while the share of international connections declines from 1.5 percent to 1.1 percent. This is an industry trend that reflects greater passenger volumes flying on a nonstop itinerary to reach their destination. Even though the CLT share of connecting passengers is declining, the actual volume of connecting passengers will increase.

3.3.1.2 High Case

In order to test the outer limit of the passenger forecast, a High Case was created. The following assumptions were made regarding the high forecast scenario for CLT:

- In an iterative process, O&D adjustments upward were made to the underlying independent variables in the regression analysis, i.e., economic growth rates forecast by Woods & Poole[17] and the U.S. Department of Agriculture Economic Research Service. The revised economic growth rates will drive changes to O&D passengers. In the High Case, the GDP growth rate increased by 0.1 percentage points.
- Connecting adjustments upward were made on the share of U.S. passenger growth that CLT connecting traffic represents. In the High Case, connecting shares of 1.9 percent for domestic, and 1.5 percent for international are held constant through the forecast period.

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[17] Complete Economic and Demographic Data Source (CEDDS), Woods & Poole Economics, Inc., 2017.

However, after review of the output, it was determined that a larger adjustment to the O&D forecast was necessary to reflect a more meaningful change in the underlying conditions. The GDP growth rate was then increased by +0.5 percentage points per annum throughout the forecast period. No change was made to initial assumptions for the connecting passenger forecast.

3.3.1.3 Low Case

In order to test the lower limit of the passenger forecast, a Low Case was created. The following assumptions were made regarding the Low Case for CLT:

- In the Low Case, the GDP growth rated was decreased by -0.1 percentage points per annum.
- Connecting shares were decreased from 1.9 percent to 1.6 percent for domestic, and 1.5 percent to 1.0 percent for international over the forecast period.

Similar to the high forecast, the results of the low forecast scenario were further analyzed and it was determined that an additional adjustment to the O&D passenger forecast was required. The GDP growth rate was adjusted to reflect a -0.5 percentage point change per year throughout the forecast period.

A high/low variance range of 20-25 percent was assumed when reviewing the outputs of the scenarios above.

3.3.2 Annual Passenger Forecasts

For 2017, the number of enplaned/deplaned passengers is expected to increase 2.4 percent from 2016, which reflects anticipated seat capacity growth shown in the 2017 schedule data and the year-to-date passenger figures as of April 2017. Based on the methodology and assumptions described above, the average growth rate is forecast to average 2.4 percent per annum between 2016 and 2020 (figures below **Table 3-1**). In the longer run, between 2016 and 2035, total enplanements will increase at 1.8 percent per annum. Yearly passengers at Charlotte will reach approximately 62.6 million by 2035, compared to 44.4 million in 2016. The resulting passenger forecasts are presented in **Table 3-1**, **Table 3-2**, and **Table 3-3** below.

Table 3-1 Passenger Forecast – Base Case

Year	Domestic O&D	Int'l O&D	Connecting	Total
2005	6,762,157	899,855	20,544,040	28,206,052
2010	8,613,655	1,091,525	28,549,027	38,254,207
2011	8,752,758	1,193,081	29,097,869	39,043,708
2012	9,107,012	1,217,000	30,904,360	41,228,372
2013	9,513,203	1,266,955	32,676,733	43,456,891
2014	9,718,241	1,248,403	33,309,205	44,275,849
2015	10,353,573	1,343,355	33,173,903	44,870,831
2016	11,162,763	1,393,853	31,865,406	44,422,022
2017	11,547,629	1,491,064	32,454,311	45,493,004
2020	12,686,885	1,761,671	34,343,300	48,791,856
2025	14,615,653	2,285,876	36,120,282	53,021,811
2030	16,524,455	2,903,787	38,265,291	57,693,533
2035	18,378,400	3,621,209	40,604,915	62,604,524
Compound Annual Growth Rates (CAGRs)				
2005 – 2010	5.0%	3.9%	6.8%	6.3%
2010 – 2015	3.7%	4.2%	3.0%	3.2%
2016 – 2020	3.3%	6.0%	1.9%	2.4%
2020 – 2025	2.9%	5.3%	1.0%	1.7%
2025 – 2030	2.5%	4.9%	1.2%	1.7%
2030 – 2035	2.1%	4.5%	1.2%	1.6%
2016 – 2035	2.7%	5.2%	1.3%	1.8%

Source: Airport Statistics data for historical; U.S. DOT T100; InterVISTAS analysis for forecasts.
Note: Data is reflected in calendar years

Table 3-2 Passenger Forecast – High Case

Year	Domestic O&D	Int’l O&D	Connecting	Total
2005	6,762,157	899,855	20,544,040	28,206,052
2010	8,613,655	1,091,525	28,549,027	38,254,207
2011	8,752,758	1,193,081	29,097,869	39,043,708
2012	9,107,012	1,217,000	30,904,360	41,228,372
2013	9,513,203	1,266,955	32,676,733	43,456,891
2014	9,718,241	1,248,403	33,309,205	44,275,849
2015	10,353,573	1,343,355	33,173,903	44,870,831
2016	11,162,763	1,393,853	31,865,406	44,422,022
2017	11,612,917	1,506,527	32,616,771	45,736,215
2020	12,970,619	1,836,321	35,048,853	49,855,794
2025	15,335,467	2,508,638	37,877,975	55,722,080
2030	17,760,411	3,351,055	41,311,086	62,422,552
2035	20,196,602	4,387,422	45,223,392	69,807,416
Compound Annual Growth Rates (CAGRs)				
2005 – 2010	5.0%	3.9%	6.8%	6.3%
2010 – 2015	3.7%	4.2%	3.0%	3.2%
2016 – 2020	3.8%	7.1%	2.4%	2.9%
2020 – 2025	3.4%	6.4%	1.6%	2.2%
2025 – 2030	3.0%	6.0%	1.8%	2.3%
2030 – 2035	2.6%	5.5%	1.8%	2.3%
2016 – 2035	3.2%	6.2%	1.9%	2.4%

Source: Airport Statistics data for historical; U.S. DOT T100; InterVISTAS analysis for forecasts.
Note: Data is reflected in calendar years

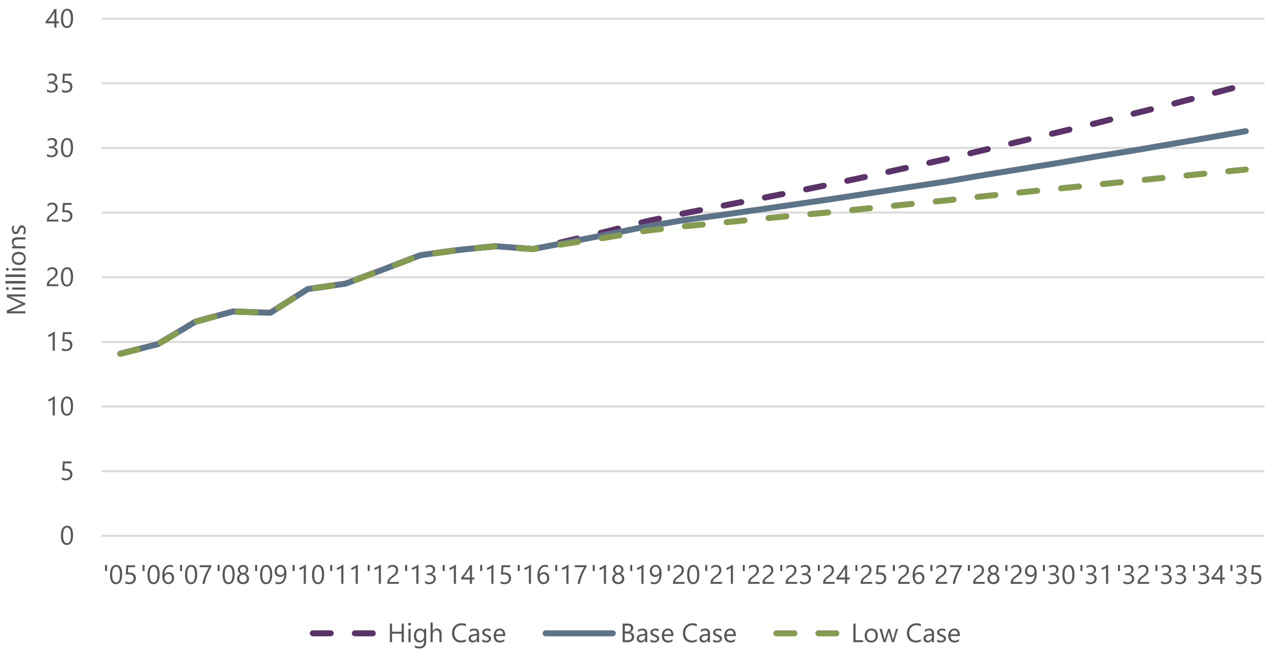
Table 3-3 Passenger Forecast – Low Case

Year	Domestic O&D	Int'l O&D	Connecting	Total
2005	6,762,157	899,855	20,544,040	28,206,052
2010	8,613,655	1,091,525	28,549,027	38,254,207
2011	8,752,758	1,193,081	29,097,869	39,043,708
2012	9,107,012	1,217,000	30,904,360	41,228,372
2013	9,513,203	1,266,955	32,676,733	43,456,891
2014	9,718,241	1,248,403	33,309,205	44,275,849
2015	10,353,573	1,343,355	33,173,903	44,870,831
2016	11,162,763	1,393,853	31,865,406	44,422,022
2017	11,482,340	1,475,601	32,319,802	45,277,743
2020	12,407,831	1,689,593	33,762,591	47,860,015
2025	13,926,024	2,082,707	34,695,996	50,704,728
2030	15,368,749	2,517,566	35,829,682	53,715,997
2035	16,715,958	2,993,229	36,958,319	56,667,506
Compound Annual Growth Rates (CAGRs)				
2005 – 2010	5.0%	3.9%	6.8%	6.3%
2010 – 2015	3.7%	4.2%	3.0%	3.2%
2016 – 2020	2.7%	4.9%	1.5%	1.9%
2020 – 2025	2.3%	4.3%	0.5%	1.2%
2025 – 2030	2.0%	3.9%	0.6%	1.2%
2030 – 2035	1.7%	3.5%	0.6%	1.1%
2016 – 2035	2.1%	4.1%	0.8%	1.3%

Source: Airport Statistics data for historical; U.S. DOT T100; InterVISTAS analysis for forecasts.
Note: Data is reflected in calendar years

The figure below (**Figure 3-1**) reflects the high and low growth scenarios compared to the base case. Forecasted enplanements for the high case are 12 percent above the base case, reaching 33.8 million enplanements in 2035. As for the low scenario, enplanements are projected to be 28.3 million, nine percent below the base case scenario. The variance for the revised high/low forecast is 23 percent.

Figure 3-1 Enplanements Forecast – Base, High, Low Cases



Source: CLT statistics data for historical; U.S. DOT T100; InterVISTAS analysis for forecasts.

3.3.3 Comparative Enplaned Passenger Forecasts

Forecasts that are part of an EIS are required to be approved by the FAA. The FAA "must ensure that the forecast is based on reasonable planning assumptions, uses current data, and is developed using appropriate forecast methods."[18] In addition, forecasts must be deemed to be consistent with the FAA's Terminal Area Forecast (TAF). The TAF is an annual forecast of passengers and aircraft operations produced by the FAA for all existing airports in the National Plan of Integrated Airport Systems[19]. The comparison shown below (**Figure 3-2**) shows the most recent version of the TAF, which uses FY 2016 as the base year and provides forecasts for FY 2017-2045. In addition to its baseline forecast, the TAF also shows optimistic and pessimistic scenarios. In order to be approved, this EIS forecast must fall within a defined, acceptable range of the baseline TAF forecast: ±10 percent in the five-year forecast period and ±15 percent in the 10-year forecast period.

As shown in the table below **(Table 3-4**), the EIS passenger forecast matches closely with the FAA TAF for the future forecast years.[20] The EIS forecast is 0.5 percent below the TAF base forecast by 2035, which is within the TAF consistency requirements required by the FAA. This forecast technical memorandum is accompanied by a letter to the FAA requesting approval for its use in this EIS process.

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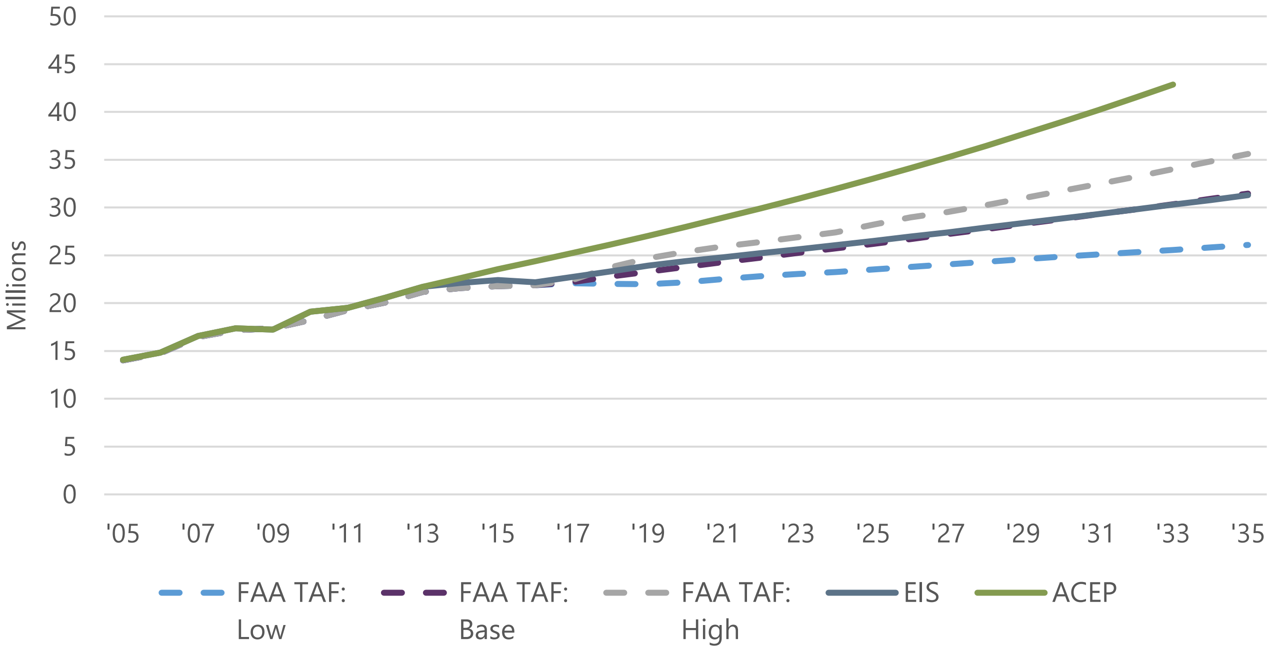
[18] FAA, Approval of Local Forecasts, 2008, page 1.

[19] CLT is a large hub airport.

[20] The TAF forecast has been converted into calendar years for comparison purposes. Calendar year figures were determined by assuming 75 percent of operations in the base fiscal year and 25 percent of operations in the following fiscal year (i.e., for CY 2016: 75 percent of FY 2016 and 25 percent of FY 2017).

Figure 3-2 Historical and Forecast Enplaned Passengers – EIS, TAF and ACEP



Source: Airport statistics data for historical; U.S. DOT T100 data; InterVISTAS analysis for forecasts.
FAA TAF: https://www.faa.gov/data_research/aviation/taf/
CLT Master Plan Update: Phase 1, Airport Capacity Enhancement Plan
Note: The forecast in the ACEP ends in 2033

Table 3-4 Historical and Forecast Enplaned Passengers Compound Average Growth Rates – EIS, TAF, and ACEP

Period	EIS	TAF	ACEP
2010 – 2016	2.5%	3.1%	4.2%
2016 – 2020	2.4%	2.1%	3.5%
2020 – 2025	1.7%	2.0%	3.4%
2025 – 2030	1.7%	1.9%	3.3%
2030 – 2035	1.6%	1.8%	3.3%
2016 – 2035	1.8%	1.9%	3.5%

Source: Airport statistics data for historical; U.S. DOT T100; InterVISTAS analysis for forecasts.
FAA TAF: https://www.faa.gov/data_research/aviation/taf/
CLT Master Plan Update: Phase 1, Airport Capacity Enhancement Plan
Note: ACEP Growth Rates are for 2030-2033, and 2013-2033
Note: Comparison is made between the baseline EIS and TAF forecasts.

The graph (**Figure 3-2**) and table (**Table 3-4**) above, also show a comparison of the EIS forecast to that in the ACEP. When compared to the enplanement forecast in the ACEP, both the EIS and TAF forecasts are 29.3 percent and 29.2 percent below the ACEP in 2033, respectively. The ACEP forecast used 2013 as a base year, while 2016 is the base year in the EIS forecast, and has overestimated enplanements in 2016 by over 2 million passengers.

Since the ACEP forecast was completed, several of the assumptions used in the forecast have changed.

- At the time the ACEP forecast was created, the merger of American Airlines and US Airways had only recently been announced. The ACEP forecast assumed that the merger "is not expected to negatively affect passenger growth at CLT."[21] While the merger has not negatively affected passenger traffic at CLT as of yet, American Airlines has altered the role of CLT in its network, specifically in international routes.
- The ACEP assumed that "Growth in the Latin American economies will be the primary driver of continued growth in international air travel at CLT."[22] While Charlotte maintained service to the Caribbean, American Airlines shifted international service among its hub and withdrew its service from Charlotte to Sao Paulo and Rio de Janeiro in Brazil, instead relying on its flights from Miami to connect the U.S. to South America. In 2016, Charlotte had no flights to South America and American Airlines is not expected to add any in the near future according to the carrier's network planners.
- In addition, the ACEP report states that "Domestic enplanements at CLT increased 4.8 percent annually between 1990 and 2013…This was primarily driven by domestic connections…"[23] However, since the ACEP forecast was completed, domestic O&D passengers continued to grow, while domestic connections have grown more slowly or even decline (-1.1 percent on average per annum from 2013-2016).
- The ACEP "assumed that connecting domestic enplanements would account for 75.0 percent of the total domestic enplanements throughout the forecast period."[24] Instead, the connecting share of passengers has declined to 71.7 percent in 2016.
- The ACEP assumed continued high fuel prices; however, fuel prices have plummeted in recent years, changing the economics of airline operations.

All of these factors/assumptions explain why the ACEP forecast is higher than that of the more recent TAF and EIS forecasts.

3.4 Operations

This section presents the methodology and results for projected aircraft operations at CLT for the 2017-2035 period.

3.4.1 Operations Forecast Assumptions

Forecasts of annual commercial passenger aircraft operations are based on forecast passenger traffic demand. Passenger aircraft landings depend on the average aircraft size and average load factor (i.e., average passenger per flight), as represented by the formula below:

$$\boldsymbol{Passenger\ Aircraft\ Operations} = (Passenger\ Forecasts)/(Avg.\ Aircraft\ Size\ x\ Avg.\ Load\ Factor)$$

$$where\ Avg.\ Aircraft\ Size\ x\ Avg.\ Load\ Factor = Avg.\ Passengers\ per\ Aircraft\ Movement$$

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[21] CLT Master Plan Update: Phase 1, Airport Capacity Enhancement Plan

[22] Ibid.

[23] Ibid.

[24] Ibid.

Forecasts of average load factors were prepared (including marginal growth) and applied to the passenger figures (**Table 3-5**).

Table 3-5 Load Factor Assumptions

Region	2016	2035
Commuter – Domestic	80.2%	81.4%
Air Carrier – Domestic	84.0%	85.0%
Air Carrier – Canada	77.4%	82.0%
Air Carrier – Caribbean, Mexico, Central America	83.8%	85.0%
Air Carrier – South America	80.0%	82.0%
Air Carrier – Trans-Atlantic	75.1%	80.0%
Air Carrier – Trans-Pacific	80.0%	85.0%

Source: InterVISTAS assumptions.

Projections of passenger operations for Base, High and Low Cases were created by applying these load factor assumptions and assumptions regarding aircraft size (discussed in Section 3.4.5 below). Forecasts of annual general aviation and military operations were increased in line with the FAA TAF forecast.

3.4.2 Cargo Operations Forecasts

In 2016, there were 2,696 air cargo operations at CLT, 0.5 percent of total aircraft operations. The forecast of cargo aircraft operations was based on historical operations and forecast air cargo tonnage. It was assumed that the proportion of air cargo that would be transported by cargo aircraft (as opposed to passenger aircraft bellyhold), would remain at 2016 levels throughout the forecast period. Furthermore, it was assumed that the tonnage per cargo aircraft would remain constant over the forecast period.

3.4.3 Annual Operations Forecasts

The resulting base case operations forecasts are presented in **Table 3-6** below. Air carrier aircraft movements are forecast to increase by an average of 1.4 percent per annum, compared with passenger growth of 1.8 percent per annum (the lower growth due to rising load factors and the number of passengers per aircraft). Total operations for the base case forecasted are projected to grow at an average annual rate of 1.2 percent.

Table 3-6 Operations Forecast – Base Case – Charlotte Douglas International Airport

Year	Air Carrier	Air Taxi	GA	Military	Total
2010	331,110	171,836	24,414	1,741	529,101
2011	329,680	184,122	24,131	1,909	539,842
2012	343,121	183,870	23,400	1,702	552,093
2013	356,079	175,051	25,426	1,392	557,948
2014	361,273	156,188	26,321	1,396	545,178
2015	363,667	152,215	25,639	2,423	543,944
2016	400,819	117,378	24,869	2,676	545,742
2017	409,357	118,994	24,935	2,676	555,962
2020	431,503	122,231	25,083	2,676	581,494
2025	464,250	127,137	25,335	2,676	619,399
2030	494,758	130,959	25,588	2,676	653,981
2035	526,759	135,135	25,845	2,676	690,415
Compound Annual Growth Rates					
2010 – 2015	1.9%	-2.4%	1.0%	6.8%	0.6%
2016 – 2020	1.9%	1.0%	0.2%	0.0%	1.6%
2020 – 2025	1.5%	0.8%	0.2%	0.0%	1.3%
2025 – 2030	1.3%	0.6%	0.2%	0.0%	1.1%
2030 – 2035	1.3%	0.6%	0.2%	0.0%	1.1%
2016 – 2035	1.4%	0.7%	0.2%	0.0%	1.2%

Source: Airport Statistics data for historical; U.S. DOT T100; InterVISTAS analysis for forecasts.
Note: Data is reflected in calendar years.
Note: The forecast does not reallocate air taxi operations to air carrier as the seating capacity increases; therefore, the average aircraft size (seats) for air taxi goes above 60 seats.

Table 3-7 Operations Forecast – High Case – Charlotte Douglas International Airport

Year	Air Carrier	Air Taxi	GA	Military	Total
2010	331,110	171,836	24,414	1,741	529,101
2011	329,680	184,122	24,131	1,909	539,842
2012	343,121	183,870	23,400	1,702	552,093
2013	356,079	175,051	25,426	1,392	557,948
2014	361,273	156,188	26,321	1,396	545,178
2015	363,667	152,215	25,639	2,423	543,944
2016	400,819	117,378	24,869	2,676	545,742
2017	411,504	119,523	24,935	2,676	558,638
2020	440,726	124,439	25,083	2,676	592,925
2025	483,014	129,731	25,335	2,676	640,757
2030	531,968	138,249	25,588	2,676	698,481
2035	585,654	147,635	25,845	2,676	761,810
Compound Annual Growth Rates					
2010 – 2015	1.9%	-2.4%	1.0%	6.8%	0.6%
2016 – 2020	2.4%	1.5%	0.2%	0.0%	2.1%
2020 – 2025	1.8%	0.8%	0.2%	0.0%	1.6%
2025 – 2030	1.9%	1.3%	0.2%	0.0%	1.7%
2030 – 2035	1.9%	1.3%	0.2%	0.0%	1.8%
2016 – 2035	2.0%	1.2%	0.2%	0.0%	1.8%

Source: Airport Statistics data for historical; U.S. DOT T100; InterVISTAS analysis for forecasts.

Note: Data is reflected in calendar years

Note: The forecast does not reallocate air taxi operations to air carrier as the seating capacity increases; therefore, the average aircraft size (seats) for air taxi goes above 60 seats.

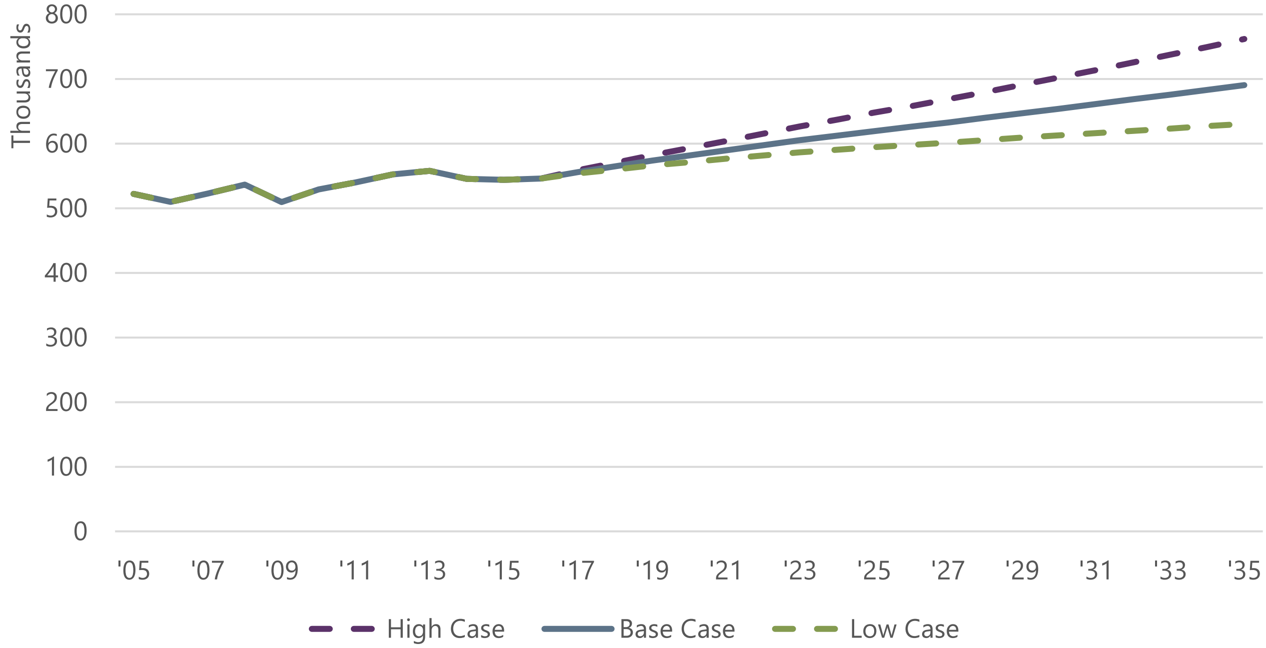
Table 3-8 Operations Forecast – Low Case – Charlotte Douglas International Airport

Year	Air Carrier	Air Taxi	GA	Military	Total
2010	331,110	171,836	24,414	1,741	529,101
2011	329,680	184,122	24,131	1,909	539,842
2012	343,121	183,870	23,400	1,702	552,093
2013	356,079	175,051	25,426	1,392	557,948
2014	361,273	156,188	26,321	1,396	545,178
2015	363,667	152,215	25,639	2,423	543,944
2016	400,819	117,378	24,869	2,676	545,742
2017	407,441	118,506	24,935	2,676	553,557
2020	423,357	120,210	25,083	2,676	571,326
2025	440,261	119,856	25,335	2,676	588,129
2030	459,150	121,963	25,588	2,676	609,377
2035	477,630	124,175	25,845	2,676	630,326
Compound Annual Growth Rates					
2010 – 2015	1.9%	-2.4%	1.0%	6.8%	0.6%
2016 – 2020	1.4%	0.6%	0.2%	0.0%	1.2%
2020 – 2025	0.8%	-0.1%	0.2%	0.0%	0.6%
2025 – 2030	0.8%	0.3%	0.2%	0.0%	0.7%
2030 – 2035	0.8%	0.4%	0.2%	0.0%	0.7%
2016 – 2035	0.9%	0.3%	0.2%	0.0%	0.8%

Source: Airport Statistics data for historical; U.S. DOT T100; InterVISTAS analysis for forecasts.
Note: Data is reflected in calendar years
Note: The forecast does not reallocate air taxi operations to air carrier as the seating capacity increases; therefore, the average aircraft size (seats) for air taxi goes above 60 seats.

In the high growth scenario, total aircraft operations at Charlotte Douglas International will reach over 761,800 operations, with an average annual growth rate of 1.8 percent through 2035 (**Figure 3-3** and **Table 3-7**). While a period of low growth is projected to reach 630,300 operations in 2035 with an average annual growth rate of 0.8 percent (**Table 3-8**).

Figure 3-3 Operations Forecast – Base, High, Low Cases – Charlotte Douglas International Airport



Source: Airport Statistics data for historical; U.S. DOT T100; InterVISTAS analysis for forecasts.

3.4.4 Comparative Operations Forecasts

The chart (**Figure 3-4)** and table (**Table 3-9**) below provide a comparison with the FAA TAF forecasts and the ACEP forecasts. The EIS forecast is lower than the baseline FAA forecast, with forecast volumes in 2033 being 9.1 percent below that of the TAF, and 27.4 percent below the ACEP forecast in 2033.[25]

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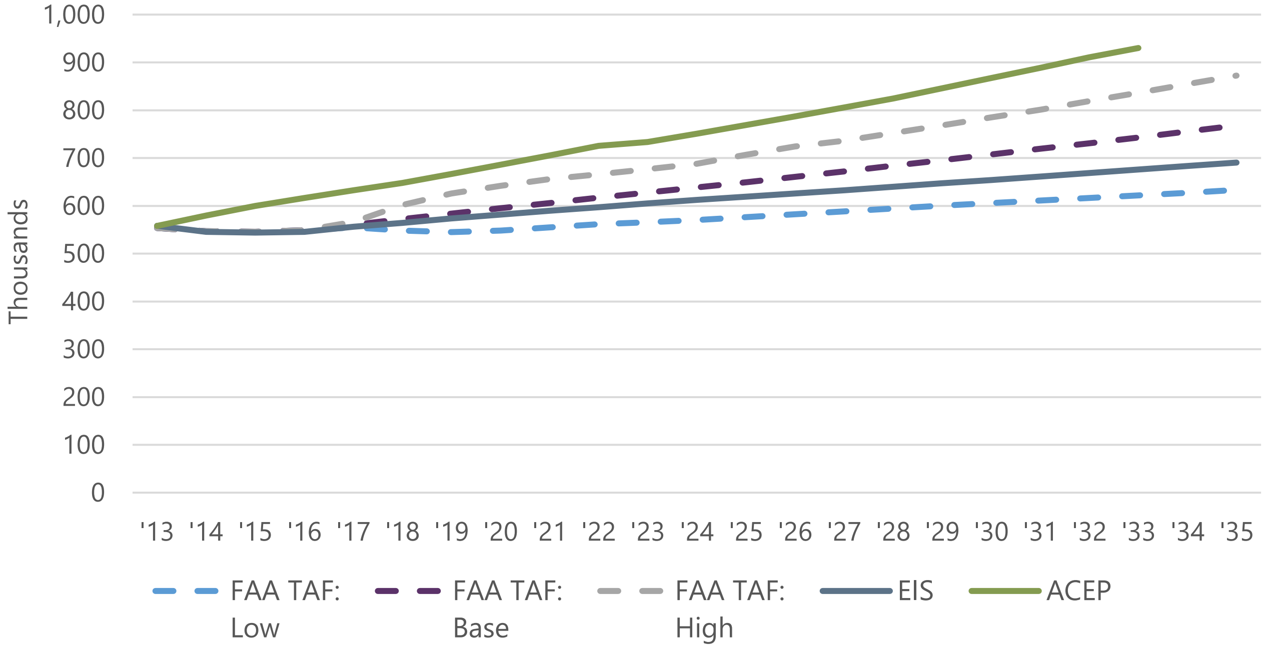
[25] The ACEP forecast extended to 2033 only.

Figure 3-4 Historical and Forecast Aircraft Operations – EIS, TAF and ACEP



Source: Airport statistics data for historical; U.S. DOT T100 data; InterVISTAS analysis for forecasts.
FAA TAF: https://www.faa.gov/data_research/aviation/taf/
CLT Master Plan Update: Phase 1, Airport Capacity Enhancement Plan

Table 3-9 Historical and Forecast Operations– EIS, TAF and ACEP

	Year	EIS	FAA TAF	ACEP	EIS vs. TAF	EIS vs. ACEP
Passenger Enplanements						
Base Year	2016	22,173,747	21,900,456	24,408,300	1.2%	-9.2%
Base Year + 1	2017	22,746,502	22,231,446	25,266,400	2.3%	-10.0%
Build Year	2028	27,893,348	27,735,137	36,449,000	0.6%	-23.5%
Build Year + 5	2033	30,298,324	30,353,627	42,865,500	-0.2%	-29.3%
Commercial Operations						
Base Year	2016	518,197	521,304	579,260	-0.6%	-10.5%
Base Year + 1	2017	528,351	532,647	594,800	-0.8%	-11.2%
Build Year	2028	611,620	655,739	783,220	-6.7%	-21.9%
Build Year + 5	2033	647,224	714,678	886,260	-9.4%	-27.0%
Total Operations						
Base Year	2016	545,742	548,653	616,400	-0.5%	-11.5%
Base Year + 1	2017	555,962	560,057	632,300	-0.7%	-12.1%
Build Year	2028	639,783	683,696	824,740	-6.4%	-22.4%
Build Year + 5	2033	675,643	742,889	930,080	-9.1%	-27.4%

Source: Airport statistics data for historical; U.S. DOT T100 data; InterVISTAS analysis for forecasts.
FAA TAF: https://www.faa.gov/data_research/aviation/taf/
CLT Master Plan Update: Phase 1, Airport Capacity Enhancement Plan
Note: A version of this table with Base Year +5,10,15 years is shown in the Appendix.
Note: Comparison is made between the baseline EIS and TAF forecasts.

3.4.5 Aircraft Fleet Mix

One of the other major assumptions required to convert the passenger forecast into aircraft operations is the average aircraft size, which includes assumptions regarding how the fleet of aircraft using CLT will change in the future. Forecasts of average aircraft size were prepared and applied, pointing to a trend of larger aircraft. In particular, the fleet orders of American Airlines which include large orders for the Airbus A321neo (starting in 2019) and the Boeing B737Max8 (starting in 2021), were included. The addition of these aircraft are expected to increase the average aircraft size at CLT (confirmed in interviews with American Airlines).

Average Aircraft Size (Seats per Departure) Assumptions:

- **Commuter** – commuter aircraft, including large and small regional jets, are assumed to increase from 59 seats in 2016 to 62 seats in 2022 and 64 seats by 2035. This increase assumes network carriers will continue retiring smaller regional jets and replace them with more efficient larger regional jets.
- **Domestic** – seats per aircraft increase from 142 in 2016 to 145 in 2022 and 148 by 2035, as airlines upgauge; e.g., moving some operations from A319 to A320, and from A320 to A321Neo, etc.
- **Canada** – seats per departure to Canada decreased following the 2008-2010 financial crisis. However, seats per departure have stabilized since 2013. Average seats are forecast to increase gradually from 62 seats in 2016 to 64 in 2022 and 67 in 2035.

- **Caribbean, Mexico, South America** – seats per departures has stayed relatively flat for this region at 159 seats - assumed to be 162 seats by 2022 and 166 seats by 2035.
- **South America** – US Airways previously serviced Brazil from 2009-2015, with average seats per departure of 204 in 2015. Service is assumed to resume by 2020, operating with 209 seats.
- **Trans-Atlantic** – seats per departures are projected to increase from 261 seats in 2016 to 265 in 2035.
- **Trans-Pacific** – does not currently have service, assumed this would remain the case through 2035

3.5 Cargo

This section presents the methodology and forecast results for cargo tonnage at CLT for the 2017-2035 period.

3.5.1 Cargo Forecast Assumptions

Cargo forecasts were prepared for Base, High and Low Cases, with differing assumptions for each case. The cargo growth forecast is based on expert judgement.

3.5.1.1 Base Case

The continuation of activity is expected to spur growth in the short term, averaging 6 percent per annum up to 2019. After that, cargo activity growth at the airport is expected to taper off in the long term as Amazon plans to build a centralized air hub at Cincinnati/Northern Kentucky Airport to support its growing fleet of Prime Air cargo planes. Cargo growth after 2020 is projected to range from 2-3 percent per annum in line with historical levels. While the Department does not currently have plans to expand its cargo facilities, the Department recently completed an expansion of the cargo ramp, providing 12,000 square yards of additional space. Airport facilities are assumed to accommodate future cargo activity levels.

The following assumptions were made concerning the cargo forecast at Charlotte:

- The U.S. economy as well as Charlotte’s local economy will experience moderate and steady growth between 2016 and 2041;
- Rapid growth due to Amazon will slow by 2019;
- Key integrated carriers (e.g., FedEx, UPS, etc.) will maintain their services at Charlotte airport;
- Passenger air carriers would continue to provide cargo services through their belly capacity; regional jets would provide limited cargo capacity
- Long-term (2020-2035) growth is forecast to average 2.4 percent per annum, close to the average between 2011 and 2016 (2.3 percent per annum – see Section 2.5).

3.5.1.2 High Case

To reflect a high growth scenario, an adjustment of +0.5 percentage points was made to the annual cargo growth rate.

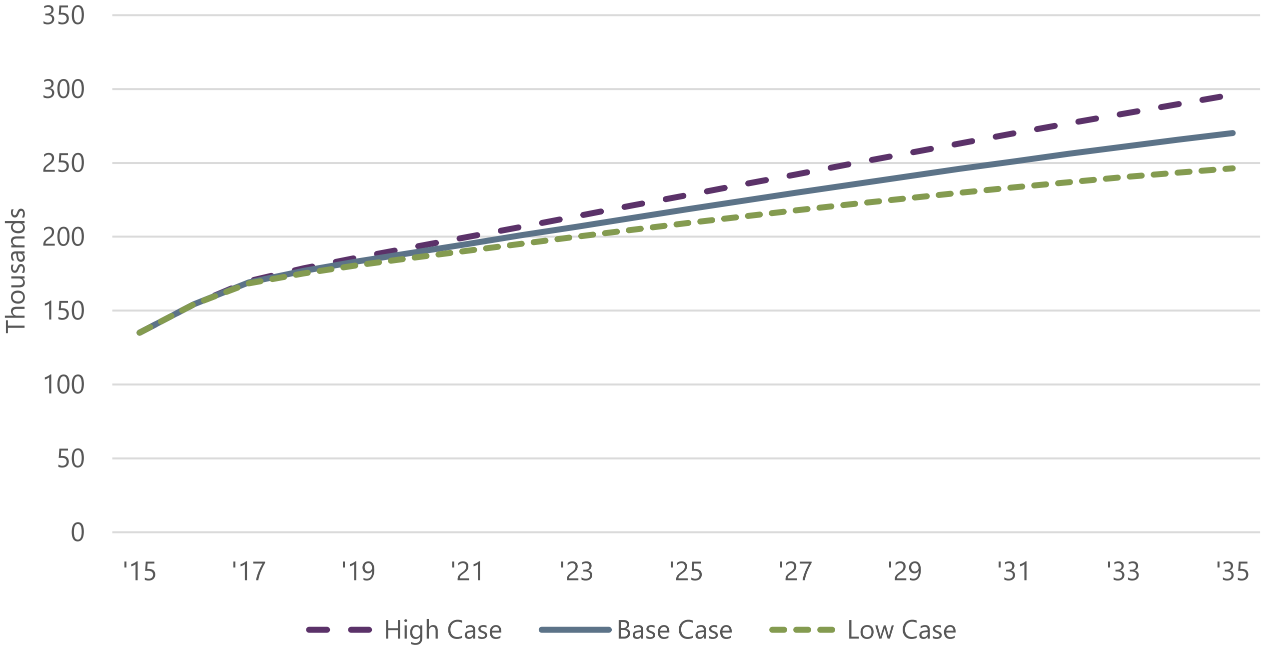
3.5.1.3 Low Case

For the low growth scenario, it was assumed Amazon growth in the early part of the forecast is curtailed, and an adjustment of -0.5 percentage points was made to the annual cargo growth rate.

3.5.2 Annual Cargo Forecasts

In the Base Case forecast, cargo tonnage is expected to grow an average of 3.0 percent per year reaching 270,215 tons in 2035, compared to 154,477 tons in 2016 (**Figure 3-5**). In the High Case forecast average annual growth increases to 3.5 percent per year, reaching 296,264 tons in 2035. While in the Low Case, cargo is projected to reach 246,346 tons by 2035, with an average annual growth rate of 2.5 percent.

Figure 3-5 Historical and Forecast Cargo Tonnage – Base, High, Low Cases – Charlotte Douglas International Airport



Source: Airport Statistics data for historical; U.S. DOT T100; InterVISTAS analysis for forecasts.

3.6 Conclusion

The forecasts presented in this technical memorandum will be used as an input into several subsequent analyses in the EIS. The Base Case forecast serves as the most likely future demand scenario given no constraints on traffic growth at the Airport; the High and Low Cases serve as indicators of how actual demand could vary above/below the Base Case depending on changes in the economic environment or changes in strategic decisions made by American Airlines. The annual forecasts for 2028 (Build Year) and 2033 (Build Year + 5) will be converted into Design Day Schedules including details of individual flights. Such schedules are required to conduct the capacity delay analysis and evaluate delays in airspace, runway usage, taxi-in/out times, and gate usage. Simulation of a Design Day Schedule for 2016 (based on current OAG schedules) will determine the presence and location of existing delays; the schedules for 2028 and 2033 will be used as inputs to model future delays in the absence of the Project (No Action).

Appendix 1: Additional Data

Domestic O&D Traffic Parameter Estimates (1998-2016)

Variable	Parameter Estimate	T-Statistic
Constant	-22.53	-5.92
Ln (Charlotte GDP)	1.19	10.10
Ln (2001 Dummy)	-0.13	-1.41
Ln (2002 Dummy)	-0.17	-1.83
Adjusted-R^2	0.89	

Canada O&D Traffic Parameter Estimates – Outbound (1998-2016)

Variable	Parameter Estimate	T-Statistic
Constant	-20.19	-5.09
Ln (Charlotte GDP)	0.97	7.91
Ln (2001 Dummy)	-0.05	-0.48
Ln (2002 Dummy)	0.17	1.72
Adjusted-R^2	0.79	

Canada O&D Traffic Parameter Estimates – Inbound (1998-2016)

Variable	Parameter Estimate	T-Statistic
Constant	-43.24	-10.38
Ln (Canadian GDP)	1.93	13.00
Ln (2001 Dummy)	-0.07	-0.92
Ln (2002 Dummy)	0.01	0.10
Adjusted-R^2	0.91	

Caribbean (including Mexico and the Caribbean) O&D Traffic Parameter Estimates – Outbound (1998-2016)

Variable	Parameter Estimate	T-Statistic
Constant	-73.08	-12.37
Ln (Charlotte GDP)	2.64	14.48
Ln (2001 Dummy)	-0.11	-0.78
Ln (2002 Dummy)	-0.03	-0.23
Adjusted-R^2	0.93	

Caribbean (including Mexico and the Caribbean) O&D Traffic Parameter Estimates – Inbound (1998-2016)

Variable	Parameter Estimate	T-Statistic
Constant	-87.26	-11.52
Ln (Regional GDP)	3.50	12.93
Ln (2001 Dummy)	-0.27	-1.74
Ln (2002 Dummy)	-0.22	-1.41
Adjusted-R^2	0.92	

South America O&D Traffic Parameter Estimates – Outbound (1998-2016)

Variable	Parameter Estimate	T-Statistic
Constant	-88.11	-8.93
Ln (Charlotte GDP)	3.03	9.94
Ln (Dummy 2001)	-0.01	-0.04
Ln (Dummy 2002)	-0.13	-0.55
Adjusted-R^2	0.87	

South America O&D Traffic Parameter Estimates – Inbound (1998-2016)

Variable	Parameter Estimate	T-Statistic
Constant	-97.56	-12.83
Ln (SAM GDP)	3.67	14.06
Ln (Dummy 2001)	0.10	0.48
Ln (Dummy 2002)	0.01	0.06
Adjusted-R^2	0.93	

Trans-Atlantic O&D Traffic Parameter Estimates – Outbound (1998-2016)

Variable	Parameter Estimate	T-Statistic
Constant	-27.81	-3.97
Ln (Charlotte GDP)	1.24	5.74
Ln (Dummy 2001)	0.08	0.47
Ln (Dummy 2002)	-0.36	-2.11
Adjusted-R^2	0.72	

Trans-Atlantic O&D Traffic Parameter Estimates – Inbound (1998-2016)

Variable	Parameter Estimate	T-Statistic
Constant	-87.76	-7.27
Ln (EU-28 GDP)	3.27	8.26
Ln (Dummy 2001)	-0.06	-0.44
Ln (Dummy 2002)	-0.40	-2.93
Adjusted-R^2	0.84	

Trans-Pacific O&D Traffic Parameter Estimates – Outbound (1998-2016)

Variable	Parameter Estimate	T-Statistic
Constant	-69.67	-10.26
Ln (Charlotte GDP)	2.49	11.85
Ln (Dummy 2001)	0.06	0.34
Ln (Dummy 2002)	0.00	0.02
Adjusted-R^2	0.90	

Trans-Pacific O&D Traffic Parameter Estimates – Inbound (1998-2016)

Variable	Parameter Estimate	T-Statistic
Constant	-37.41	-16.85
Ln (Asia GDP)	1.57	21.47
Ln (2001 Dummy)	0.04	0.51
Ln (2002 Dummy)	0.00	-0.04
Adjusted-R^2	0.97	

Historical Values of the Independent Variables

Year	CLT GRP Real 2009 ($mns)	Canada GDP Real 2010 ($bns)	Caribbean GDP Real 2010 ($bns)	South America GDP Real 2010 ($bns)	Trans-Atlantic GDP Real 2010 ($bns)	Trans-Pacific GDP Real 2010 ($bns)	2001 Dummy	2002 Dummy
1998	79,625	1,211	297	3,742	14,627	9,932	0	0
1999	84,943	1,271	308	3,743	15,050	10,262	0	0
2000	86,498	1,337	318	3,887	15,634	10,741	0	0
2001	89,212	1,359	332	3,920	15,973	11,052	1	0
2002	92,383	1,397	341	3,933	16,178	11,465	0	1
2003	96,233	1,424	351	3,998	16,405	12,012	0	0
2004	102,951	1,469	362	4,245	16,834	12,685	0	0
2005	111,670	1,515	379	4,437	17,191	13,382	0	0
2006	122,351	1,555	399	4,675	17,785	14,223	0	0
2007	128,762	1,586	415	4,937	18,346	15,251	0	0
2008	137,250	1,605	423	5,127	18,456	15,808	0	0
2009	128,097	1,561	419	5,062	17,669	16,128	0	0
2010	116,819	1,614	427	5,354	18,038	17,399	0	0
2011	120,718	1,662	437	5,599	18,350	18,250	0	0
2012	129,882	1,694	446	5,760	18,278	19,140	0	0
2013	126,752	1,728	457	5,918	18,308	20,096	0	0
2014	131,396	1,771	470	5,975	18,547	20,986	0	0
2015	140,388	1,789	483	5,959	18,882	21,922	0	0
2016	144,331	1,829	499	6,013	19,264	22,867	0	0

Source: US Department of Agriculture Economics Research Centre; Woods & Poole 2017

Summary of Domestic Connecting Traffic Forecast (millions)

Year	U.S. Domestic Traffic	CLT Share	CLT Domestic Connections
2016	718.7	1.9%	14.0
2017	738.0	1.9%	14.2
2020	791.4	1.9%	15.0
2025	847.6	1.8%	15.7
2030	917.9	1.8%	16.5
2035	998.0	1.7%	17.4
CAGR			
2016 – 2020	**2.4%**		**1.9%**
2020 – 2025	**1.4%**		**0.8%**
2025 – 2030	**1.6%**		**1.0%**
2030 – 2035	**1.7%**		**1.1%**
2016 – 2035	1.7%		1.2%
Total Change in CLT Share		-10.0%	

Summary of International Connecting Traffic Forecast (millions)

Year	U.S. International Traffic	CLT Share	CLT International Connections
2016	102.3	1.5%	1.6
2017	105.2	1.5%	1.6
2020	118.3	1.5%	1.7
2025	142.7	1.4%	1.9
2030	169.9	1.2%	2.1
2035	201.3	1.1%	2.3
CAGR			
2016 – 2020	**3.7%**		**2.3%**
2020 – 2025	**3.8%**		**2.4%**
2025 – 2030	**3.5%**		**1.9%**
2030 – 2035	**3.4%**		**1.7%**
2016 – 2035	3.6		2.1%
Total Change in CLT Share		-25.0%	

Summary of Charlotte Douglas International Airport Forecast – FAA Template

	Forecast					Compound Annual Growth Rates			
	Base Year 2016	**Base Year+1 2017**	**Base Year+5 2021**	**Base Year+10 2026**	**Base Year+15 2031**	**Base Year+1 2017**	**Base Year+5 2021**	**Base Year+10 2026**	**Base Year+15 2031**
Passenger Enplanements									
Air Carrier	15,640,736	15,850,803	17,411,598	19,089,474	20,951,150	1.3%	2.2%	2.0%	2.0%
Commuter	6,533,011	6,895,699	7,398,772	7,864,182	8,374,605	5.6%	2.5%	1.9%	1.7%
Total	**22,173,747**	**22,746,502**	**24,810,370**	**26,953,656**	**29,325,755**	**2.6%**	**2.3%**	**2.0%**	**1.9%**
Aircraft Operations									
Air Carrier	400,819	409,357	438,230	469,999	501,066	2.1%	1.8%	1.6%	1.5%
Air Taxi	117,378	118,994	123,291	127,823	131,798	1.4%	1.0%	0.9%	0.8%
Subtotal	*518,197*	*528,351*	*561,520*	*597,822*	*632,864*	*2.0%*	*1.6%*	*1.4%*	*1.3%*
General Aviation	24,869	24,935	25,134	25,386	25,639	0.3%	0.2%	0.2%	0.2%
Military	2,676	2,676	2,676	2,676	2,676	0.0%	0.0%	0.0%	0.0%
Total Operations	**545,742**	**555,962**	**589,330**	**625,884**	**661,180**	**1.9%**	**1.5%**	**1.4%**	**1.3%**
Peak Hour Operations	114	116	*	*	*	1.8%			
Cargo/Mail									
Enplaned and Deplaned Tons	154,477	169,152	195,221	224,125	251,111	9.5%	4.8%	3.8%	3.3%
Operational Factors									
Average Aircraft Size (seats)									
Air Carrier	144	144	146	147	149	0.0%	0.3%	0.2%	0.2%
Air Taxi	59	59	61	62	63	0.0%	0.7%	0.5%	0.4%
Average Enplaning Load Factor									
Air Carrier	83.6%	83.7%	83.9%	84.2%	84.5%				
Air Taxi	80.2%	80.3%	80.7%	81.2%	81.4%				

Source: Airport Statistics data for 2016; InterVISTAS analysis for forecast

* Forecast peak hour was only estimated for 2028 (Build Year) and 2033 (Build Year +5). See Table 1-1.

Comparison of EIS and TAF Forecasts – FAA Template

	Year	EIS	FAA TAF	EIS vs TAF
Passenger Enplanements				
Base Year	2016	22,173,747	21,900,456	1.2%
Base Year + 1	2017	22,746,502	22,231,446	2.3%
Base Year + 5	2021	24,810,370	24,283,346	2.2%
Base Year + 10	2026	26,953,656	26,714,161	0.9%
Base Year + 15	2031	29,325,755	29,301,711	0.1%
Commercial Operations				
Base Year	2016	518,197	521,304	-0.6%
Base Year + 1	2017	528,351	532,647	-0.8%
Base Year + 5	2021	561,520	578,313	-2.9%
Base Year + 10	2026	597,822	632,765	-5.5%
Base Year + 15	2031	632,864	691,018	-8.4%
Total Operations				
Base Year	2016	545,742	548,653	-0.5%
Base Year + 1	2017	555,962	560,057	-0.7%
Base Year + 5	2021	589,330	605,921	-2.7%
Base Year + 10	2026	625,884	660,623	-5.3%
Base Year + 15	2031	661,180	719,127	-8.1%

Source: Airport statistics data for historical; U.S. DOT T100 data; InterVISTAS analysis for forecasts.
FAA TAF: https://www.faa.gov/data_research/aviation/taf/

Note: TAF has been converted to Calendar Years for comparison.

FINAL

Gating Analysis

Charlotte Douglas International Airport Environmental Impact Statement

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5/8/2019

Record of Changes/Version History

Change/ Version Number	Date of Change	Sections Changed	Description	Person Entering Change
1	10/17/2018	All	Draft #1	VHB, TransSolutions
2	4/30/2019	All	Draft #2	TransSolutions
3	5/8/2019	All	Final	VHB, TransSolutions

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1

Gating Analysis Approach and Assumptions

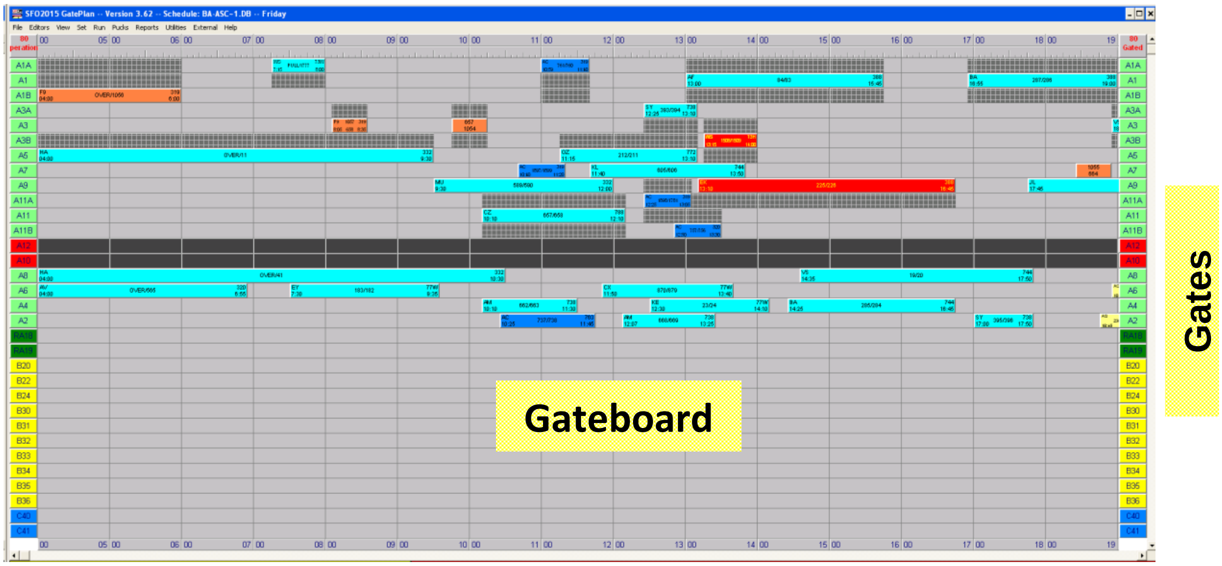
The objectives of this study were to quantify the gate requirements for the CLT EIS flight schedule forecasts for 2016, 2028 and 2033 and to verify if the number of gates identified in the Airport Capital Enhancement Program (ACEP) is still valid. This memo documents the assumptions and approach used in the gating analysis.

1.1 Approach

TransSolutions utilized a gating tool, GatePlan® for this study. Gate characteristics such as aircraft size constraints, assigned airlines, and flight origin (domestic and international) were considered and implemented into the tool. Each flight was gated, adhering to the parameters built into GatePlan®, producing a gateboard similar to that shown in **Figure 1-1**, with gates from top to bottom and the time or hours from left to right. As flights are assigned to gates, they appear in the gateboard, displaying the flight arrival time and departure time.

Parameters used included gate buffer times between flights, minimum gate occupancy times based on domestic versus international flights, splitting flights that have 3 hours or more of ground time to free up contact gates and use hardstand positions. These are described in more detail in the sections below.

Figure 1-1 Sample of GatePlan Gateboard



For this gating analysis, the gates were categorized as regional jet, narrow-body aircraft and widebody aircraft so that the gate requirements could be quantified regardless of the specific terminal layout. Gate requirements were also identified as international-only, domestic-only, or swing gates capable of accommodating both international and domestic arrivals.

1.2 Flight Demand

The flight demands that drive this study are based on the 2028 and 2033 forecasts developed for the Environmental Impact Statement (EIS). **Table 1-1** summarizes the Average Day Peak Month (ADPM) current and projected commercial passenger flights at CLT in the future.

Table 1-1 Current and Projected Daily Commercial Passenger Operations

	Forecast Years Operations		
	2016	**2028**	**2033**
Arrival	737	880	937
Departure	737	880	937

Source: CLT 2035 Activity Forecast, Inter*VISTAS*, June 2017

Table 1-2 summarizes the commercial passenger flight schedule fleet mix for 2016, 2028, and 2033.

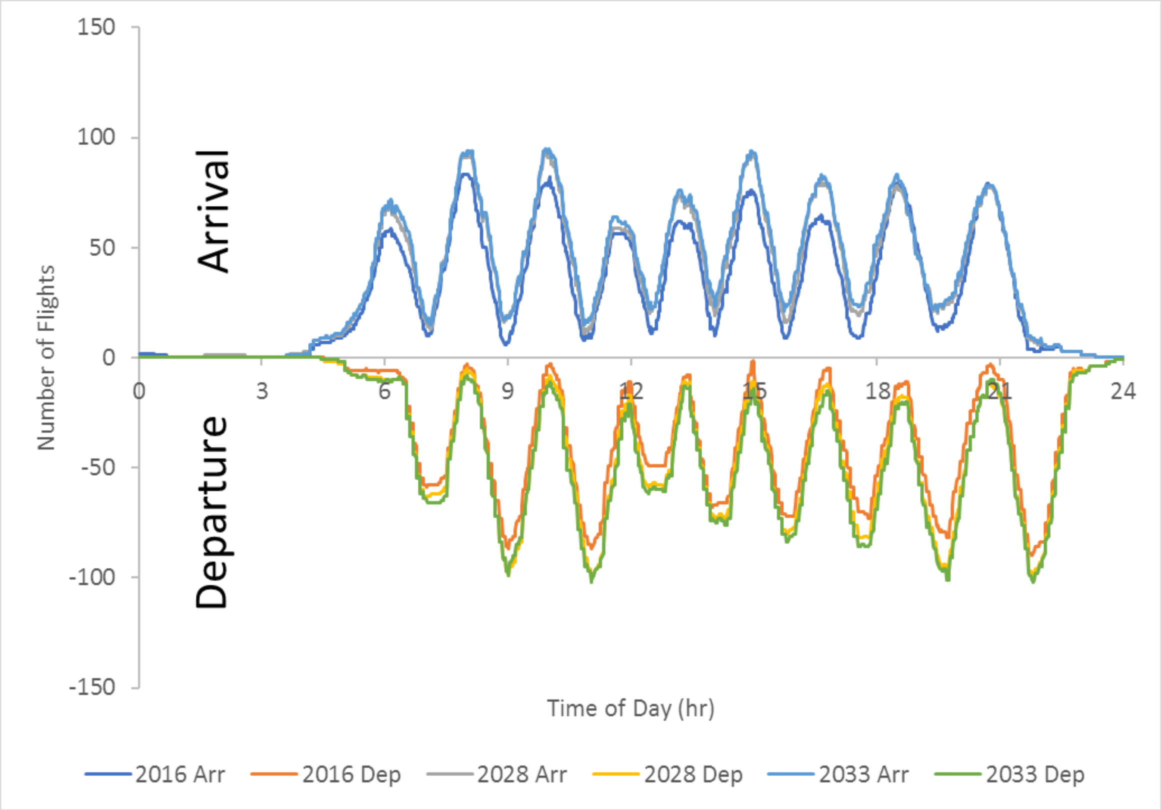
Table 1-2 Current and Projected ADPM Commercial Passenger Fleet Mix (Daily Operations Count)

	2016		**2028**		**2033**	
Aircraft Group	**Arrivals**	**Departures**	**Arrivals**	**Departures**	**Arrivals**	**Departures**
Regional Jet	398	398	481	481	494	494
Narrow-body	330	330	388	389	431	432
Widebody	9	9	11	10	12	11
Total	737	737	880	880	937	937

Source: CLT 2035 Activity Forecast, Inter*VISTAS*, June 2017

Figure 1-2 illustrates the rolling 60-minute commercial passenger arrival and departure operations at CLT.

Figure 1-2 Rolling 60-Minute Commercial Passenger Flight Profile



Source: TransSolutions analysis of EIS forecasts CLT EIS Study, 2018

The majority of the flights in the design day flight schedules were routed, meaning that the arriving and departing flights were paired, or matched. For flights with less than three hours' ground time, the average ground time was 62 minutes (58 minutes for regional and 68 minutes for mainline operations). Approximately 15-percent of the flights have a ground time longer than 3 hours.

1.3 Assumptions

To quantify the number of gates required to accommodate the flight schedules, the analysis assumed there are no adjacency constraints between nearby gates.

International flights must be programmed to arrive at an international-capable gate, while international departure flights may depart from any gate. Note that arrivals from airports with United States (U.S.) preclearance facilities do not require an international gate. In the CLT flight schedules, there are flights from the preclear airports of Aruba (AUA), Bermuda (BDA), Dublin (DUB), and Montreal (YUL).

For domestic flights, a minimum of 15 minutes "buffer" time was used so that at least 15 minutes was planned between the departure from a gate and the subsequent arrival to the gate. For international flights, American Airlines Operations at CLT identified that the "buffer" time used should be at least 20 minutes (email received from Rodney Frascht, April 3, 2019).

To maximize utilization of each gate, flights with longer than three (3) hours of ground time were assumed to be towed to a hardstand as necessary. For the flights that were not matched, or those that were towed to/from a hardstand, the gate occupancy times in **Table 1-3** were used. These times were confirmed with American Airlines Operations personnel at CLT.[1]

Table 1-3 Gate Occupancy Times (in minutes)

	Domestic Flights		International Flights	
Aircraft Type	**Originating/ Pull**	**Terminating/ Push**	**Originating/ Pull**	**Terminating/ Push**
Regional Jet	50	35	55	50
Narrowbody	65	40	85	55
Widebody	70	50	130	75

Source: American Airlines Operations, CLT.

1.4 Gating Scenarios

Gate requirements were quantified for both 2028 and 2033 schedules for two gate assignment policy scenarios as described below. A scenario (Scenario 1: All Gates Shared), where all gates would be shared (common use) for all carriers, was identified but not analyzed as it was not considered to be a realistic planning option.

Predominant carrier – domestic and international. In this scenario (Scenario 2: AA Gates Dedicated; OA Gates Shared), each gate was used by the primary carrier American Airlines (AA) or by other airlines (OA). Results estimated the number of gates for these 12 categories:

- AA Widebody international
- AA Widebody domestic
- AA Narrowbody international
- AA Narrowbody domestic
- AA Regional international
- AA Regional domestic
- AA Widebody international
- OA Widebody international
- OA Widebody domestic
- OA Narrowbody international
- OA Narrowbody domestic
- OA Regional international
- OA Regional domestic

If the international gates could be used for domestic flights at other times of day such that the overall domestic gate requirement is reduced, the international gates were designated as swing gates.

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[1] Email received from Rodney Frascht, FAA, April 4, 2019.

Dedicated airline gates – domestic and international. In this scenario (Scenario 3: All Gates Dedicated), each gate was dedicated for an individual airline; no sharing of gates by multiple airlines was allowed. The results show the number of gates for the same categories as above, but the "OA" gates were split for each airline forecasted to operate at CLT. As in the above scenarios, international gates were designated as swing gates if it reduced the overall gate requirements.

Table 1-4 summarizes the gating scenarios considered in this study.

Table 1-4 Gating Scenarios

Scenario	Dedicated Gates by Airline	Domestic/ International	Aircraft Type (NB, WB, Reg)	Demand Year
Scenario 2: AA Gates Dedicated; OA Gates Shared (Predominant carrier – domestic or international operations)	Only for AA	✓	✓	2028 2033
Scenario 3: All Gates Dedicated (Dedicated airlines – domestic or international operations)	✓	✓	✓	2028 2033

NB: Narrowbody
WB: Widebody
Reg: Regional

The total number of contact gates and hardstands required to accommodate the ADPM flight schedules are reported in **Chapter 2**. The requirements ensure that all flights are gated, with the most efficient gate assignments, in other words using the fewest number of gates such that all flights are assigned to a gate. All gates used at any point in the day are counted in the totals. The requirements are reported by aircraft type and by airline (if relevant), along with number of operations or turns per gate per day for each of the two different scenarios.

2

Gating Analysis

2.1 Gating Solutions

The gating solutions from GatePlan® showing the total number of contact gates required by each of the defined 12 categories are summarized below in **Table 2-1**. Note that the solution for AA was the same in both scenarios.

Table 2-1 Gating Solution Summaries

Scenario 2: AA Gates Dedicated; OA Gates Shared

	AA Gates						OA Gates						
	International			Domestic			International			Domestic			
Planning Year	Wide body	Narrow body	Regional	Wide body	Narrow body	Regional	Wide body	Narrow body	Regional	Wide body	Narrow body	Regional	Total Gates
2016	6	6	0	0	40	50	1	0	0	0	5	5	113
2028	6	8	0	0	43	61	1	0	0	0	6	8	133
2033	6	8	0	0	46	62	1	1	0	0	10	6	140

Scenario 3: All Gates Dedicated

	AA Gates						OA Gates						
	International			Domestic			International			Domestic			
Planning Year	Wide body	Narrow body	Regional	Wide body	Narrow body	Regional	Wide body	Narrow body	Regional	Wide body	Narrow body	Regional	Total Gates
2016	6	6	0	0	40	50	1	0	0	0	8	9	120
2028	6	8	0	0	43	61	1	0	0	0	10	11	140
2033	6	8	0	0	46	62	1	1	0	0	17	9	150

In each of the scenarios, one swing gate was used for AA's DUB arriving flight, which was gated at an international gate even though it is from a TSA Preclearance airport and could be accommodated at a domestic widebody gate. No other domestic flights were accommodated at international gates.

The number of operations per gate in each scenario for each year is shown in **Table 2-2** below.

Table 2-2 Operations Per Gate

	Number of Operations Per Gate		
Planning Year	Scenario 2: AA Gates Dedicated; OA Gates Shared	Scenario3: All Gates Dedicated	Difference Between Scenarios
2016	7.13	6.69	0.44
2028	7.27	6.96	0.31
2033	7.32	6.85	0.47

As part of the gating analysis approach, some flights that were on the ground for more than three (3) hours were designated to be towed to a hardstand position. Additionally, for any gates that had multiple terminating flights, the earlier arriving terminating flights were accounted for at hardstand positions. Similarly, for any gates that had multiple originating flights, the later departing flights were accounted for at hardstand positions. A summary of the total number of hardstand positions needed for these two scenarios is summarized in **Table 2-3**.

Table 2-3 Total Position Requirements

	Total Positions Required					
	Scenario 2: AA Gates Dedicated; OA Gates Shared			Scenario 3: All Gates Dedicated		
Planning Year	Contact Gates	Hardstand Positions	Total Positions	Contact Gates	Hardstand Positions	Total Positions
2016	113	33	146	120	32	152
2028	133	36	169	140	35	175
2033	140	32	172	150	29	179

Note: Each hardstand positions were assumed to be able to accommodate any size aircraft.

The number of hardstand positions changes as the number of contact gates change due to a change in the fleet mix which alters the aircraft remaining overnight that can be accommodated at contact gates rather than at hardstands. Additionally, under the All Gates Dedicated scenario, fewer flights with ground times of more than 3 hours need to be split and moved to hardstand positions.

2.2 Gate Assignment – Gateboards

The gateboards showing the gate assignments for each scenario are included in **Appendix A.**

The following bullets provide information needed to interpret that gateboards,

› The gate names on the far left are for labeling purposes only and do not identify any actual current or future gates. The yellow gates represent domestic gates and the blue gates represent international gates.

› The gate assignments are separated by solid black lines; each grouping represents one of the following.

  - AADO – AA Domestic
  - AAIN – AA International
  - OADO – OA Domestic

  - OAIN – OA International
  - HS - Hardstands
- For the individual flight pucks, the following color scheme applies.
  - Blue – Regional Jets + Turbo props
  - Green – Narrow body
  - Orange – Widebody

2.3 Conclusion

The gating analysis shows that the number of contact gates and total positions required consistently grows as both the schedule grows and as the more restrictive requirements are applied in the All Gates Dedicated scenario.

For the 2033 schedule, in the All Gates Dedicated scenario, 150 contact gates are required as well as an additional 29 hardstand positions for a total of 179 positions.

The number of operations per gate is notably higher in the scenarios that allows sharing between airlines with between 0.3 and 0.5 more operations per gate per day in the less restrictive scenarios.

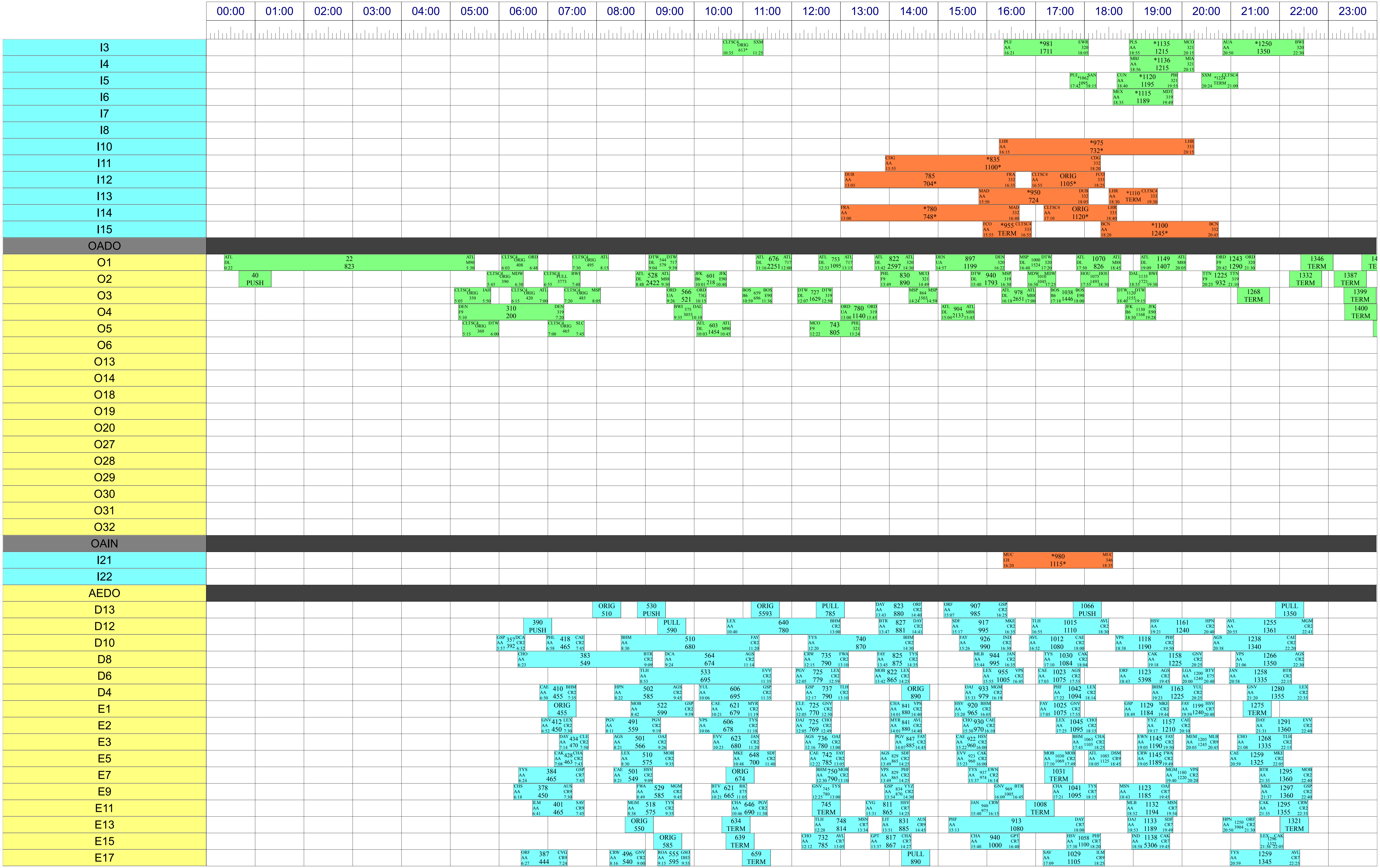
Appendix A: Gateboard Scenarios

1

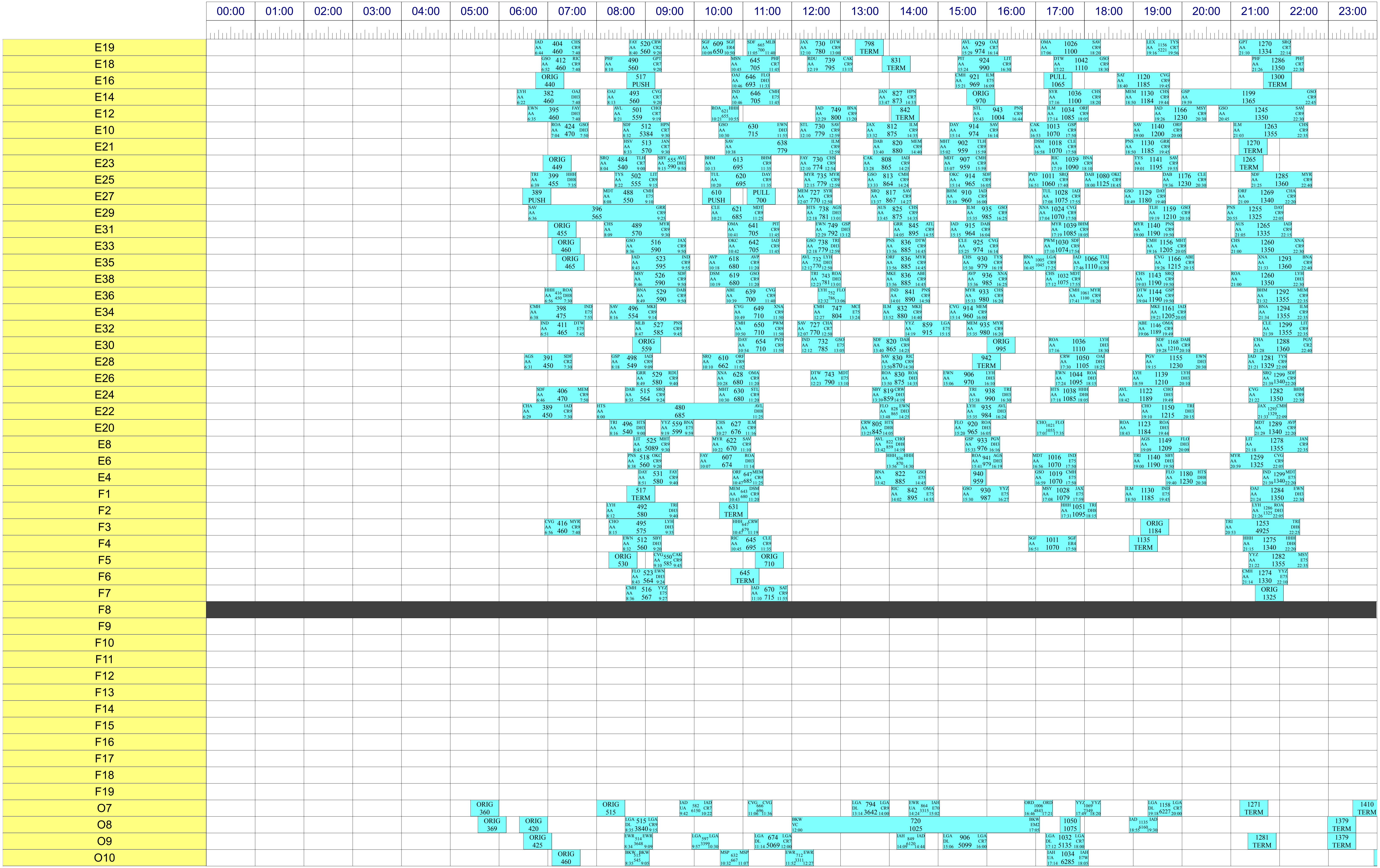
CLT 2016 Gating Scenario 2

CLT 2016-Scenario 2

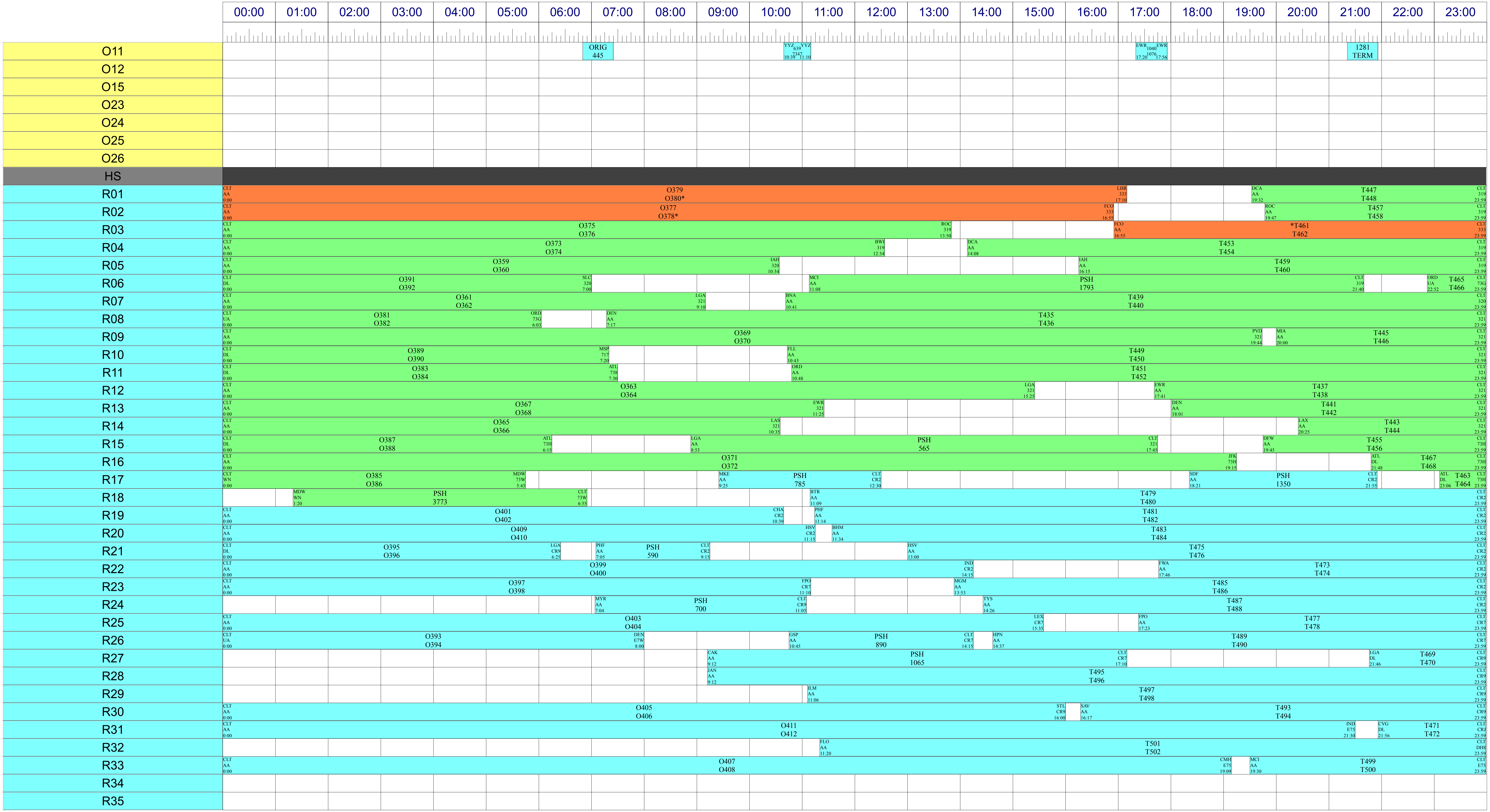
CLT 2016-Scenario 2



CLT 2016-Scenario 2



CLT 2016-Scenario 2

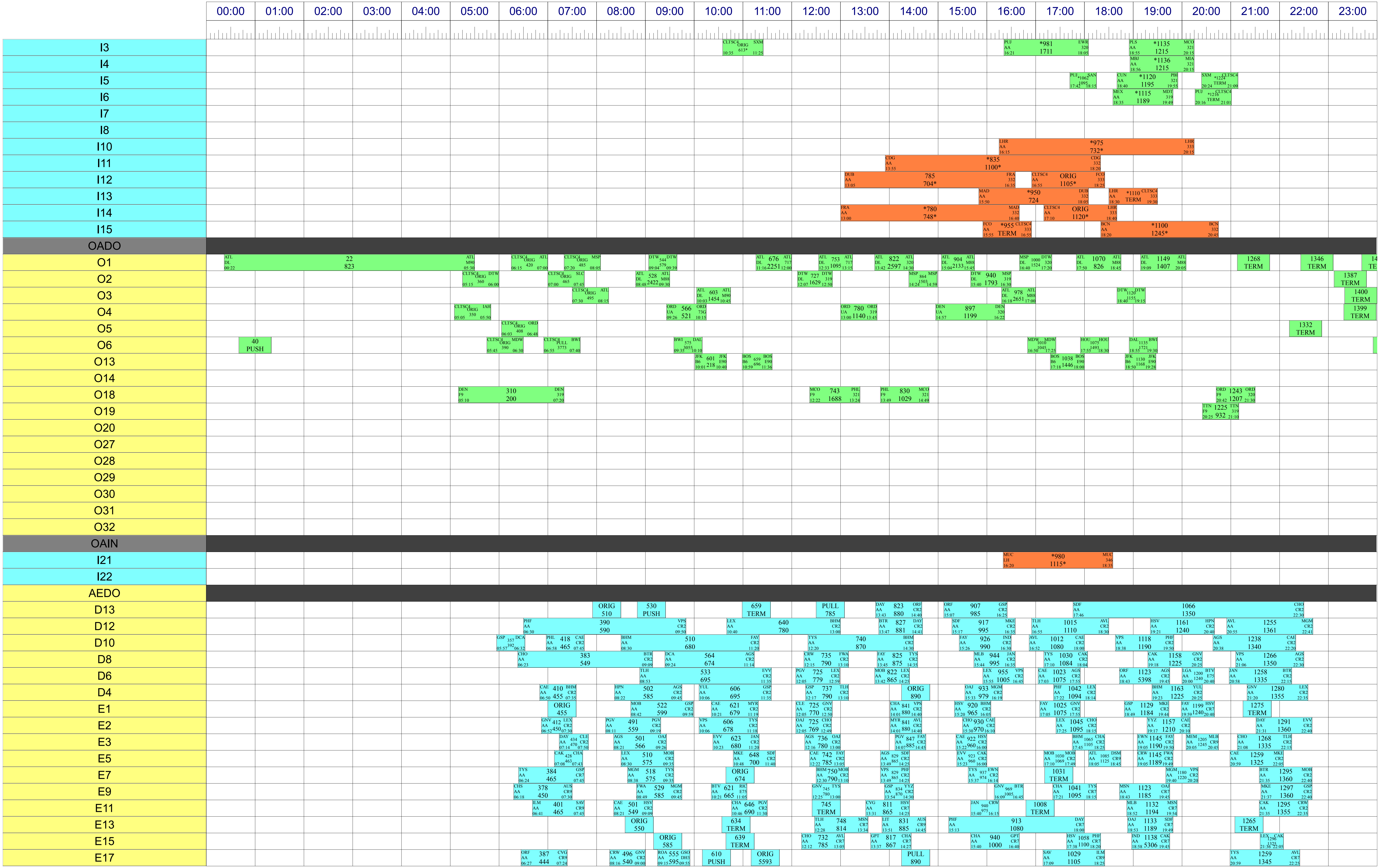


O11	ORIG 445 YYZ 639 7347 YYZ 10:39 11:10 EWR 1040 1076 EWR 17:20 17:56 1281 TERM
O12	
O15	
O23	
O24	
O25	
O26	
HS	
R01	CLT AA 0:00 O379 O380* LHR 333 17:10 DCA AA 19:32 T447 T448 CLT 319 23:59
R02	CLT AA 0:00 O377 O378* FCO 333 16:55 ROC AA 19:47 T457 T458 CLT 319 23:59
R03	CLT AA 0:00 O375 O376 ROC 319 13:50 FCO AA 16:55 *T461 T462 CLT 333 23:59
R04	CLT AA 0:00 O373 O374 BWI 319 12:34 DCA AA 14:08 T453 T454 CLT 319 23:59
R05	CLT AA 0:00 O359 O360 IAH 320 10:34 IAH AA 16:15 T459 T460 CLT 319 23:59
R06	CLT DL 0:00 O391 O392 SLC 320 7:00 MCI AA 11:08 PSH 1793 CLT 319 21:40 ORD UA 22:52 T465 T466 CLT 73G 23:59
R07	CLT AA 0:00 O361 O362 LGA 321 9:10 BNA AA 10:41 T439 T440 CLT 320 23:59
R08	CLT UA 0:00 O381 O382 ORD 73G 6:03 DEN AA 7:17 T435 T436 CLT 321 23:59
R09	CLT AA 0:00 O369 O370 PVD 321 19:44 MIA AA 20:00 T445 T446 CLT 321 23:59
R10	CLT DL 0:00 O389 O390 MSP 717 7:20 FLL AA 10:43 T449 T450 CLT 321 23:59
R11	CLT DL 0:00 O383 O384 ATL 738 7:30 ORD AA 10:48 T451 T452 CLT 321 23:59
R12	CLT AA 0:00 O363 O364 LGA 321 15:25 EWR AA 17:41 T437 T438 CLT 321 23:59
R13	CLT AA 0:00 O367 O368 EWR 321 11:25 DEN AA 18:01 T441 T442 CLT 321 23:59
R14	CLT AA 0:00 O365 O366 LAS 321 10:35 LAX AA 20:25 T443 T444 CLT 321 23:59
R15	CLT DL 0:00 O387 O388 ATL 73H 6:15 LGA AA 8:53 PSH 565 CLT 321 17:45 DFW AA 19:45 T455 T456 CLT 73H 23:59
R16	CLT AA 0:00 O371 O372 JFK 73H 19:15 ATL DL 21:48 T467 T468 CLT 73H 23:59
R17	CLT WN 0:00 O385 O386 MDW 73W 5:45 MKE AA 9:25 PSH 785 CLT CR2 12:30 SDF AA 18:21 PSH 1350 CLT CR2 21:55 ATL DL 23:06 T463 T464 CLT 73H 23:59
R18	MDW WN 1:20 PSH 3773 CLT 73W 6:55 BTR AA 11:09 T479 T480 CLT CR2 23:59
R19	CLT AA 0:00 O401 O402 CHA CR2 10:39 PHF AA 11:14 T481 T482 CLT CR2 23:59
R20	CLT AA 0:00 O409 O410 HSV CR2 11:15 BHM AA 11:34 T483 T484 CLT CR2 23:59
R21	CLT DL 0:00 O395 O396 LGA CR9 6:25 PHF AA 7:05 PSH 590 CLT CR2 9:15 HSV AA 13:00 T475 T476 CLT CR2 23:59
R22	CLT AA 0:00 O399 O400 IND CR2 14:15 FWA AA 17:46 T473 T474 CLT CR2 23:59
R23	CLT AA 0:00 O397 O398 FPO CR7 11:10 MGM AA 13:53 T485 T486 CLT CR2 23:59
R24	MYR AA 7:04 PSH 700 CLT CR9 11:05 TYS AA 14:26 T487 T488 CLT CR2 23:59
R25	CLT AA 0:00 O403 O404 LEX CR7 15:35 FPO AA 17:23 T477 T478 CLT CR7 23:59
R26	CLT UA 0:00 O393 O394 DEN E7W 8:00 GSP AA 10:45 PSH 890 CLT CR7 14:15 HPN AA 14:37 T489 T490 CLT CR7 23:59
R27	CAK AA 9:12 PSH 1065 CLT CR7 17:10 LGA DL 21:46 T469 T470 CLT CR9 23:59
R28	JAN AA 9:12 T495 T496 CLT CR9 23:59
R29	ILM AA 11:06 T497 T498 CLT CR9 23:59
R30	CLT AA 0:00 O405 O406 STL CR9 16:00 SAV AA 16:17 T493 T494 CLT CR9 23:59
R31	CLT AA 0:00 O411 O412 IND E75 21:30 CVG DL 21:56 T471 T472 CLT CRJ 23:59
R32	FLO AA 11:20 T501 T502 CLT DH8 23:59
R33	CLT AA 0:00 O407 O408 CMH E75 19:09 MCI AA 19:30 T499 T500 CLT E75 23:59
R34	
R35	

CLT 2016 Gating Scenario 3

CLT 2016-Scenario 3

CLT 2016-Scenario 3



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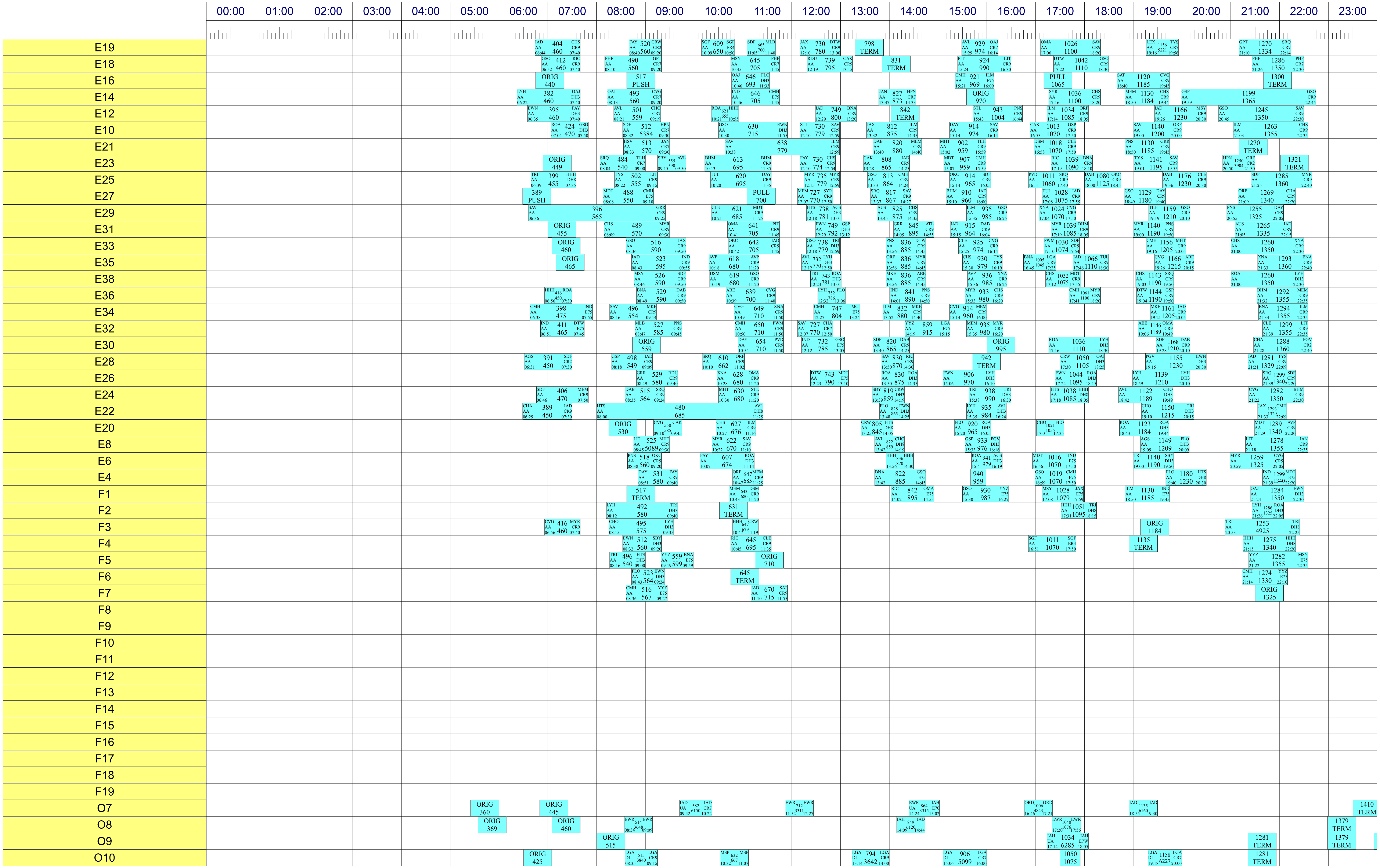

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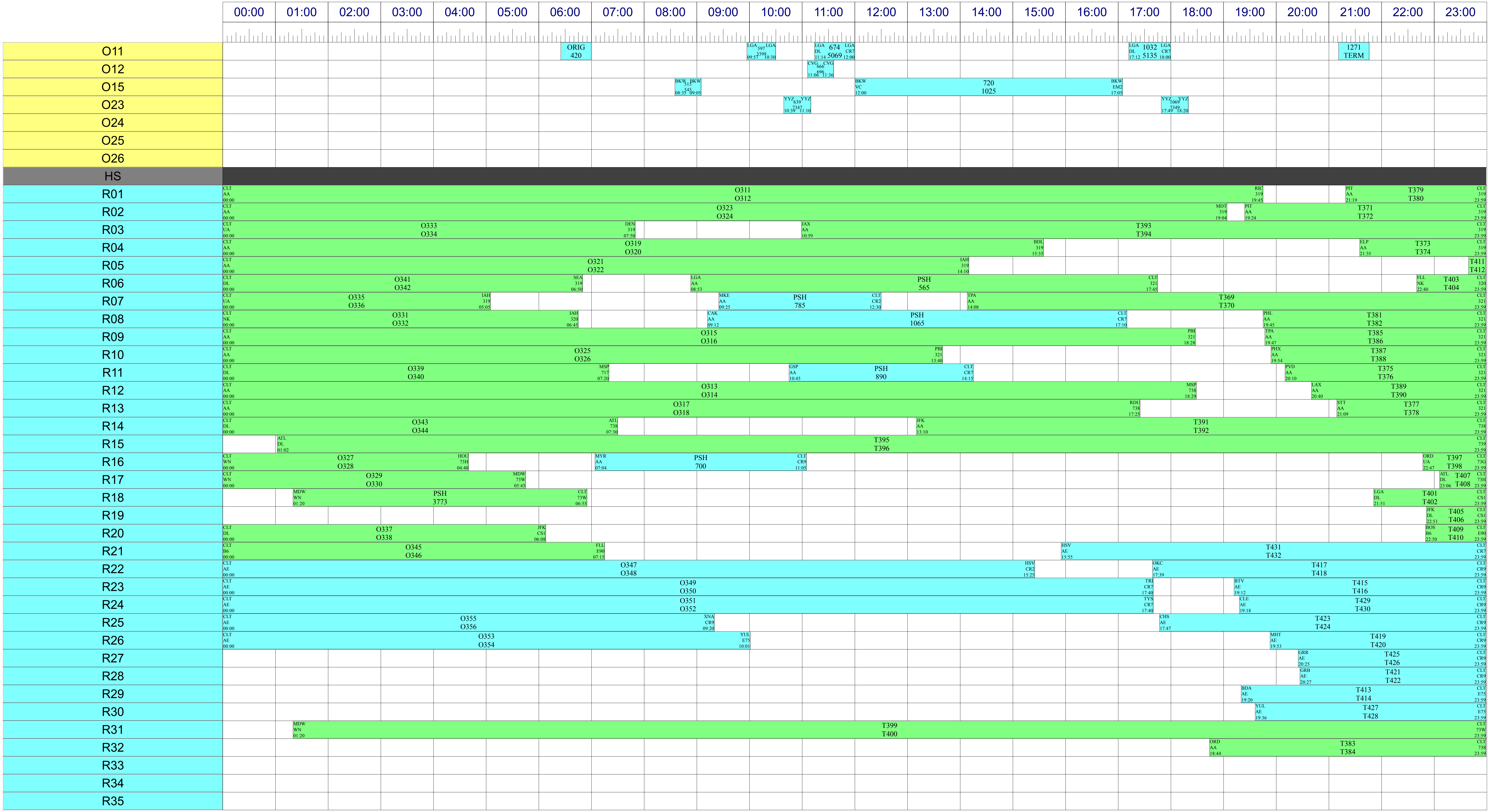
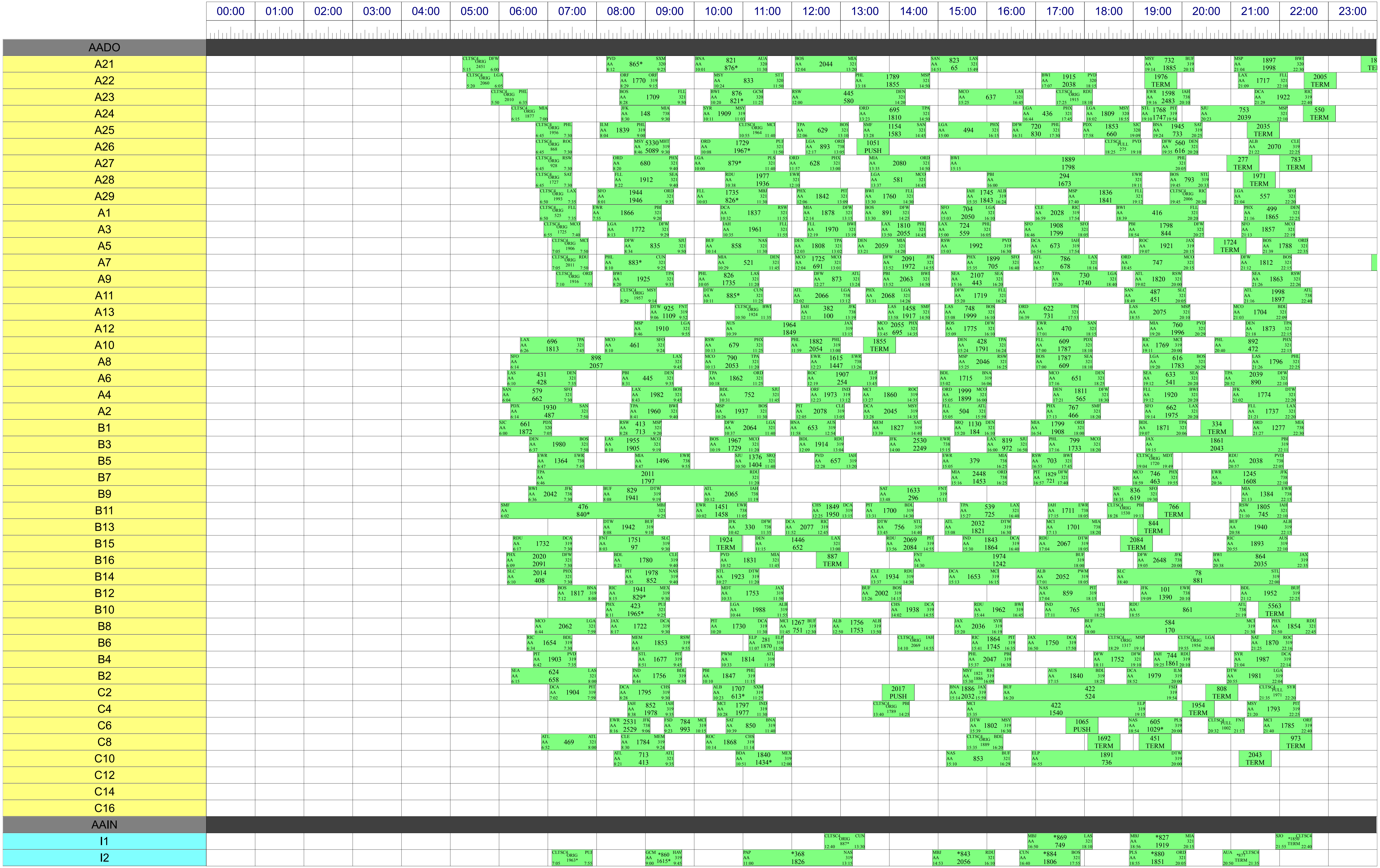


O11	ORIG 420 LGA 597 LGA 3399 09:57 10:30 LGA DL 11:14 674 5069 LGA CR7 12:00 LGA DL 17:12 1032 5135 LGA CR7 18:00 1271 TERM
O12	CVG 666 CVG 696 11:06 11:36
O15	BKW 515 BKW 545 08:35 09:05 BKW VC 12:00 720 1025 BKW EM2 17:05
O23	YYZ 639 YYZ 7347 10:39 11:10 YYZ 1069 YYZ 7349 17:49 18:20
O24	
O25	
O26	
HS	
R01	CLT AA 00:00 O311 O312 RIC 319 19:45 PIT AA 21:19 T379 T380 CLT 319 23:59
R02	CLT AA 00:00 O323 O324 MDT 319 19:04 PIT AA 19:24 T371 T372 CLT 319 23:59
R03	CLT UA 00:00 O333 O334 DEN 319 07:50 JAX AA 10:59 T393 T394 CLT 319 23:59
R04	CLT AA 00:00 O319 O320 BDL 319 15:35 ELP AA 21:35 T373 T374 CLT 319 23:59
R05	CLT AA 00:00 O321 O322 IAH 319 14:10 T411 T412
R06	CLT DL 00:00 O341 O342 SEA 319 06:50 LGA AA 08:53 PSH 565 CLT 321 17:45 FLL NK 22:40 T403 T404 CLT 320 23:59
R07	CLT UA 00:00 O335 O336 IAH 319 05:05 MKE AA 09:25 PSH 785 CLT CR2 12:30 TPA AA 14:08 T369 T370 CLT 321 23:59
R08	CLT NK 00:00 O331 O332 IAH 320 06:45 CAK AA 09:12 PSH 1065 CLT CR7 17:10 PHL AA 19:45 T381 T382 CLT 321 23:59
R09	CLT AA 00:00 O315 O316 PBI 321 18:28 TPA AA 19:47 T385 T386 CLT 321 23:59
R10	CLT AA 00:00 O325 O326 PBI 321 13:40 PHX AA 19:54 T387 T388 CLT 321 23:59
R11	CLT DL 00:00 O339 O340 MSP 717 07:20 GSP AA 10:45 PSH 890 CLT CR7 14:15 PVD AA 20:10 T375 T376 CLT 321 23:59
R12	CLT AA 00:00 O313 O314 MSP 738 18:29 LAX AA 20:40 T389 T390 CLT 321 23:59
R13	CLT AA 00:00 O317 O318 RDU 738 17:25 STT AA 21:09 T377 T378 CLT 321 23:59
R14	CLT DL 00:00 O343 O344 ATL 738 07:30 JFK AA 13:10 T391 T392 CLT 738 23:59
R15	ATL DL 01:02 T395 T396 CLT 739 23:59
R16	CLT WN 00:00 O327 O328 HOU 73H 04:40 MYR AA 07:04 PSH 700 CLT CR9 11:05 ORD UA 22:47 T397 T398 CLT 73G 23:59
R17	CLT WN 00:00 O329 O330 MDW 73W 05:45 ATL DL 23:06 T407 T408 CLT 73H 23:59
R18	MDW WN 01:20 PSH 3773 CLT 73W 06:55 LGA DL 21:51 T401 T402 CLT CS1 23:59
R19	JFK DL 22:51 T405 T406 CLT CS1 23:59
R20	CLT DL 00:00 O337 O338 JFK CS1 06:08 BOS B6 22:50 T409 T410 CLT E90 23:59
R21	CLT B6 00:00 O345 O346 FLL E90 07:15 HSV AE 15:55 T431 T432 CLT CR7 23:59
R22	CLT AE 00:00 O347 O348 HSV CR2 15:25 OKC AE 17:39 T417 T418 CLT CR9 23:59
R23	CLT AE 00:00 O349 O350 TRI CR7 17:40 BTV AE 19:12 T415 T416 CLT CR9 23:59
R24	CLT AE 00:00 O351 O352 TYS CR7 17:40 CLE AE 19:18 T429 T430 CLT CR9 23:59
R25	CLT AE 00:00 O355 O356 XNA CR9 09:20 CHS AE 17:47 T423 T424 CLT CR9 23:59
R26	CLT AE 00:00 O353 O354 YUL E75 10:01 MHT AE 19:53 T419 T420 CLT CR9 23:59
R27	GRR AE 20:25 T425 T426 CLT CR9 23:59
R28	GRB AE 20:27 T421 T422 CLT CR9 23:59
R29	BDA AE 19:20 T413 T414 CLT E75 23:59
R30	YUL AE 19:36 T427 T428 CLT E75 23:59
R31	MDW WN 01:20 T399 T400 CLT 73W 23:59
R32	ORD AA 18:44 T383 T384 CLT 738 23:59
R33	
R34	
R35	

CLT 2028 Gating Scenario 2

CLT 2028-Scenario 2



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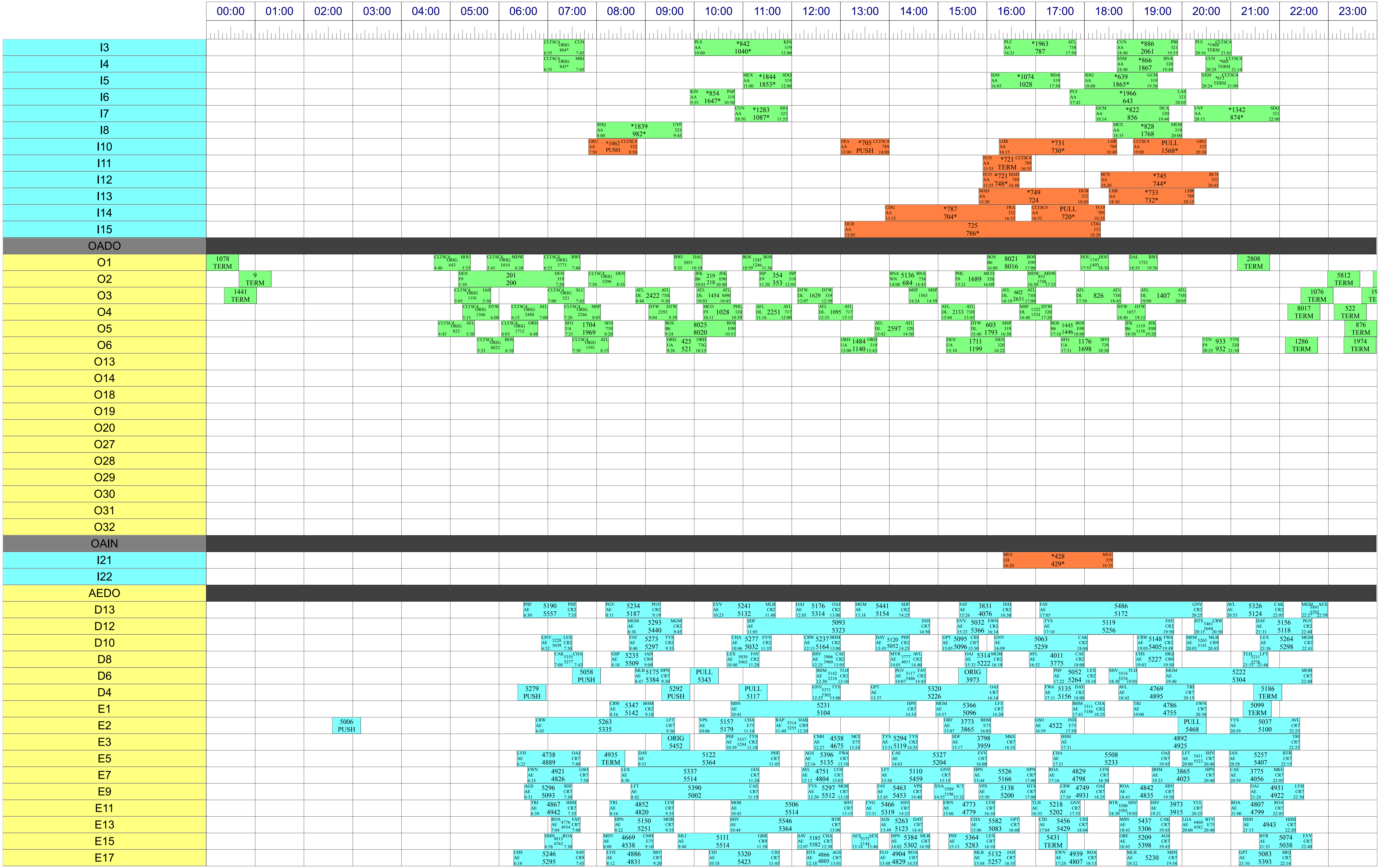

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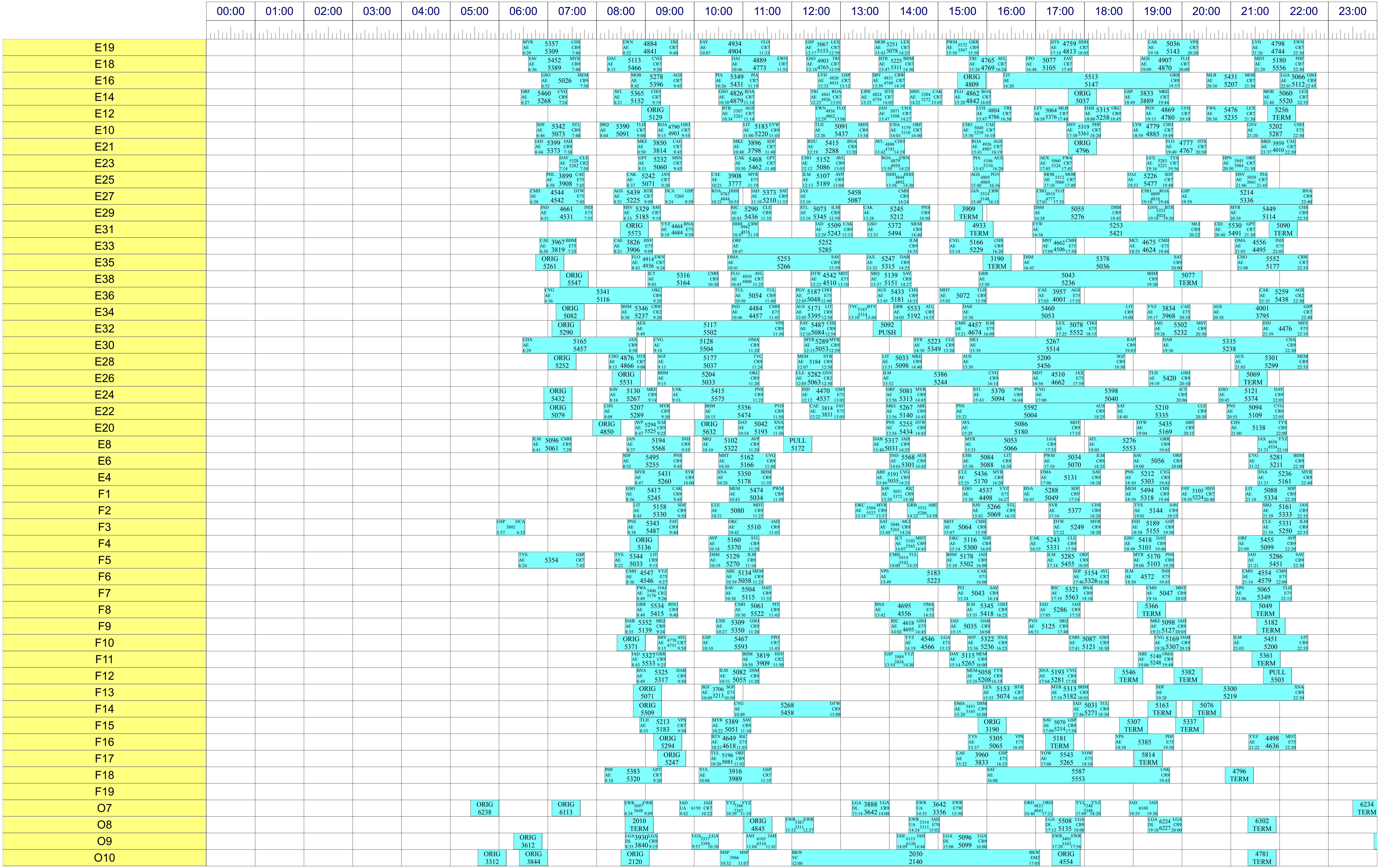

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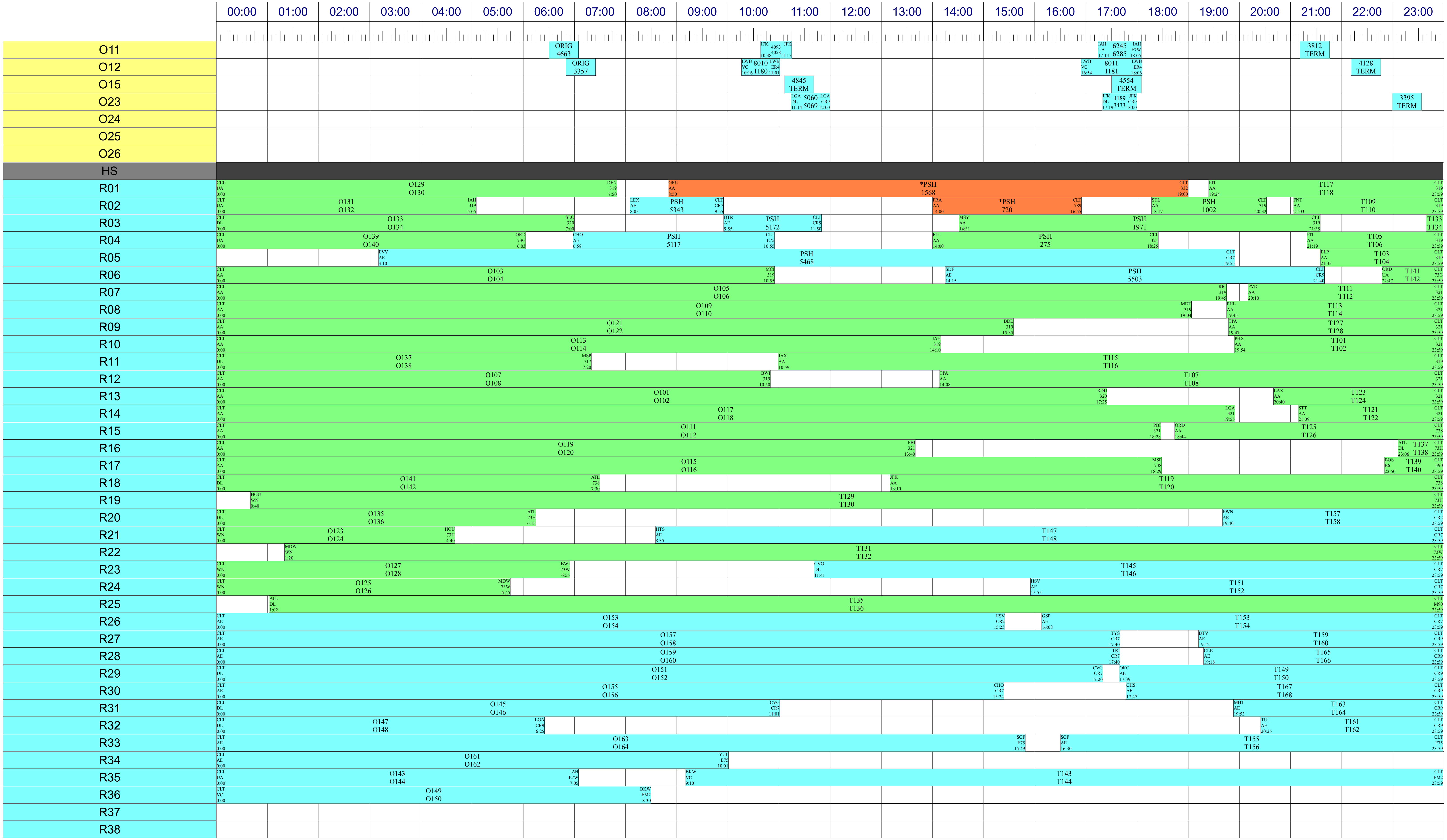

CLT 2028 Gating Scenario 3

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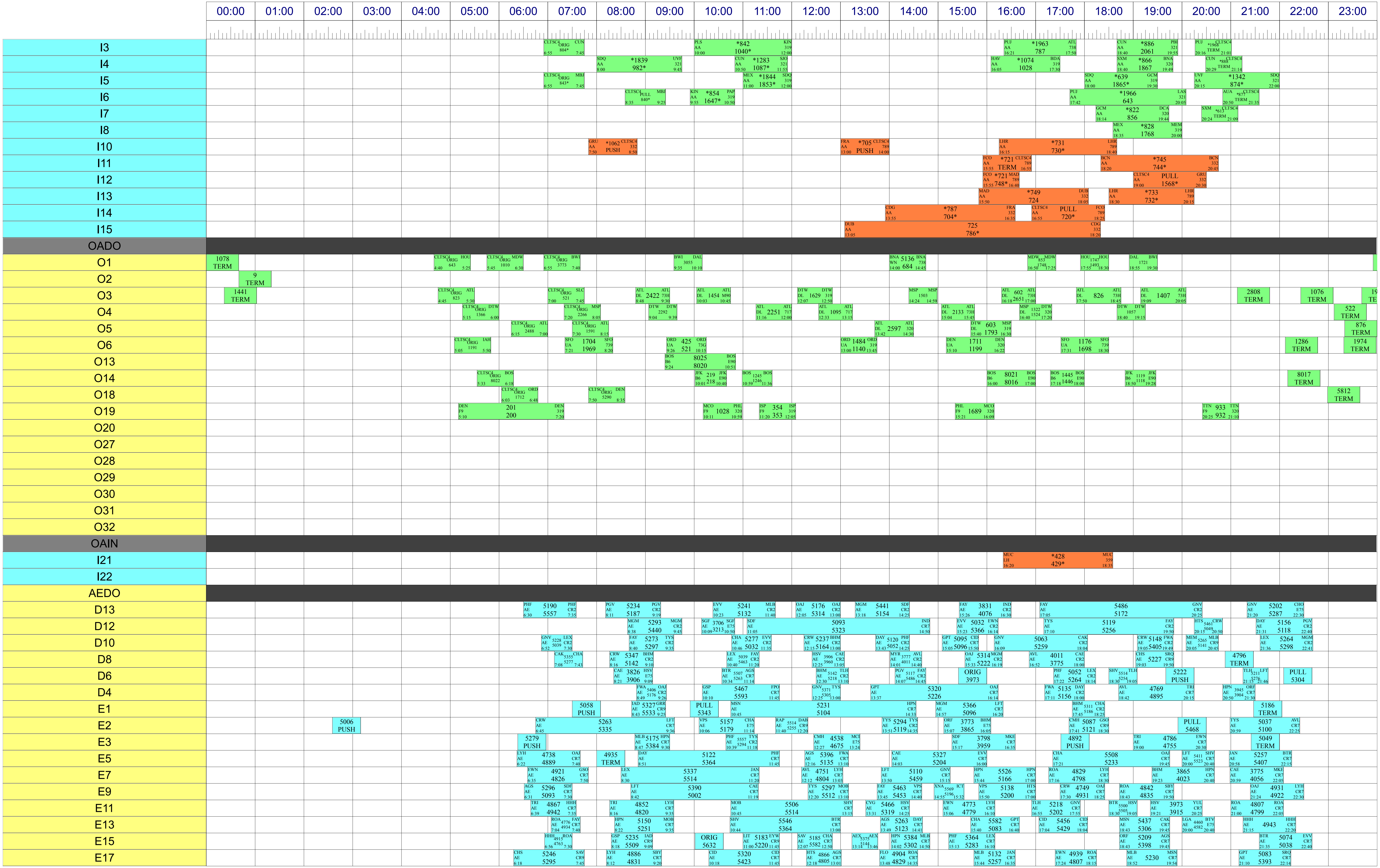
CLT 2028-Scenario 3

CLT 2028-Scenario 3



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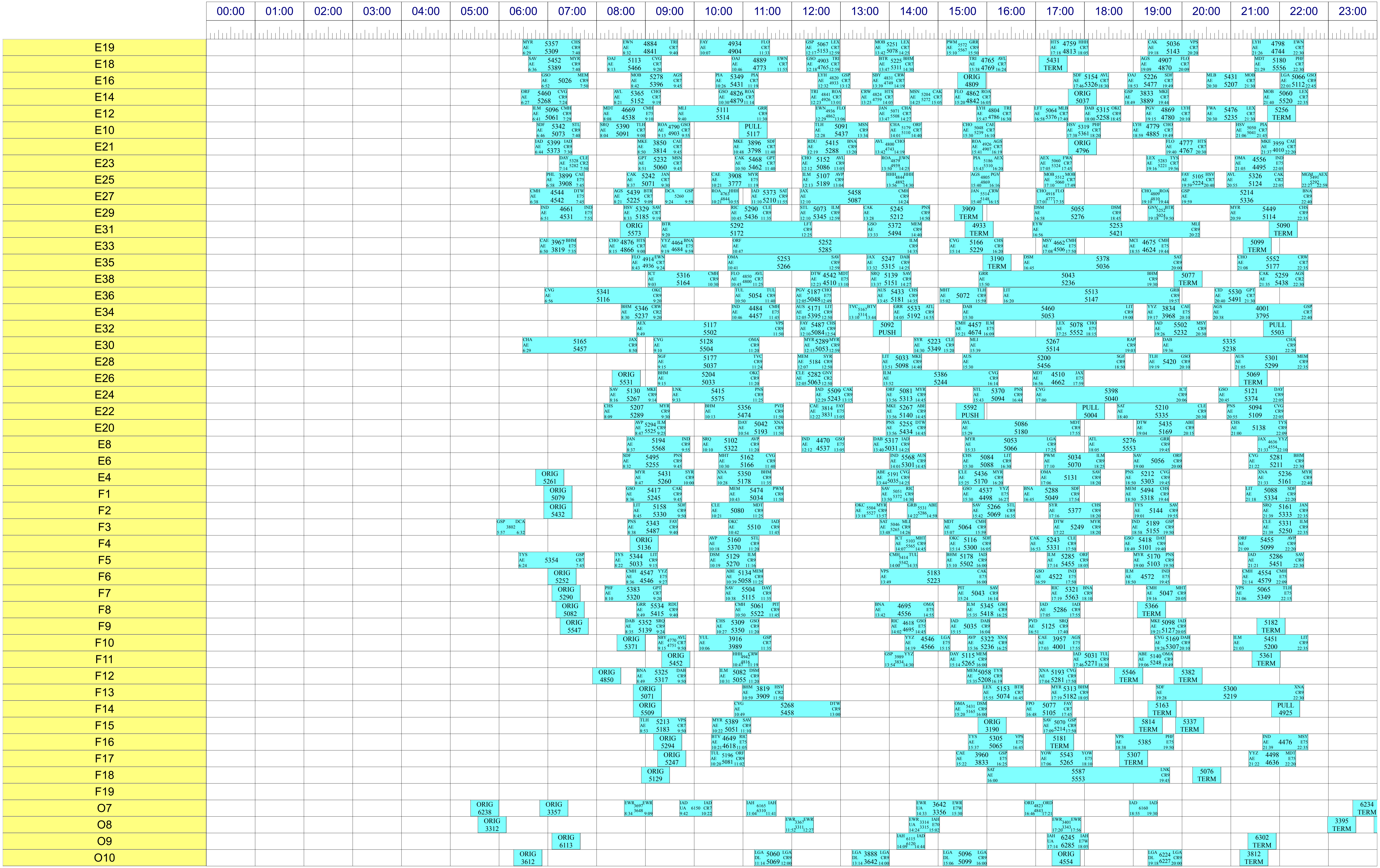

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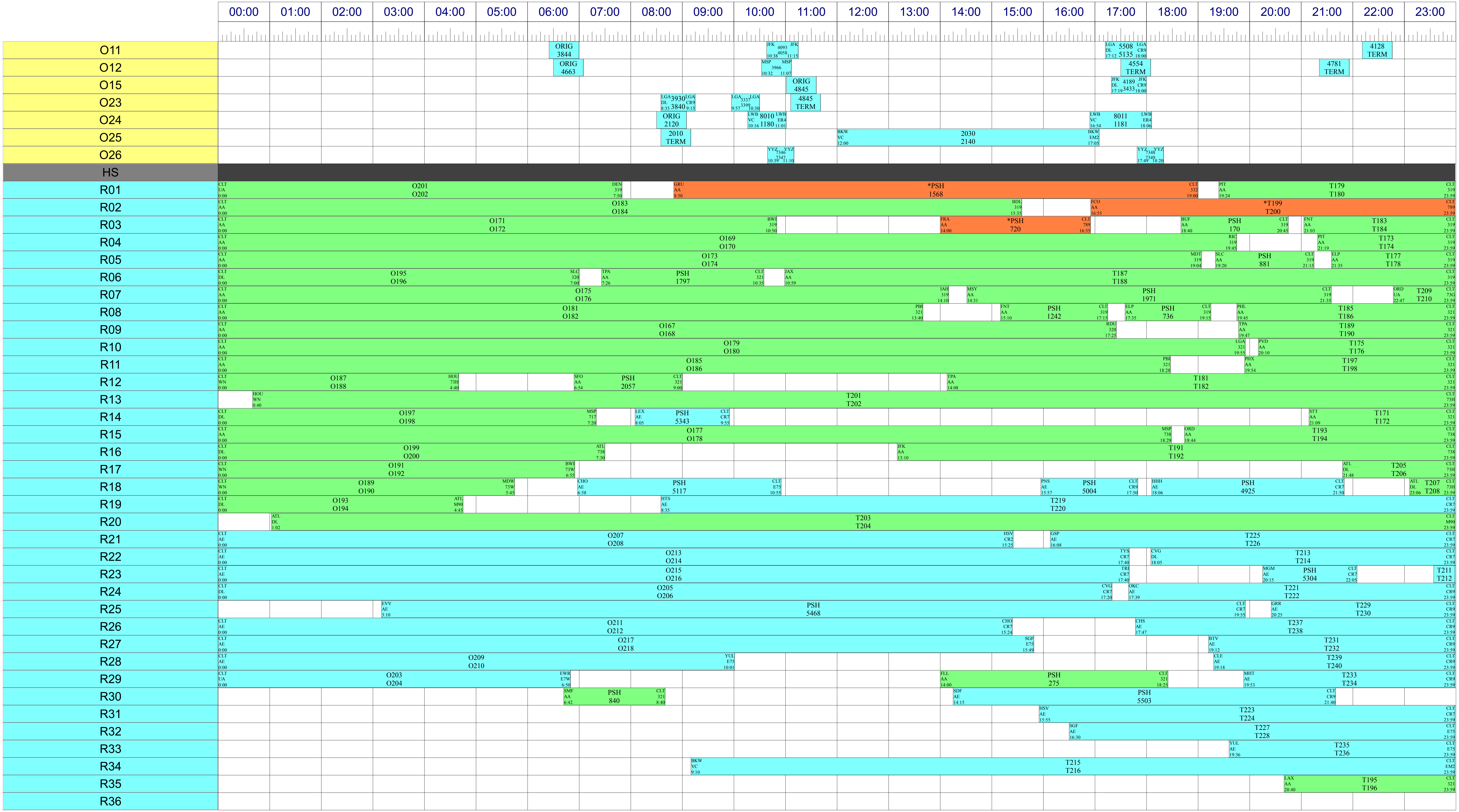

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CLT 2033 Gating Scenario 2

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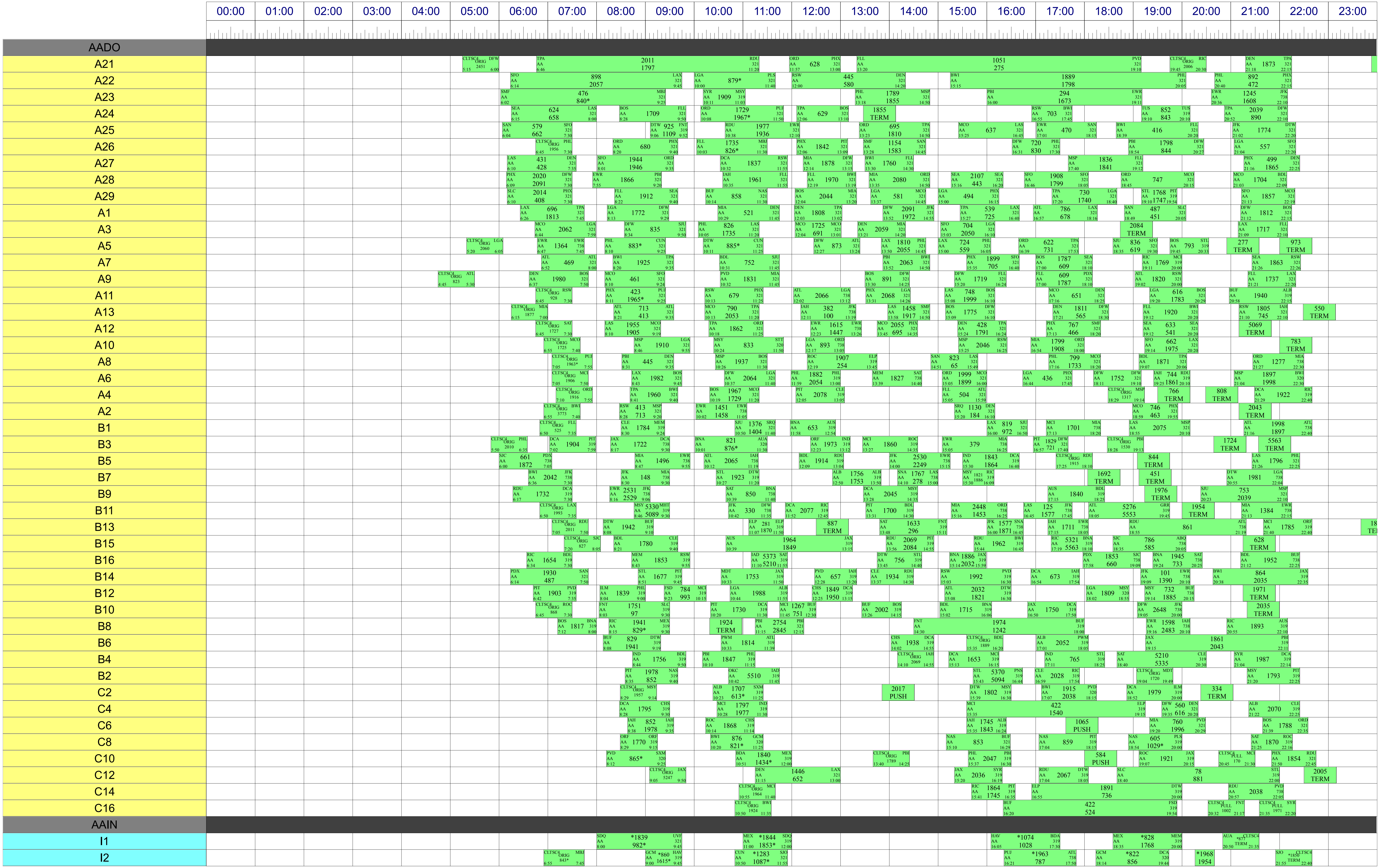
CLT 2033-Scenario 2



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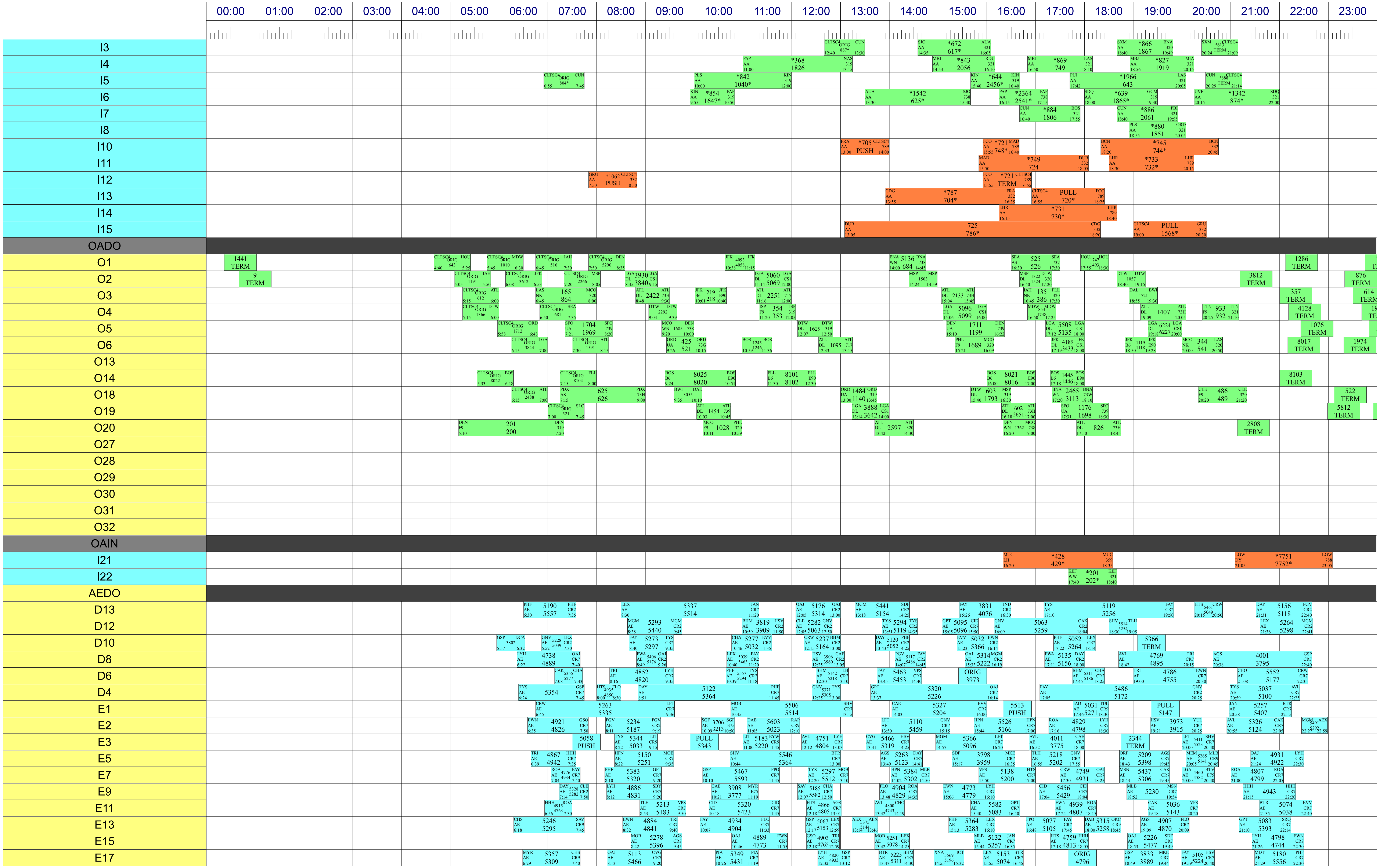
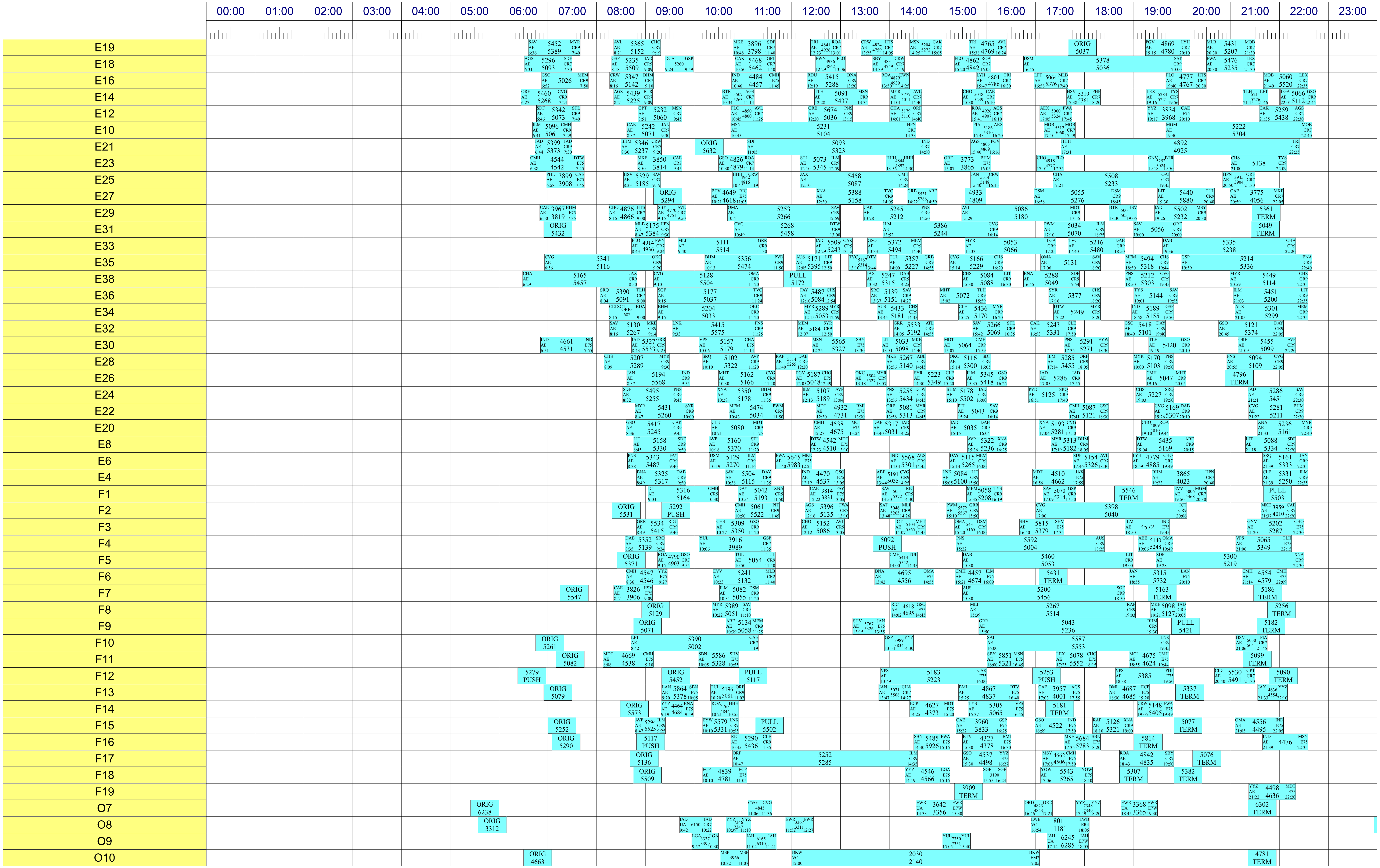


CLT 2033-Scenario 2



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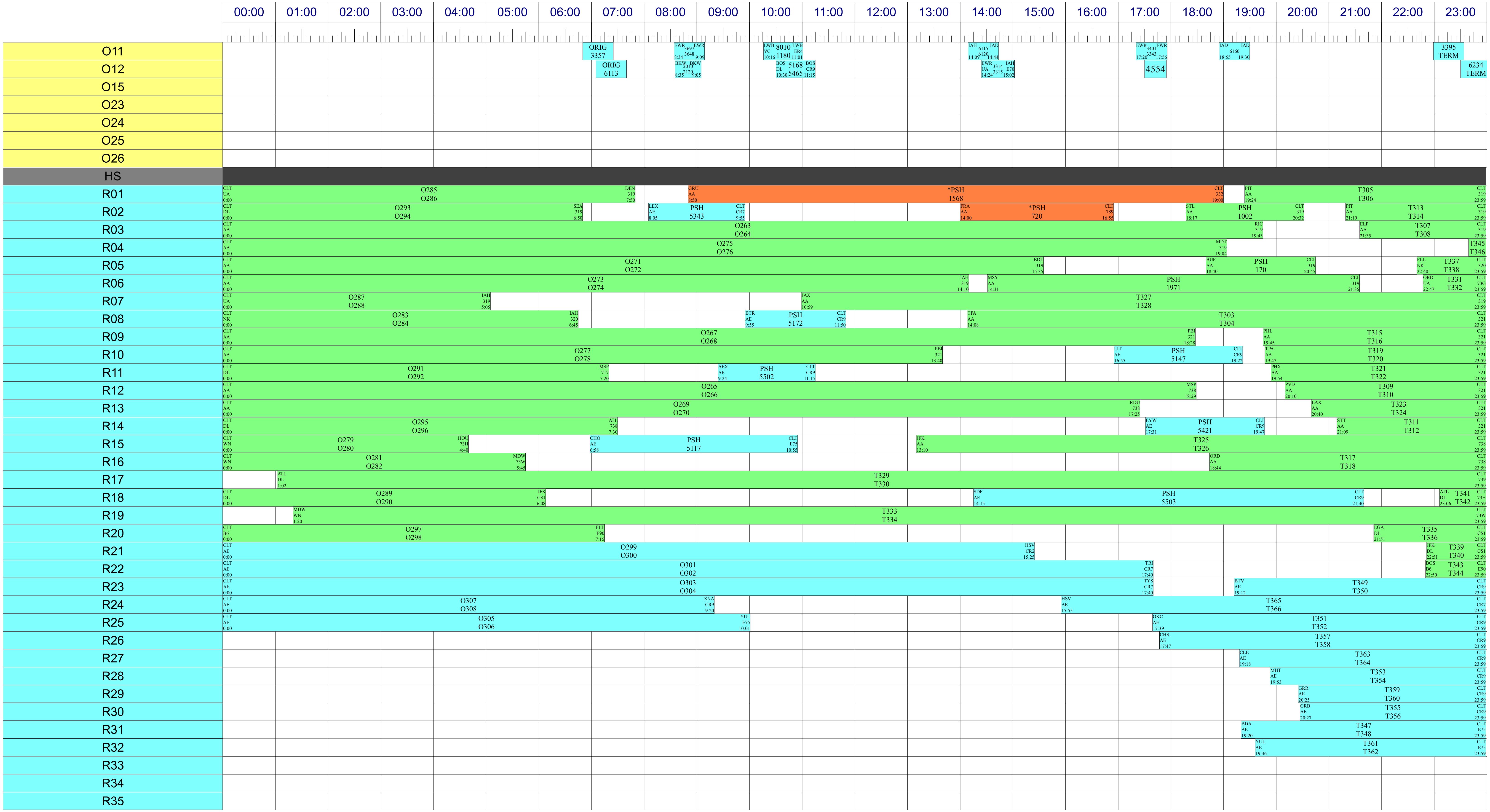
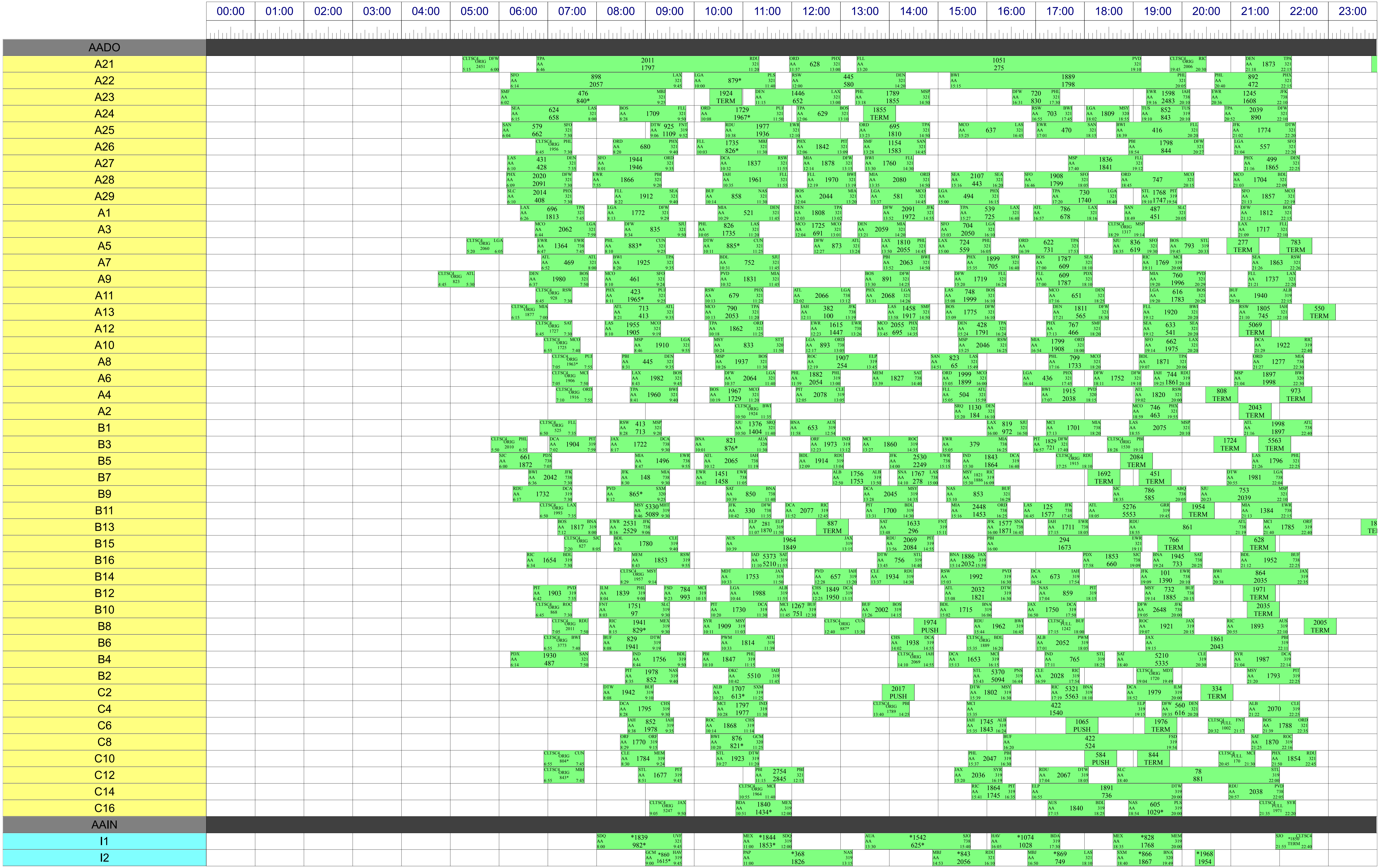


CLT 2033 Gating Scenario 3

CLT 2033-Scenario 3



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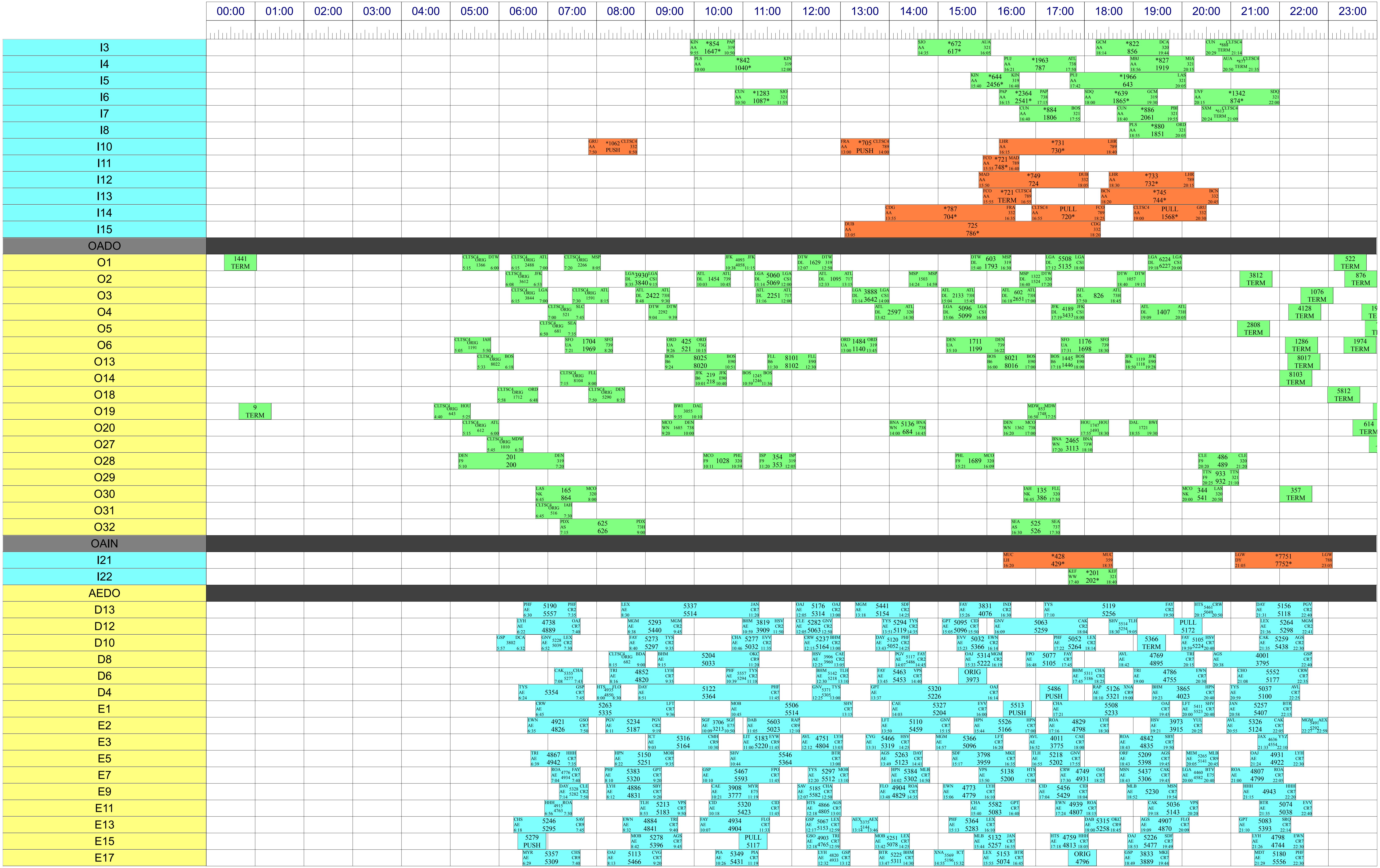

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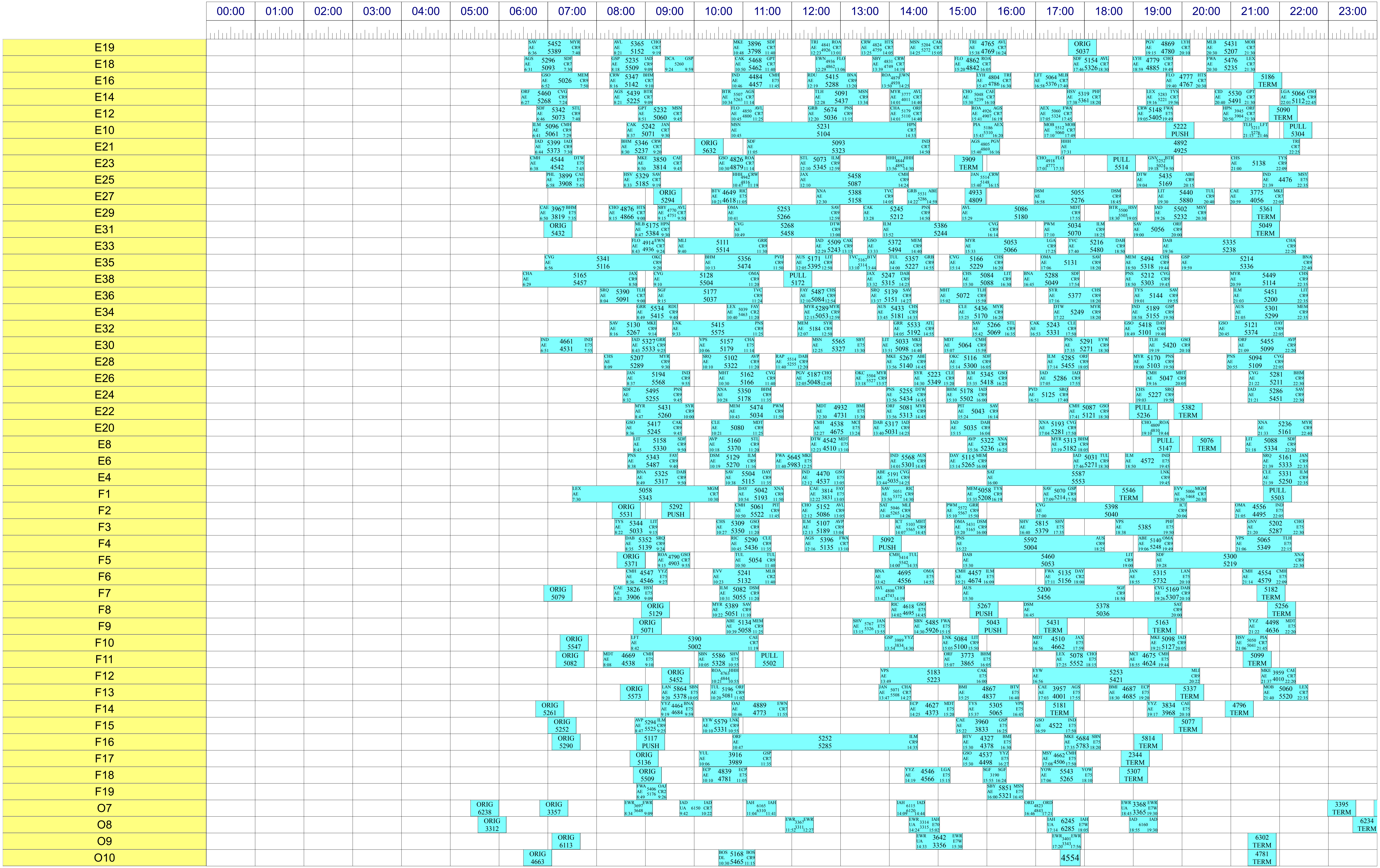
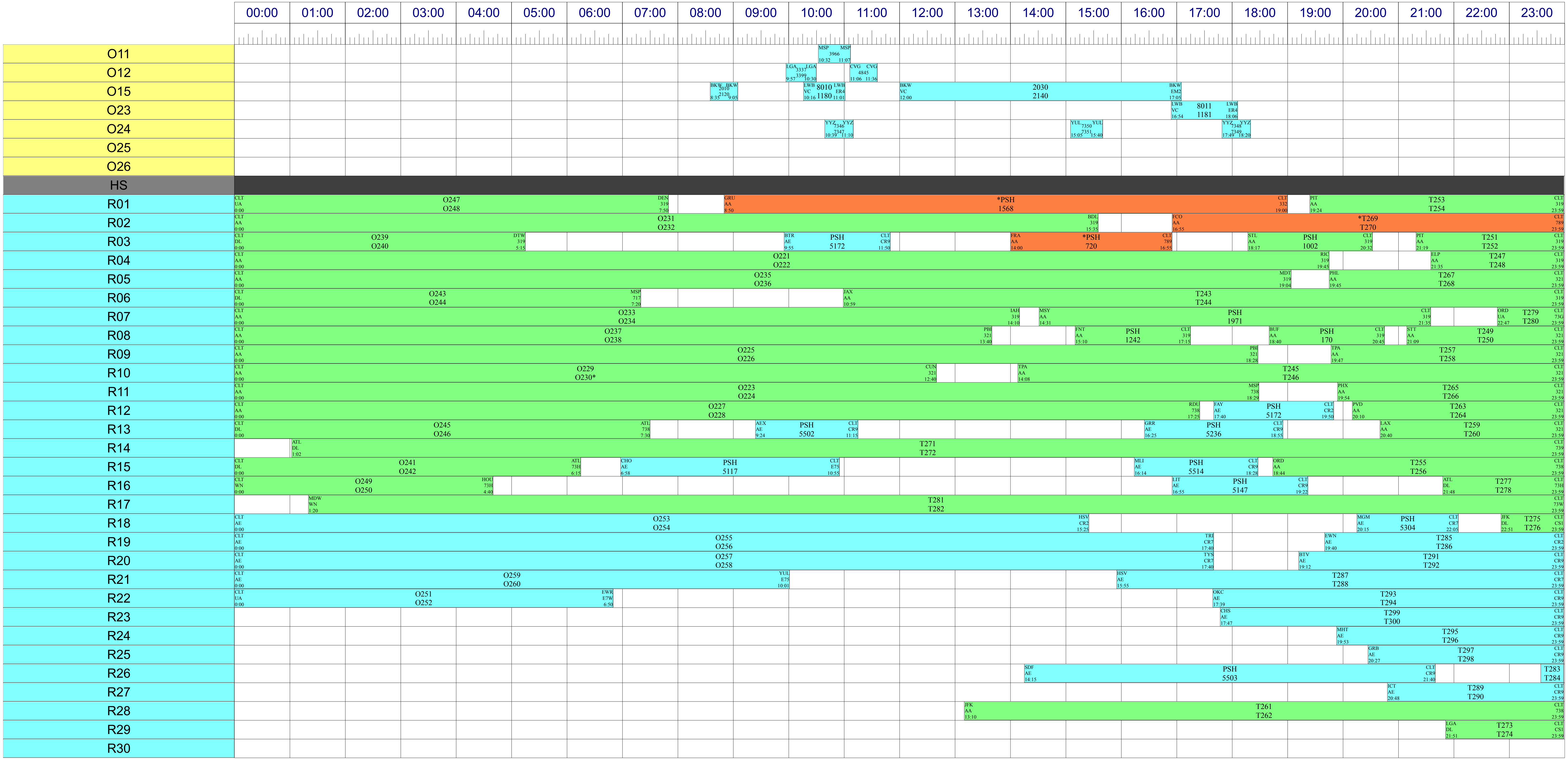


CLT 2033-Scenario 3



TECHNICAL MEMORANDUM - FINAL

Capacity/Delay Analysis and Airfield Modeling Technical Memorandum

Charlotte Douglas International Airport Environmental Impact Statement

PREPARED FOR

FEDERAL AVIATION ADMINISTRATION

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TRANSSOLUTIONS

TransSolutions

7/16/2018

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Summary of Findings

1.1 Introduction

A comprehensive development program (Airport Capital Enhancement Plan, or ACEP) was initiated by the City of Charlotte, North Carolina (Aviation Department or the "Department") to address the existing and anticipated demand at Charlotte Douglas International Airport (CLT). A Consultant Team is evaluating the existing planning data and preparing an Environmental Impact Statement (EIS) at the direction of the Federal Aviation Administration (FAA), to satisfy requirements of the National Environmental Policy Act of 1969 (NEPA). TransSolutions, LLC performed the airfield capacity/delay analysis for the Existing Conditions (2016) based on the current airfield and aviation demand in 2016, and a future No-Action alternative based on the current airfield, improvements currently under construction, and forecast demand levels representing 2028 and 2033.

The airfield capacity/delay analysis was performed using ATAC Corporation's *SIMMOD Plus!*® version 8.1 software, based on the FAA's Airfield and Airspace Simulation Model, SIMMOD. Simulations were run for the four predominant operational configurations: South Flow Visual Meteorological Conditions (VMC), South Flow Instrument Meteorological Conditions (IMC), North Flow VMC, and North Flow IMC. As part of the EIS effort, the Consultant Team updated the operations and passenger forecasts that were originally documented in the ACEP in early 2016 to reflect the merger of American Airlines and US Airways, as well as current trends. The Existing Conditions traffic demand level (2016) was analyzed along with the two updated forecast demand levels representing 2028 and 2033, years which reflect the construction phasing of the proposed airport improvements that are the subject of the EIS.

This summary provides findings of the following:

- Peak hour throughput and hourly capacity
- Average aircraft taxi times and arrival airspace delay
- Average delay per operation
- Average arrival gate and ramp delays
- Comparison to the ACEP

A description of the modeling methodology is presented in Section 2 and was previously reviewed by the FAA and the Department. Detailed modeling results of each simulation scenario are presented in Section 3 of this Technical Memorandum. Section 4 provides a brief discussion of the conclusions reached based on the modeling results.

1.2 Peak Hour Throughput and Hourly Capacity

Due to CLT's role as a major hub operation for American Airlines, peak hour demand and capacity are key determinants of the airport system's (airfield, terminal and landside components) ability to operate efficiently, including maintaining proper schedule integrity. American Airlines' hub operation currently each day serves a total of 18 "banks"[1], or periods of time during the day when there is heavy aircraft arrival activity coming into CLT (the hub) followed by periods of heavy departure activity leaving CLT. As shown in **Figure 1-1**, the banks consist of nine departure banks and nine arrival banks.

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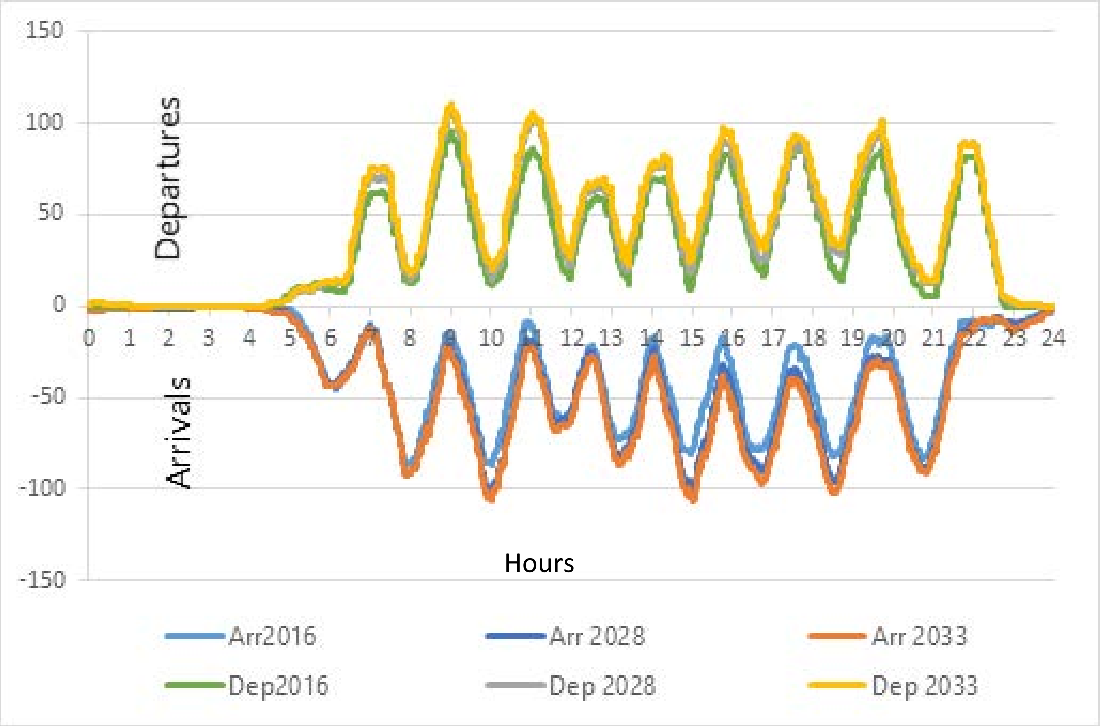
[1] *Airport Capacity Enhancement Plan*, Landrum & Brown, February 2016, Page 1-1

Figure 1-1 Hourly Departures and Arrival Demand (2016, 2028 and 2033)



Source: TransSolutions, LLC

Peak hour throughput is generally defined as the maximum number of aircraft operations that an airfield configuration can accommodate during a specified interval of time when there is a continuous demand for service (i.e., aircraft are always waiting to depart or land). The peak hour throughput is achievable under specific circumstances, but is not a good indication of the capacity that can be sustained for several hours. Thus the 90th percentile is often used as the measure of capacity. [2]

The simulation results were analyzed to obtain rolling hour airport throughput for individual days (iterations) in each operational configuration using the highest demand level (2033) in the simulation because it will likely have the highest throughput. The maximum hourly throughput for each operational configuration and hourly capacity (90th percentile of maximum throughput) is summarized by arrivals only, departures only and all operations. The average maximum hourly throughput and capacity is also provided based on the annualized average use of each operational configuration (Section 3.5).

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[2] According to the *Airport Capacity Enhancement Plan* (Pg. 6-54), the DORA stakeholder group recommended that all throughput and capacity results from the ACEP simulation modeling analysis be weighted using the 90th percentile methodology, which yields a more conservative and sustainable runway throughput rate than the maximum throughput rate.

Table 1-1 Airport Peak Hour Throughput and Capacity

	Arrivals		Departures		Total Operations	
Operational Configuration	**Maximum Throughput**	**Capacity**	**Maximum Throughput**	**Capacity**	**Maximum Throughput**	**Capacity**
South VMC	84	72	78	65	141	130
South IMC	74	68	69	66	134	130
North VMC	77	68	78	65	138	131
North IMC	76	68	68	63	137	127
Annualized Average	**80**	**70**	**76**	**65**	**139**	**130**

Note: Capacity based on the 90th percentile of peak hour throughput for 0700-2200 local time; Annualized average based on annualized average use of each operational configuration (see Section 3.4)
Source: TransSolutions, LLC; *Simmod PLUS*!

1.3 Average Aircraft Taxi Times and Airspace/Ground Delays

The primary simulation metrics used in an airfield capacity/delay analysis are arrival airspace delay, taxi-in times, and taxi-out times. Arrival airspace delay is measured as the difference in the amount of time an aircraft lands on the runway and the time it would have taken to land on the runway if it were able to move unimpeded through the airspace. In the simulation analyses, most arrival delays at CLT occur when aircraft must maintain required separations and merge onto final approach, and on the airfield while waiting for a gate. While convective or adverse weather is a large source of delay in the National Airspace System (NAS), the modeling done for this project does not account for delays associated with such weather. Arrival taxi-in measures the time from when an aircraft lands on the runway until it taxis into its gate or parking position (including landing roll time on the runway, taxi time, and any taxiway or ramp delays). Taxi-out is associated with departures and measures the time from when an aircraft leaves its gate or parking position until it leaves the runway (including push-back from the gate, taxi time, departure queue wait time, and runway takeoff roll time).

The modeling results for arrival airspace delays and taxi-in times, and departure taxi-out times of each operational configuration and the annualized average are provided in **Table 1-2**. Taxi-in times increase uniformly from 2016 to 2033 in each operational configuration due to increased demand. Airspace delays increase more rapidly in the South Flow IMC and the two North Flow operational configurations. Departure taxi-out times increase in the South Flow and North Flow IMC operational configurations due to increased demand, resulting in ramp and taxiway congestion.

Table 1-2 Average Airspace Delay and Taxi Times (in minutes)

		Arrival		Departure
Operational Configuration	**Year**	**Average Airspace Delay**	**Average Taxi-In Time**	**Average Taxi-Out Time**
South Flow VMC	2016	2.2	10.3	13.6
	2028	3.3	12.8	13.4
	2033	4.5	15.4	14.8
South Flow IMC	2016	4.3	12.4	17.7
	2028	7.3	15.2	17.9
	2033	12.6	15.4	23.4
North Flow VMC	2016	3.8	10.2	14.8
	2028	7.8	13.9	14.6
	2033	10.9	14.9	15.4
North Flow IMC	2016	3.9	11.1	18.6
	2028	8.6	12.3	23.2
	2033	12.0	12.5	26.6
Annualized Average	**2016**	**3.2**	**10.6**	**15.0**
	2028	**5.8**	**13.4**	**15.3**
	2033	**8.3**	**14.9**	**17.1**

Note: Annualized average is based on annualized average use of each operational configuration (see Section 3.4)
Source: TransSolutions, LLC; *Simmod PLUS*!

1.4 Average Arrival Gate and Ramp Delays

As noted previously in Section 1.2, demand at CLT is driven by the banking characteristics of the airline hub operations at the airport. Of the 18 daily banks, nine are arrival banks with heavy demand for gates in advance of each departure bank. At CLT, if the ramp is full of waiting aircraft, additional arriving flights will either wait on taxiways or arrival hold pads, which in turn affects arrival taxi-in times. The latter typically initiates a domino effect that results in a rolling increase in delay over time until the next bank begins.

The simulation model tracked any arrival aircraft that must wait for a gate to become available after landing. **Table 1-3** summarizes 95th percentile ramp delay time (in minutes)[3], the total time spent waiting for a gate each day, and the average number of daily flights. With the current (2016) traffic demand, an annualized average of 267 arrivals per day, or 34 percent of all modeled arrivals, must wait for an available gate. By 2028, an average of 472 arrivals per day, or 51 percent of all modeled arrivals, would wait for a gate, and this grows to an average of 575 arrivals per day, or 58 percent of all modeled arrivals by 2033.[4]

Table 1-3 Arrival Aircraft Waiting for Available Gates

Operational Configuration	Year	95th Percentile Waiting Time for a Gate (minutes)	Total Time Waiting for a Gate Each Day (minutes)	Average Number of Daily Flights that Wait for Gate
South Flow VMC	2016	5.9	470.1	237
	2028	8.0	1093.1	453
	2033	12.7	1862.7	519
South Flow IMC	2016	6.1	424.6	239
	2028	5.4	1095.1	472
	2033	6.7	1202.7	582
North Flow VMC	2016	6.0	636.1	292
	2028	6.4	940.8	453
	2033	5.4	1423.6	562
North Flow IMC	2016	5.6	577.9	260
	2028	6.2	993.6	434
	2033	6.2	1423.7	517
Annualized Average	**2016**	**5.9**	**532.7**	**258**
	2028	**7.0**	**1033.1**	**453**
	2033	**9.0**	**1602.7**	**540**

Note: Annualized average is based on annualized average use of each operational configuration (see Section 3.4)
Source: TransSolutions, LLC; *Simmod PLUS*!

Note that aircraft ramp waiting time increases more substantially in the South Flow VMC operational configuration (when arrival capacity increases due to the use of Runway 23) compared to all other scenarios with only the parallel runways in use. The increase in ramp waiting time is a function of more arrivals getting to the ramp and waiting for a gate due to the increase in runway capacity, which is evidence of an imbalance in airfield capacity and aircraft gate capacity. Also during the South Flow VMC operational configuration, the “hotspot” area near Taxiway F described in Section 1.3 causes gate waiting-related delays.

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[3] The 95th percentile is a reasonable indication of maximum wait times, without the extreme conditions that occur on rare occasions.

[4] Percentage of modeled arrivals based on TransSolutions’ analysis of Aerobahn© data between January 2015 and April 2017.

1.5 Average Delay per Operation

Average minutes of delay per operation is a general indicator of the capacity of an airfield to meet existing and forecast aviation demand. As noted in Section 1.2, CLT serves as a major hub operation for American Airlines. When average delays per operation reach approximately 4 to 6 minutes, the schedule integrity of a hub operation may not be maintained. Average delay of 10 minutes or more may be considered severe at some airports, and starts to increase exponentially beyond 10 minutes of average aircraft delay.[5]

As listed in **Table 1-4**, the minutes of average delay per operation was 7.4 minutes in 2016, and would increase to 9.1 minutes in 2028 and 12.0 minutes in 2033 with the current airfield facilities and gates (except for the additional Concourse A gates in 2028 and 2033 that are currently under construction). Average minutes of delay per day were 11,725 in 2016, and would increase to 16,854 in 2028 and 23,529 in 2033.

Table 1-4 Annualized Average Delay

Year	Delay per Operation (minutes)	Number of Daily Operations	Minutes of Delay per Day
2016	7.4	1,582	11,725
2028	9.1	1,857	16,854
2033	12.0	1,968	23,529

Source: TransSolutions, LLC; *Simmod PLUS*!; Aerobahn®, January 2015 – April 2017, analyzed by TransSolutions

1.6 Comparison to ACEP

Table 1-5 lists the annualized average delay per operation in minutes for the existing and future demand levels to show how Existing Conditions (2016) and modeled future No-Action conditions airfield modeling results have changed since the completion of the ACEP. It is important to note that the EIS simulations modeled lower aviation demand levels than the ACEP because of the revised forecast effort[6], including:

- Two percent fewer aircraft operations in the EIS Existing Conditions (2016) compared to the ACEP Existing Conditions (2013), both in actual operations as well as simulated operations;
- 13 percent fewer aircraft operations in the EIS first future year (2028) compared to the ACEP first future year (2023); and,

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[5] *FAA Airport Benefit-Cost Analysis Guidance*, Office of Aviation Policy and Plans, Federal Aviation Administration, December 15, 1999, Pg. 39

[6] *Forecast Technical Memorandum*, Charlotte Douglas International Airport Environmental Impact Statement, VHB in association with InterVISTAS, November 10, 2017

- 27 percent fewer aircraft operations in the EIS second future year (2033) compared to the ACEP second future year the second future year (2033), and 7.5 percent fewer aircraft operations compared to the ACEP first future year (2023).

As average delay levels per operation approach 10 minutes, increases in demand will increase delay exponentially. Therefore, the modeled ACEP delay results are much greater than the percentage differences in operations when compared to the EIS modeled delay results.

It is also important to note that the ACEP modeling analysis was conducted using an "unconstrained" level of aviation activity. Average delay per operation of 20 minutes represents the highest level of average delay realized in actual practice, even at highly congested airports. At that level growth in operations would be constrained. Therefore, differences between the ACEP and EIS delay modeling results would be much less in reality due to constrained operations because delay would not exceed 20 minutes.

Table 1-5 Annualized Average Delay – Comparison to ACEP

	ACEP		**EIS**	
Year	**Number of Daily Operations**	**Delay per Operation (minutes)**	**Number of Daily Operations**	**Delay per Operation (minutes)**
Existing (ACEP: 2013; EIS: 2016)	1,610	8-9	1,582	7.4
Future Year 1 (ACEP: 2023; EIS: 2028)	2,127	21-23	1,857	9.1
Future Year 2 (ACEP and EIS: 2033)	2,679	118-143	1,968	12.0

Sources: ACEP: Landrum & Brown, Exhibit 3-40; EIS: TransSolutions, LLC; *Simmod PLUS*!

In addition to the differences in forecasts of operations, the EIS analysis considered the following items:

- Full implementation of FAA's Charlotte Metroplex Project[7] (see Section 2.5) to improve airspace efficiency

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[7] A Metroplex is a geographic airspace area covering several airports, serving major metropolitan areas and a diversity of aviation stakeholders. FAA is focusing on airspace optimization at the Metroplex level, which provides solutions on a

- Inclusion of the Concourse A Improvement Project that is currently under construction, resulting in eight more gates in the EIS future No-Action than modeled in the ACEP analysis
- Observed[8] or actual data for the following modeling inputs:
  - Varied final aircraft approach speeds based on weight category (Section 2.8)
  - Take-off and landing roll distances (Section 2.9)
  - Aircraft taxi speeds (Section 2.13)
  - Aircraft push-back times9 (Section 2.14)
  - Flight dependability10 (Section 2.16)
- Assumption that, by Future Year 1, a system/technology will be implemented to eliminate miles-in-trail (MIT) restrictions to/from CLT airspace.

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regional scale, rather than focusing on a single airport or set of procedures. The overall goal of FAA's NextGen Metroplex program is to improve the operational efficiency of the airspace serving large airports.

[8] On-site observations at CLT Air Traffic Control Tower (ATCT) and interviews with the Air Traffic Manager, including subsequent TRACON personnel, conducted June 14-15, 2017.

[9] Push-back is the time from when an aircraft leaves the gate to the time when the aircraft starts using its own power.

[10] Flight dependability is the probability that a flight arrives or departs earlier or later than scheduled.

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2

Approach/Methodology

This section represents the approach and methodology used for the capacity/delay analysis. The operating assumptions are presented as well as the SIMMOD model calibration.

2.1 Objective

The objective of this analysis is to conduct an airfield capacity-delay analysis to establish an Existing Conditions and future No-Action Baseline at Charlotte Douglas International Airport (CLT) for current and future conditions, respectively. The delay analysis includes delays associated with runway use, airfield, airspace and terminal gates. This analysis does not consider any potential airfield or terminal gate improvements (aside from any that are already under construction) to enhance capacity and/or reduce delay.

2.2 Approach

ATAC Corporation's *SIMMOD Plus*!® version 8.1 was used to model the airspace/airfield operations for this analysis. The baseline in this study includes three demand levels – 2016 (Existing Conditions), 2028 and 2033 (future No-Action). For each of the three demand levels, there were two operational flows (South and North) and two weather conditions (Visual Meteorological Conditions [VMC] and Instrument Meteorological Conditions [IMC]) modeled. This analysis quantifies how the airport performs operationally under current and forecast traffic demand levels.

Information and assumptions that were used in the SIMMOD models were compiled from previous analyses and updated requirements including the following.

- Airport Capacity Enhancement Plan (ACEP) Final Report (February 2016)[11] prepared by Landrum & Brown, specifically the following elements:
  - Airside demand/capacity operating assumptions.
  - ACEP Simmod input files.
- Aerobahn®[12] data provided by CLT for January 2015 through April 2017.

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[11] Relevant sections of the ACEP "Chapter 3 Airside Demand/Capacity" include the Existing Airport Operating Assumptions.

[12] Aerobahn is a product by Saab Sensis Corporation for tracking aircraft movement. The data captured for each individual flight includes airline, flight number, aircraft type, runway, gate and time-stamps for runway use, gate arrival and gate departure.

- On-site observations at CLT Air Traffic Control Tower (ATCT) and interviews with the Air Traffic Manager, Traffic Management Coordinators, and subsequent Terminal Radar Approach Control (TRACON) personnel, conducted June 14-15, 2017.
- Teleconference interview conducted with American Airlines CLT Ramp Tower Operations Manager and personnel on January 29th, 2018.
- Documents provided by CLT ATCT, such as noise abatement procedures, CLT-specific orders, ramp hand-off spot locations, etc.
- Documents provided by the City of Charlotte, Airport Department (the Department) including Letters of Agreement, terminal gate layouts, CLT Metroplex plans, and FAA Notices to Airmen (NOTAM) records.

All data, performance goals, runway use configurations, and descriptions of the runway planning are summarized in this chapter.

2.3 Runway Flow Usage

The CLT airfield consists of three parallel runways in the north/south direction (18-36) and a single crosswind runway (5-23), as depicted in **Figure 2-1**.

Operational flows at CLT are split between North Flow and South Flow operations depending on prevailing wind conditions. The runway usage configurations during different flows are described below.

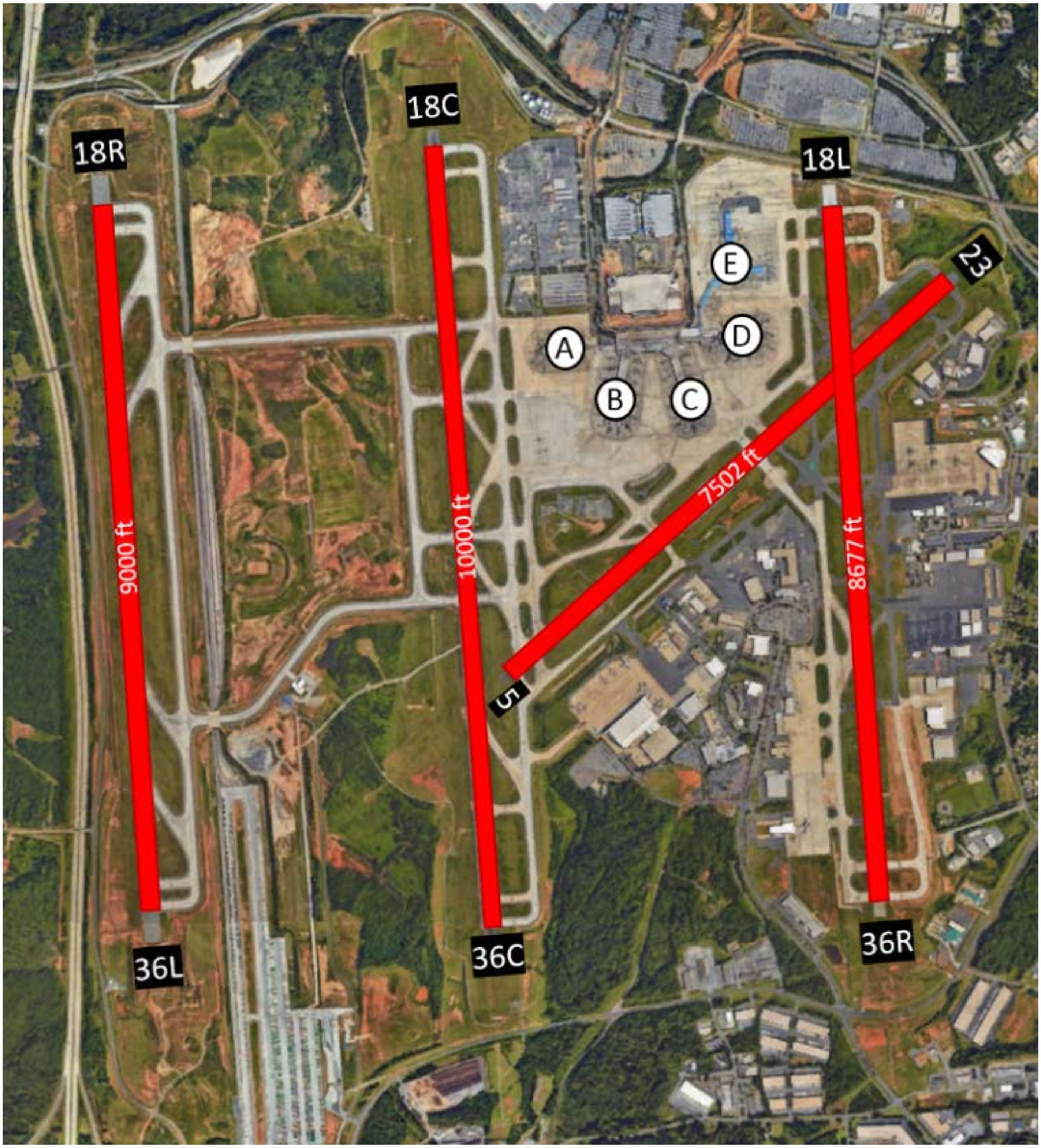
North Flow:

- Primary arrival Runways: 36L and 36R.
- Primary departure Runways: 36C and 36R.
- Runway 5-23 is typically used as a taxiway.

South Flow:

- Primary arrival Runways: 18R and 23.
- Primary departure Runways: 18C and 18L.
- In IMC, Runway 23 is not used.

Figure 2-1 CLT Airfield and Runways



Source: Charlotte Douglas International Airport

Table 2-1 summarizes runway use by operational flows with the primary arrival/departure runways highlighted. These percentages were used in the Existing Conditions and future No-Action baseline scenarios.

Table 2-1 Current Runway Usage

Flow	Runway	Arrivals	Departures	Overall
North	5	0.5%	0.9%	0.7%
	36C	11.9%	57.7%	34.1%
	36L	51.9%	0.5%	26.9%
	36R	35.7%	40.9%	38.2%
South	23	28.2%	0.6%	14.5%
	18C	11.9%	46.6%	29.1%
	18L	9.6%	52.6%	30.9%
	18R	50.3%	0.2%	25.5%

Source: Aerobahn®, January 2015 – April 2017, analyzed by TransSolutions.[13]

Figure 2-2 illustrates the runway usage at CLT since January 2015, including all 24 hours of each day. Note that in North Flow:

- The percentage of arrivals on Runway 36L has been steadily increasing as the other runways have reached capacity.
- The percentage of arrivals on Runway 36C has been steadily decreasing as more arrivals land on Runway 36L.
- Usage of specific departure runways has remained fairly consistent.

And in South Flow:

- The percentage of arrivals on Runway 18R has been steadily increasing.
- The percentage of arrivals on Runway 23 has been steadily decreasing. This is likely due to:
  - Runway 23 arrivals constrain Runway 18C departures with the current Converging Runway Operations (CRO) and Arrival Departure Window (ADW) procedural change that took effect in early 2015.
  - Runway 23 arrivals exit into the commercial ramp area causing additional congestion to the traffic already in that area.

  During peak departure times, more departure capacity is needed than can be achieved during CRO conditions, whereas the airport then switches to an all parallel runway configuration to

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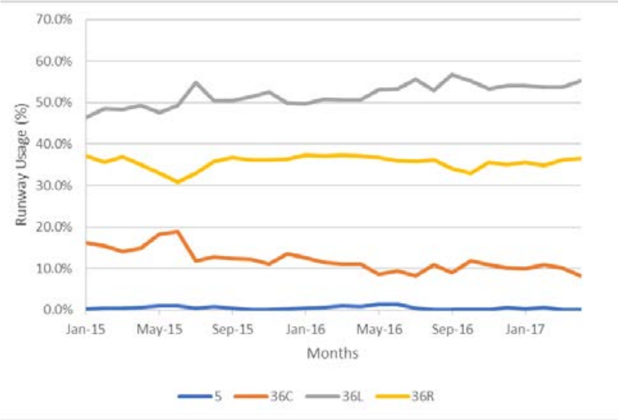
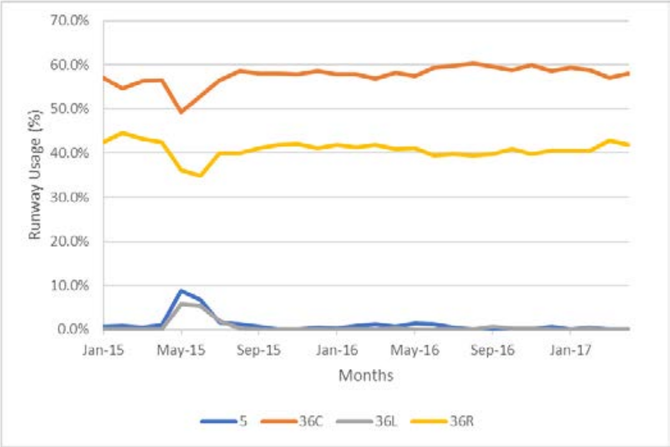
[13] Data was analyzed for all hours (24), including noise abatement periods (2300-0700 local time).

achieve more efficiency. The Runway 23 arrivals are then assigned to other runways so that departures can be better accommodated on Runway 18C.

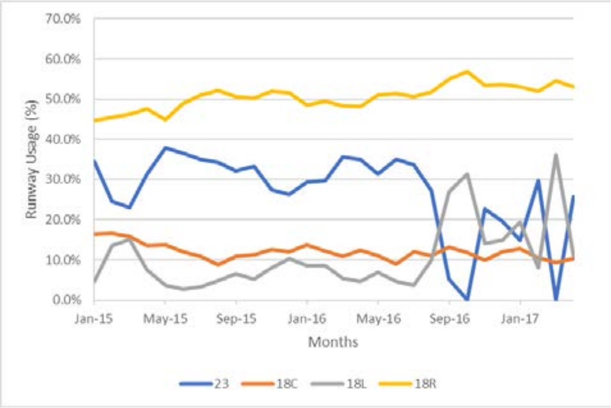
Figure 2-2 Historical Runway Usage at CLT



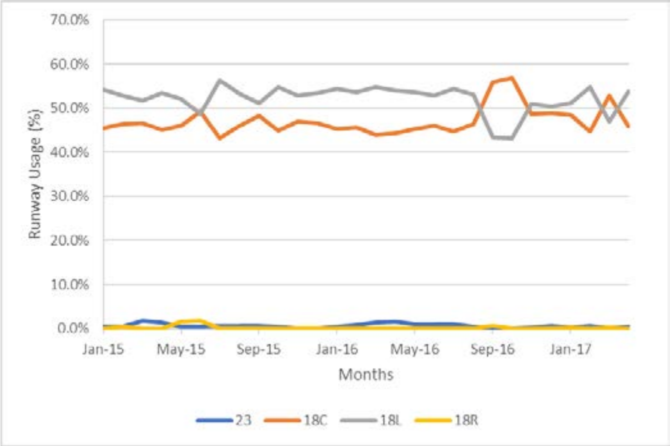
North Flow – Arrival



North Flow – Departure



South Flow – Arrival



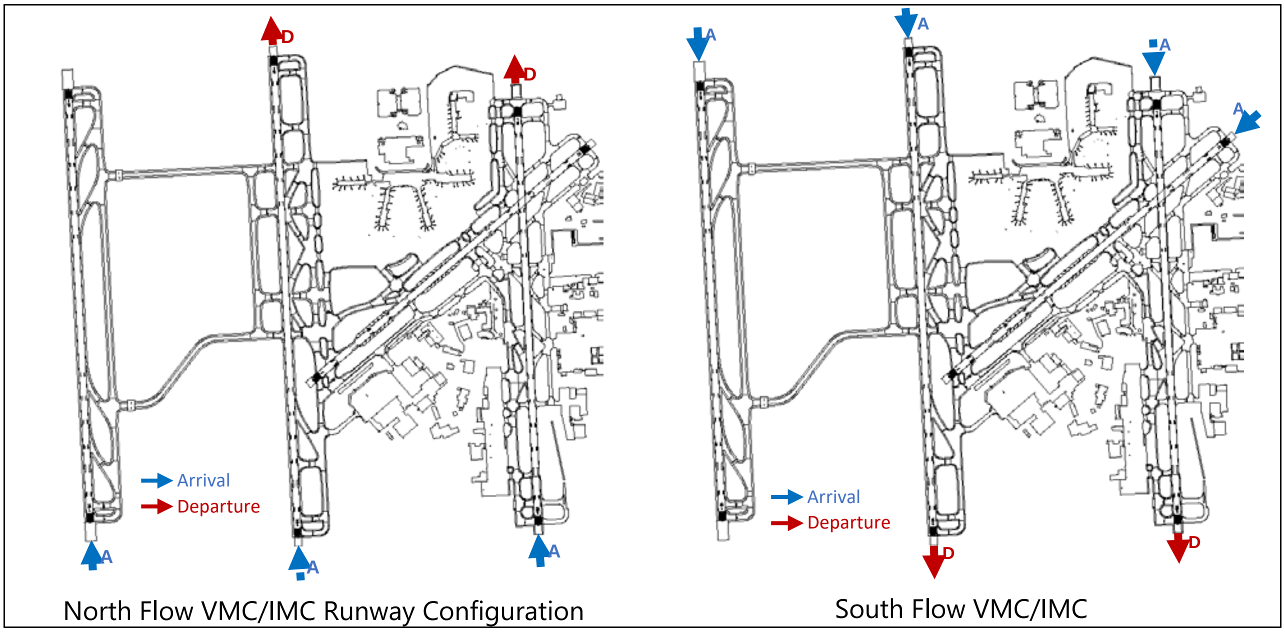
South Flow – Departure

Source: Aerobahn®, January 2015 – April 2017, analyzed by TransSolutions

Note that a rehabilitation project of Taxiway C occurred in fall 2016, which closed Runway 5-23 for most of August, September, October and half of November. Periodic runway closures occurred throughout the winter. Runway 5-23 was closed all of March 2017 for boring work in the Runway Safety Area (RSA). When the crosswind Runway 23 is not used, arrivals that would typically land on Runway 23 instead land on Runway 18L. At the same time, there is a reduced use of Runway 18L for departures and an increased use of Runway 18C by departures.

Figure 2-3 illustrates the arrival and departure runway configurations for North Flow and South Flow.

Figure 2-3 Arrival and Departure Runway Configurations



North Flow VMC/IMC Runway Configuration

South Flow VMC/IMC

Source: ACEP Final Report, Exhibits 3-2 and 3-3, February 2016

2.4 Additional Runway Usage Assumptions

The following section outlines the additional runway use assumptions that were used in the modeling effort.

2.4.1 Long-Haul Aircraft Operations

Runway use is mostly assigned by the direction of flight. Using this approach, some heavy and long-haul departures to the West Coast require Runway 18C-36C. More specifically:

- In North Flow, aircraft will depart Runway 36C with no arrivals on Runway 36C until the arrival peaks require that Runway 36C also be used for arrival traffic.
- In South Flow, aircraft will depart Runway 18C and arrive Runway 18L or 23 until the traffic peaks require that Runway 23 arrivals be re-assigned so that Runway 18L is used for arrival traffic with three parallel arrival runways.

2.4.2 General Aviation and Military Operations

In most circumstances, General Aviation (GA) and military flights primarily land/depart on Runway 18L-36R due to the proximity of their assigned ramps to this runway. In addition, Runway 23 is frequently utilized in South Flow conditions by GA and military arrivals.[14]

2.4.3 Cargo Operations

In general, more than 50 percent of cargo flights operate on Runway 18C–36C due to its longer length compared to other runways. Another 25 percent of cargo traffic operates on Runway 18L–36R due to its proximity to the cargo ramps/facilities.[15]

2.4.4 Noise Abatement Procedures

Noise abatement procedures are included in the simulation model, based on the FAA Order CLT ATCT 1050.1j, effective December 1, 2013. Noise abatement procedures are in effect from 2300 – 0700, local time. During this time, Runway 5-23 is preferred.

For noise abatement, jet and large four-engine props aircraft are assigned the following headings until two (2) Nautical Miles (NM) from the departure end of the following runways.

- Runway 18L, 18C, 23 and 5: runway heading.
- Runway 36R: 025 degrees.
- Runway 36C: 330 degrees.
- Runway 36L: 315 degrees.
- Runway 18R: 200 degrees.

2.5 Terminal Radar Approach Control (TRACON) Airspace

The air traffic control area managing arrivals to and departures from CLT is the TRACON. Simulation functions that direct the movement of aircraft through the airspace are described in this section.

2.5.1 Metroplex Airspace

A Metroplex is a geographic airspace area covering several airports, serving major metropolitan areas and a diversity of aviation stakeholders. Currently, the FAA is focusing on airspace optimization at the Metroplex level, which provides solutions on a regional scale, rather than focusing on a single airport or set of procedures. The overall goal of FAA's NextGen Metroplex

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[14] TransSolutions analysis of Aerobahn® data

[15] TransSolutions analysis of Aerobahn® data

program is to improve the operational efficiency of the National Airspace System (NAS) in serving large airports.

The FAA implemented the Charlotte Metroplex airspace changes in three phases:

- Phase 1: October 2015.
- Phase 2: May 2016.
- Phase 3: July 2016.

The Charlotte Metroplex includes CLT as well as Columbia Metropolitan Airport(CAE), Piedmont Triad International Airport (GSO), Greenville-Spartanburg International Airport(GSP), Concord Regional (JQF) Airport, and Raleigh-Durham International Airport (RDU). The Metroplex airspace includes new arrival and departure routings serving CLT as well as procedural improvements that take advantage of some NextGen technological developments. As described in the FAA's Finding of No Significant Impact (FONSI) and Record of Decision (ROD) for the CLT Metroplex, the airspace changes consist of 46 procedures, several of which utilize Area Navigation (RNAV).[16] The airspace changes are described in detail in the FAA's Environmental Assessment (EA) of the Charlotte Metroplex.[17]

Figure 2-4 illustrates the Metroplex airspace. The Existing Conditions and future No-Action Baseline simulation models include the implemented Metroplex airspace in the SIMMOD model based on the latitude-longitude coordinates obtained from FAA National Flight Data Center (NFDC). **Figure 2-5** depicts the simulated Metroplex airspace in south-flow conditions while **Figure 2-6** depicts the simulated Metroplex airspace in north-flow conditions. In these figures, arrival routes are shown in blue while departure routes are shown in purple.

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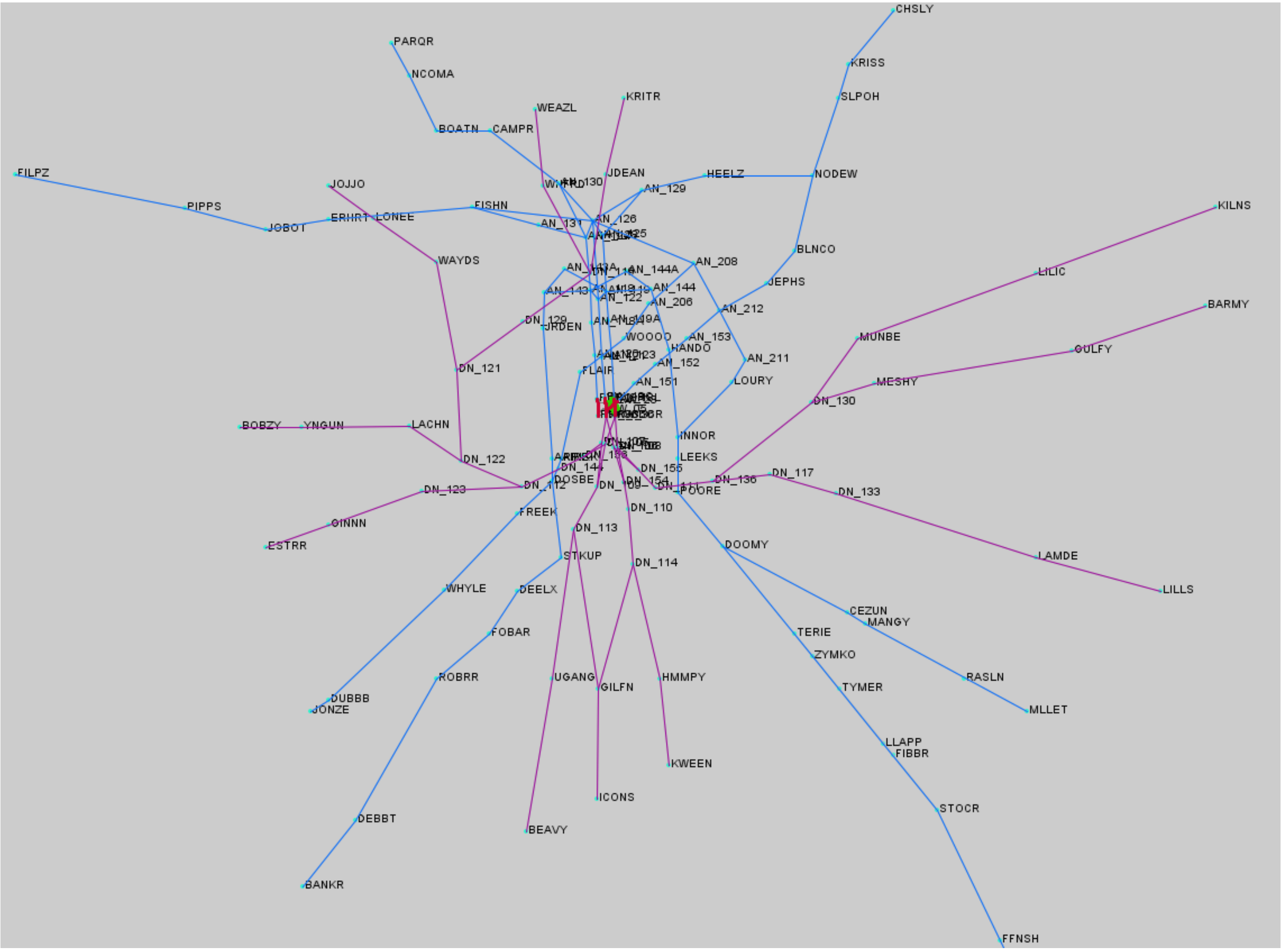
[16] Finding of No Significant Impact (FONSI) and Record of Decision (ROD) For the Charlotte Optimization of the Airspace and Procedures in the Metroplex (CLT OAPM), FAA, May 19, 2015

[17] Draft Environmental Assessment for Charlotte Optimization of Airspace and Procedures in the Metroplex, FAA, December 2014.

Figure 2-4 Metroplex Airspace

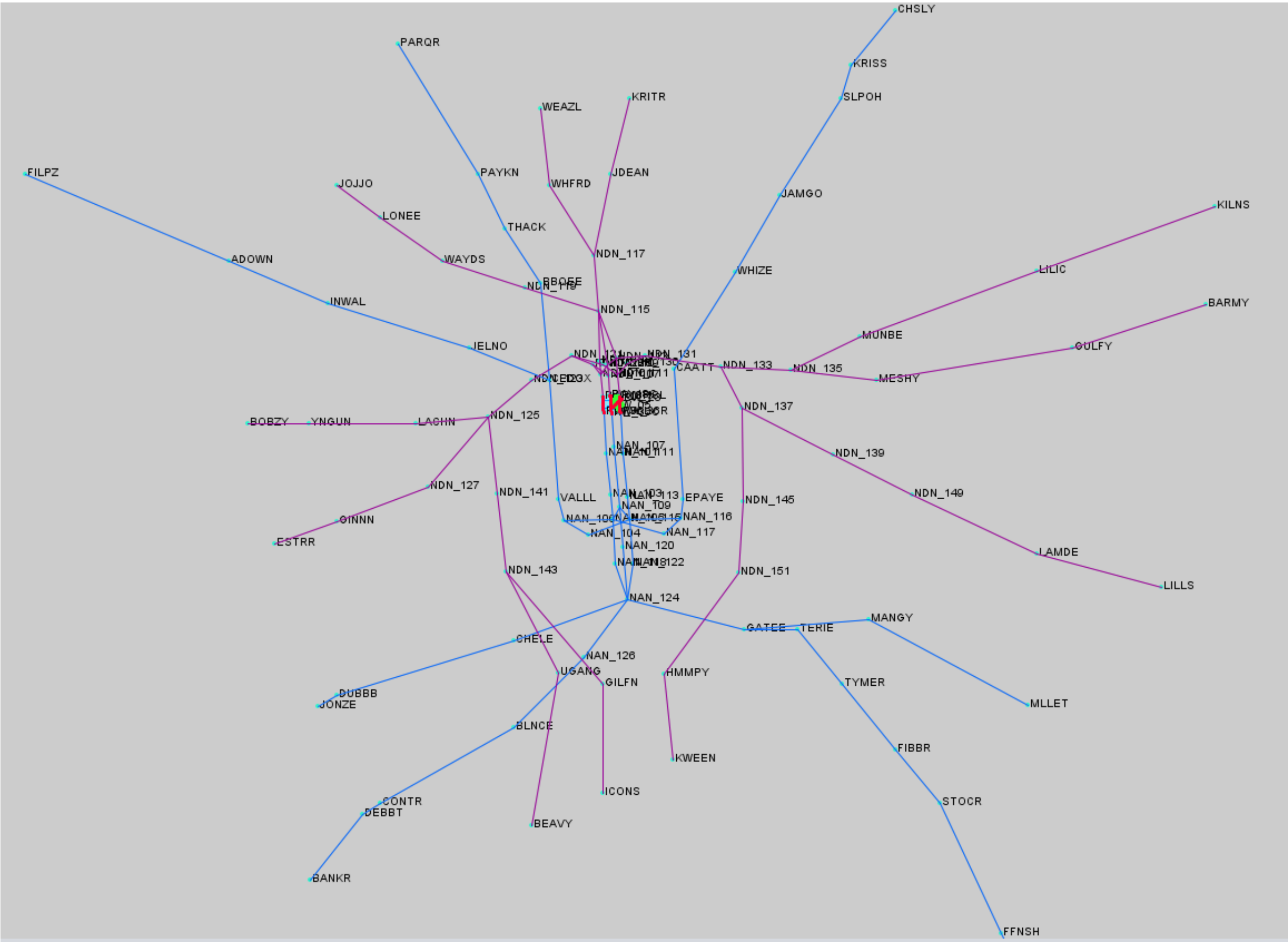
Source: FAA, CLT Airport Traffic Control Tower

Figure 2-5 Simulated Airspace for South-flow



Source: TransSolutions SIMMOD model

Figure 2-6 Simulated Airspace for North-flow



Source: TransSolutions SIMMOD model

2.5.2 Airspace Separations

The airspace modeled in the future No-Action baseline scenarios encompasses the CLT Terminal Radar Control Facility (TRACON), which extends a maximum of 30 nautical miles from CLT. Aircraft separations in the SIMMOD model were maintained in the airspace based on the following:

- Wake turbulence separation.
- Route separation.
- Departure separation.

The simulation models calculated the required separation for each of these and then applied the maximum separation between two aircraft. Each of these separations is described below.

2.5.2.1 Wake Turbulence Separations

The FAA wake turbulence recategorization (RECAT) separations, summarized in **Table 2-2** below, were applied to the simulation models in the study for aircraft operating directly behind or following another aircraft. Wake turbulence separations are maintained when different category aircraft follow one another. Smaller aircraft following larger aircraft may encounter wake turbulence (vortices generated by an aircraft's wingtip) generated by larger aircraft – creating a potentially hazardous situation. Because of this, additional separation between aircraft may be required for a trailing aircraft to avoid the larger aircraft's wake turbulence. The wake turbulence separation defines the separation between arrivals to the same runways.

Table 2-2 FAA RECAT Specifications (NM)

		Trailing Aircraft				
		Upper Heavy (A332, B777)	**Lower Heavy (B763)**	**Upper Medium (A320, E190)**	**Lower Medium (AT72, CRJ9)**	**Small (GA prop)**
Leading Aircraft	Upper Heavy	3.0	4.0	5.0	5.0	7.0
	Lower Heavy	3.0	3.0	3.5	3.5	6.0
	Upper Medium	3.0	3.0	3.0	3.0	4.0
	Lower Medium	3.0	3.0	3.0	3.0	3.0
	Small	3.0	3.0	3.0	3.0	3.0

Source: Federal Aviation Administration Order 7110.659A

2.5.2.2 Route Separations

The future No-Action Baseline will use the route separations in the ACEP SIMMOD models namely:

- South VMC and IMC: 3 NM.
- North VMC and IMC: 2.5 NM.

The route separation defines the minimum distance between flights that are assigned the same flight path consecutively, one after another.

2.5.2.3 Departure Separations

In the airspace surrounding CLT, consecutive departing aircraft are required to maintain departure separations for take-off from the same runway. **Table 2-3** summarizes the standard aircraft separations for consecutive departures that were used in the ACEP and were incorporated in the simulation models. These define the separation between departures from the same runways. In addition, lateral separation was achieved within the SIMMOD model by ensuring these same separations are provided between the various aircraft routings.

Table 2-3 Runway Departure Separations (in seconds)

	Lead Aircraft Category			
Trail Aircraft	**Heavy**	**B757**	**Large**	**Small**
Heavy	90	120	120	120
B757	90	90	90	120
Large	[1]60/72	[1]60/72	[1]60/72	[1]60/72
Small	[1]60/72	[1]60/72	[1]60/72	[1]60/72

* VMC/IMC in-trail separations

Source: ACEP Final Report, Table 3-4, February 2016

To replicate variability in actual air traffic operations, the SIMMOD models will incorporate separation multipliers (both arrivals and departures) which vary the distance between aircraft on the same route. In VMC, the multipliers range from 0.55 to 1.55, which adjust a 3.0 nautical mile (nmi) separation to vary between 1.65 nmi to 4.65 nmi, with an average separation of 3.24 nmi. In IMC, the lowest multiplier is 0.978, which may reduce the 3.0 nmi separation to 2.93 nmi separation.

2.5.3 Enroute Assignments and Metering

Flights are assigned to specific arrival routes based on their originating airport, and are assigned specific departure routes based on their destination airport. A few representative airports along with the assigned arrival and departure route are provided in **Table 2-4**.

Table 2-4 Arrival and Departure Route Assignment Examples

City/Airport	Direction	Arrival Route	Departure Route
Albany, NY (ALB)	NE	CHSLY	KILNS, BARMY
Atlanta, GA (ATL)	WSW	FILPZ	BOBZY
Augusta, GA (AGS)	SSW	BANKR	BEAVY
Boston, MA (BOS)	E	MILLET	BARMY
Buffalo, NY (BUF)	NNE	CHSLY	KILNS, KRITR
Canton/Akron, OH (CAK)	N	CHSLY	JOJJO, WEAZL, KRITR
Charleston, SC (CHS)	SSE	STOCR	KWEEN
Columbus, OH (CMH)	NNW	PARQR	WEAZL
Dallas/Fort Worth (DFW)	W	FILPZ	ESTRR, BOBZY
Des Moines, IA (DSM)	WNW	FILPZ	BOBZY
Frankfurt, Germany (FRA)	ENE	CHSLY	BARMY
Houston (IAH)	W	FILPZ	ESTRR, BOBZY
Indianapolis, IN (IND)	NW	PARQR	JOJJO
Los Angeles, CA (LAX)	W	FILPZ	ESTRR, BOBZY
Miami, FL (MIA)	S	STOCR, BANKR	KWEEN, ICONS, BEAVY

Myrtle Beach, SC (MYR)	SE	MILLET	LILLS
Mexico City, Mexico (MEX)	SW	JONZE	BEAVY
Nashville, TX (BNA)	W	FILPZ	ESTRR, BOBZY
New York (JFK/LGA)	E	MILLET	BARMY
Philadelphia, PA (PHL)	E	MILLET	BARMY
Washington, DC (DCA)	E	MILLET	BARMY
Wilmington, NC (ILM)	ESE	MILLET	LILLS

Source: Aerobahn, analyzed by TransSolutions

While flights can get to any route from any runway, typically arrivals at CLT from the west land on Runway 18R-36L, and flights from the east land on Runway 18L-36R or Runway 23. Departures to the west typically depart Runway 18C-36C while departures to the east typically depart Runway 18L-36R. Some logical adjustments were made in the SIMMOD model to the directional assignments in order to coincide with the runway usage noted in Table 2-1.

In 2017, CLT began testing the Airspace Technology Demonstration 2 (ATD-2) specifically for departures to the enroute airspace of Washington Air Route Traffic Control Center (ARTCC), or Washington Center. Previously, departures to the northeast over the BARMY and KILNS fixes often had a miles-in-trail (MIT) restriction to handoff from the CLT airspace to Washington Center. With ATD-2, the flights going into Washington Center are assigned a take-off time prior to pushing-back from the gate, thus metering the departures into the airspace. Operating with ATD-2 has eliminated the MIT restrictions except in the event of convective weather. Based on feedback from the FAA ATC staff at CLT, it was assumed that ATD-2 or a system/technology providing a similar capability will remain in place at CLT, hence, the baseline simulations for future years did not include MIT separations. Note however that the 2016 baseline simulation assumed a 15-nmi in-trail restriction to routes departing CLT airspace into the Washington Center.

2.6 Runway Separations and Dependencies

Due to the crossing runway configurations at CLT, certain operations are subject to Converging Runway Operations (CRO) procedures in South Flow as described below.

- Converging Runway Operations (CRO) Arrival Departure Window (ADW) on Runway 23.
  - When arrivals to Runway 23 are within 1.8 NM of landing, departures are blocked from Runway 18C until the arrival aircraft is 0.2 NM beyond the Runway 23 threshold (i.e., after the arriving aircraft crosses over Taxiway D).
  - This configuration operates with 3.0 NM between arrivals to get a Runway 18C departure between each pair of arrivals.
- When arrivals to Runway 23 are within 2.0 NM of landing, departures are blocked from Runway18L until the arrival aircraft crosses Runway 18L.

Due to the runway separation, operations on the parallel runways are independent in both VMC and IMC.

- South Flow VMC/IMC: Runways 18R, 18C, and 18L are independent.
- North Flow VMC/IMC: Runways 36L, 36C, and 36R are independent.

Table 2-5 shows the time between consecutive operations on the same runway observed from the Aerobahn® data from January 2015 to April 2017. Note that this analysis included consecutive operations less than 2.5 minutes, since operations with separations greater than that are likely not during a high demand period. This data provided the basis for the simulation model runway procedures.

Table 2-5 Aerobahn® Runway Separation Observations

Operations	Flow	Runway	5th Percentile (min)	Avg (min)
Arrival - Arrival	North	36L	1.1	1.5
		36C	1.3	1.8
		36R	1.3	1.9
		Overall	**1.1**	**1.6**
	South	23	1.2	1.7
		18L	1.4	1.9
		18C	1.3	1.9
		18R	1.1	1.5
		Overall	**1.1**	**1.6**
Departure - Departure	North	36L	0.7	1.3
		36C	0.7	1.3
		36R	0.7	1.5
		Overall	**0.7**	**1.4**
	South	18L	0.6	1.3
		18C	0.8	1.4
		18R	0.7	1.4
		Overall	**0.6**	**1.4**
Arrival - Departure	North	36C	0.4	0.8
		36R	0.3	0.5
		Overall	**0.3**	**0.6**
	South	18C	0.4	0.8
		18L	0.5	0.8
		Overall	**0.4**	**0.8**
Departure - Arrival	North	36C	1.4	1.9
		36R	1.3	1.7
		Overall	**1.3**	**1.7**
	South	18C	1.5	1.9
		18L	1.1	1.6
		Overall	**1.1**	**1.7**

Source: Aerobahn®, January 2015 – April 2017, analyzed by TransSolutions

2.7 Aircraft Final Approach Speed

Aircraft final approach speeds are specified in the ACEP report as 140 knots for all aircraft types. In reference to FAA guidelines, aircraft final approach speeds that will be used in the Existing Conditions and future No-Action Baseline simulation models are summarized in **Table 2-6** below.

Table 2-6 FAA Aircraft Characteristics

SIMMOD Aircraft Category	Avg. Final Approach Speed (knots)
Upper Heavy[1]	140
Lower Heavy[2]	140
Upper Medium[3]	130
Lower Medium[4]	110
Small[5]	105

Source: Federal Aviation Administration AC 150/5300-13A, Change 1: "Airport Design"

[1] Includes: 332, 333, 346, 359, 788, 789

[2] Includes: A300F, A306, DC10, DC10F

[3] Includes: 752

[4] Includes: 319, 320, 321, 32A, 32N, 3N1, 717, 733, 737, 738, 739, 73G, 73H, 73J, 73W, 7M7, 7M8, 7M9, C130, CR2, CR7, CR9, CRA, CRJ, DH3, DH8, E70, E75, E7W, E90, ER4, ERJ, M88, M90

[5] Includes: B350, BE20, BE30, BE40, BE58, BE9L, C210, C25A, C25B, C303, C510, C550, C560, C56X, C750, CL30, CL35, CL60, CS1, E50P, E55P, EM2, F2TH, F900, FA50, G150, G280, GALX, GL5T, GLEX, GLF4, GLF5, GLF6, H25B, J328, LJ35, LJ45, LJ60, LR60, P180, PA27, PA34, PC12, SR22, SW3, SW4, TBM7, TBM8, TBM9

2.8 Aircraft Take-Off and Landing Roll

The ACEP take-off distance distribution inputs were used as follows.

- Heavy Aircraft: 6,500-7,500 feet.
- All other aircraft types: 5,000-6,600 feet.

The Existing Conditions and future No-Action Baseline simulation uses the take-off rolls observed in June 2017, and was supplemented by the ACEP inputs when no data were recorded, as shown in **Table 2-7**. Note that while take-off rolls are required input to the SIMMOD model, this specific parameter has no significant effect or impact on the SIMMOD model results as the runway departure separations detailed above in **Table 2-4** primarily control departure operations.

Table 2-7 Take-Off Roll Distances

Type	Avg. Distance (ft.)
Turboprop	3,385
Regional Jets	5,350
Narrow Body	6,640

Source: Data collected at CLT, 77 observations recorded June 14-15, 2017.

The Existing Conditions and future No-Action Baseline simulation model landing rolls used runway exit percentages obtained from Aerobahn® data. Note that the analysis of the Aerobahn® data shows a difference in runway exit location designations after January 2016, and the details of the previous data labels are not available. Thus, **Table 2-8** summarizes the runway exit percentages analyzed from Aerobahn® for February 2016 – April 2017, which were used in this study.

Table 2-8 Runway Exit Usage by Aircraft Type

North Flow						South Flow					
Runway	**Exits**	**T-Prop**	**RJ**	**NB**	**WB**	**Runway**	**Exits**	**T-Prop**	**RJ**	**NB**	**WB**
36L	W7	100%	97%	76%	73%	18R	W4	99%	95%	69%	54%
	W8	0%	3%	24%	27%		W3	1%	5%	31%	46%
36C	S	21%	0%	0%	1%	18C	E6	7%	2%	1%	0%
	E6	71%	52%	19%	13%		V4	24%	12%	4%	0%
	V5*	5%	25%	37%	33%		E5	45%	45%	20%	6%
	E8	2%	22%	38%	43%		S	4%	22%	17%	5%
	N	0%	1%	5%	5%		E4	19%	19%	56%	83%
	E9	0%	0%	1%	5%		E3	0%	0%	2%	6%
36R	D4	14%	0%	0%	0%	18L	C9	2%	0%	0%	0%
	D5	7%	0%	0%	0%		D7	3%	0%	0%	0%
	R	37%	22%	45%	24%		R	22%	0%	0%	0%
	D6	19%	0%	0%	0%		C8	21%	7%	3%	0%
	C9	1%	4%	6%	11%		D5	32%	0%	0%	0%
	A	5%	8%	19%	15%		C7	1%	2%	2%	0%
	M	0%	2%	27%	29%		D4	5%	0%	0%	0%
	C10	13%	57%	3%	18%		C6	5%	61%	42%	28%
	C11	1%	3%	1%	1%		C5	0%	12%	13%	12%
	C	2%	4%	0%	0%		D3	9%	0%	0%	0%
							C4	0%	16%	37%	58%
							C3	0%	0%	1%	2%
						23	C	3%	0%	0%	0%
							R	6%	0%	0%	0%
							G	6%	0%	0%	0%
							B	52%	46%	29%	12%
							A4	28%	0%	0%	15%
							M2	0%	5%	3%	1%
							F	5%	48%	68%	72%

Source: Aerobahn®, February 2016 – April 2017.

* Note that over 30% of Runway 36C arrivals indicated exiting at Taxiway E7, which is a reverse exit; the SIMMOD model assumed these arrivals use exit Taxiway V5.

2.9 Ramp Areas

The current aircraft ramps are divided into four types:

- Commercial Passenger.
- General Aviation.
- Cargo.
- Military/Air National Guard.

The location of each type is shown on the map in **Figure 2-5**.

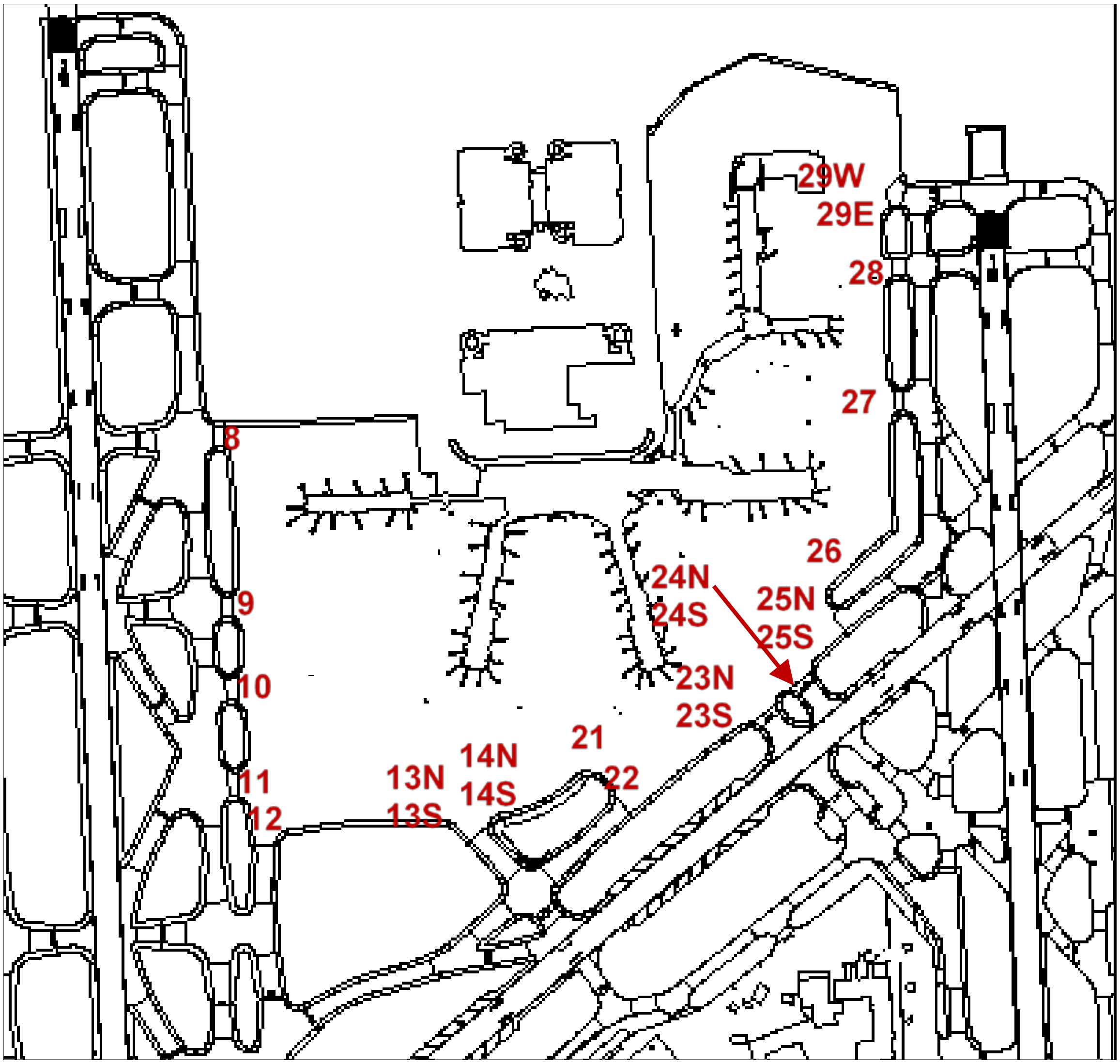
Figure 2-5 Aircraft Ramps

Source: TransSolutions, LLC

2.10 Ramp Entry and Exit

Figure 2-6 illustrates aircraft entry and exit points at the ramp.

Figure 2-6 Ramp Entry and Exit Points



Source: CLT Air Traffic Control, 2017

Aerobahn® data were analyzed to determine the usage of each entry and exit point at the ramp. The data also indicated a change in operations or airfield configuration after January 2016 where certain entry and exit points were no longer used or available. **Table 2-9** summarizes the ramp entry and exit points for the operations from February 2016 to April 2017.

Table 2-9 Ramp Entry and Exit Point Usage

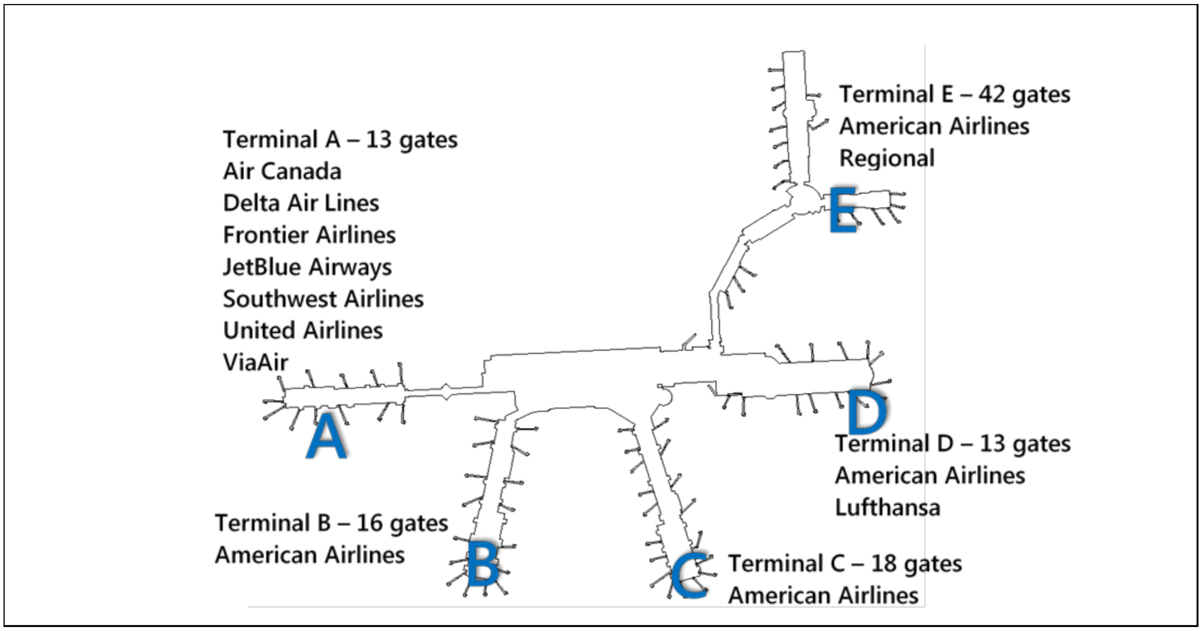
Ramp Entry/Exit	North		South	
	Arrivals	Departures	Arrivals	Departures
8	4%	0%	1%	4%
9	52%	0%	0%	41%
10	2%	0%	0%	2%
11	4%	0%	45%	0%
12	0%	16%	12%	0%
22	0%	6%	20%	0%
27	5%	3%	5%	8%
28	6%	1%	6%	0%
13S,14S,13N,14N	1%	7%	5%	0%
23S,23N	0%	62%	5%	0%
24S,24N	13%	1%	0%	0%
25N,25S	4%	0%	0%	26%
29E,29W	9%	4%	1%	19%
Total	**100%**	**100%**	**100%**	**100%**

Source: Aerobahn®, February 2016 – April 2017

2.11 Airline Gate Assignment

Figure 2-7 shows the current terminal locations, number of gates, and the airlines assigned.

Figure 2-7 CLT Terminal Concourse Location, Number of Gates, and Airline Assignments



Source: Charlotte Douglas International Airport

As observed during the Project Team's site visit at the CLT Air Traffic Control tower, a waiting area on the ramp was included in the simulation model in the southwest area of the commercial ramp (south of Concourse A) so that flights can hold there until the assigned gate becomes available. While this is predominantly used by American Airlines, all flights may wait in this area for an available gate.

For the future demand levels, additional remote stands were modeled at Concourse E for American Eagle flights to account for:

- The heavy traffic and fast turn-around times for American Eagle flights.
- The arrival/departure distribution applied to each flight that varies each flight's simulated times from the scheduled times.

The new pier currently being constructed at Concourse A (additional eight gates) was included in the SIMMOD model for the future No-Action traffic demands.

2.12 Aircraft Taxi Speeds

Aircraft taxi speeds used in the ACEP are summarized in **Table 2-10**.

Table 2-10 ACEP Taxi Speeds

Area of Airfield	Speed (knots)
Outer Perimeter Taxiways (Arrivals)	25 knots
Runway Crossings	10 knots
Ramp Area Taxiways	12 knots
Ramp Area Taxilanes	10 knots
Gate Power-In	5 knots

Source: ACEP Final Report, Table 3-6, February 2016

The Existing Conditions and future No-Action Baseline used a combination of the ACEP and the on-site observations of taxi speeds collected at CLT on June 14-15, 2017, as shown in **Table 2-11** and illustrated in **Figure 2-8**.

Table 2-11 2017 Taxi Speeds

Area of Airfield	Speed (knots)
Runways	70
Rapid Exit Taxiways (Angled Exits)	32
Perpendicular Runway Exits	15
Taxiways N and S (between Runways 18C-36C and 18R-36L)	20
Taxiways	15
Ramp Areas	10
Runway Crossings	18

Source: Data collected at CLT, 381 observations recorded, June 14-15, 2017

Figure 2-8 Different Taxi Speeds in the Airfield

Source: TransSolutions analysis, 2017

2.13 Aircraft Pushback Times

The pushback time begins when an aircraft starts moving from its gate, and the pushback time ends when the aircraft starts to taxi using its own power. Note that during aircraft pushback, the majority of aircraft parked in adjacent gates are able to pushback independently, However, there are a few areas near the terminal where adjacent aircraft are blocked from pushing back if the pushback paths overlap. In addition, heavy aircraft pushing back from the north side of Concourse D block pushbacks from the southeast side of Concourse E.

The ACEP applied a three (3) minute pushback time to all passenger flights.

- The Existing Conditions and future No-Action Baseline will use the 2017 observed pushback times, shown in **Table 2-12**. The simulation will apply the on-site observed pushback times, as follows.
    - Pushback times vary from 2 to 5.5 minutes, shown in **Figure 2-9.**
    - The average time is 3.6 minutes, shown in **Table 2-12**.

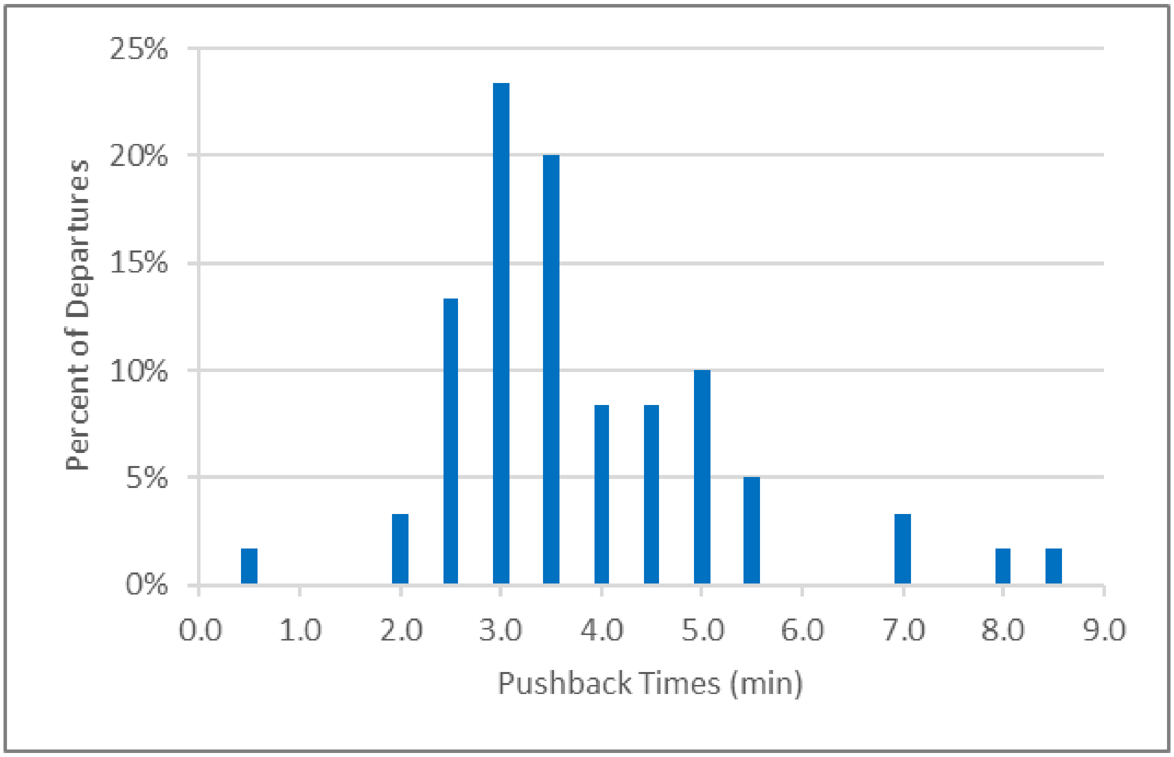
- The same pushback distribution will be used for all commercial passenger aircraft types as they are not significantly different across different aircraft types.

Table 2-12 Average Pushback Time

Type	Avg. Times (min)
T-Prop	3.2
RJ	3.8
NB	3.6
Total	3.6

Source: Data collected at CLT, 60 observations recorded, June 14-15, 2017

Figure 2-9 2017 Observed Pushback Times

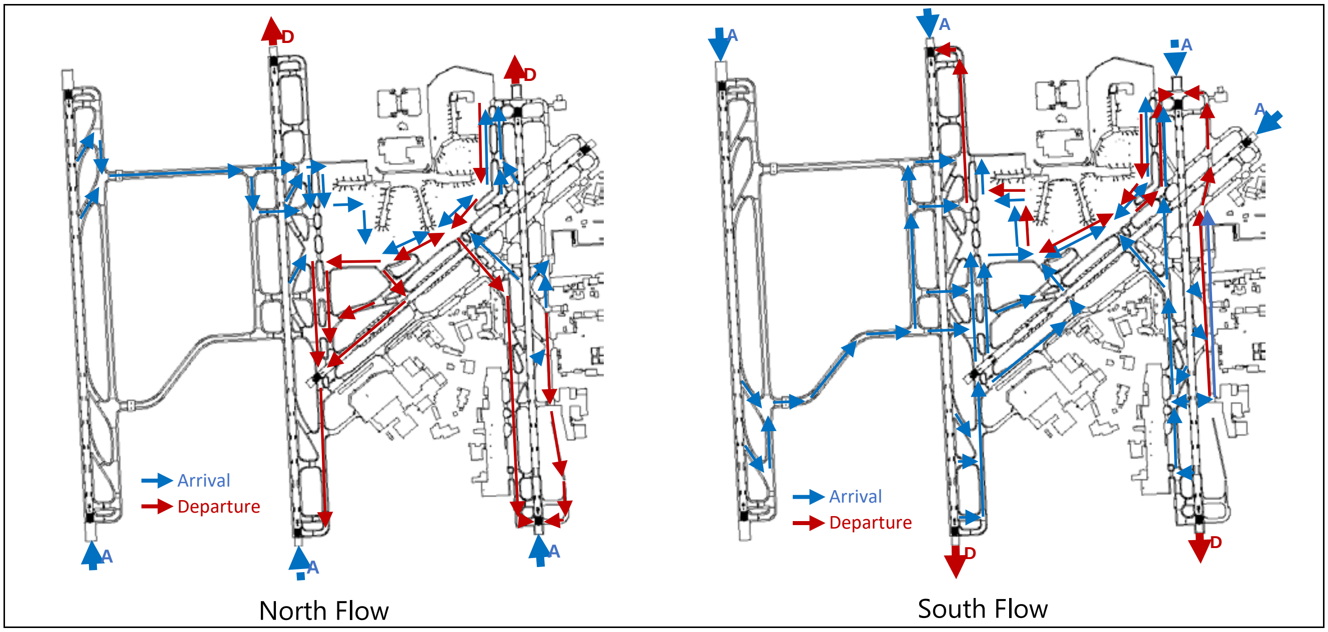


Source: Data collected at CLT, June 14-15, 2017

2.14 Taxiflows

The Existing Conditions and future No-Action Baseline used both the ACEP and 2017 observed taxi-flows, illustrated in **Figure 2-10**.

Figure 2-10 North and South Taxi Flows – Integrated ACEP and 2017 Observations



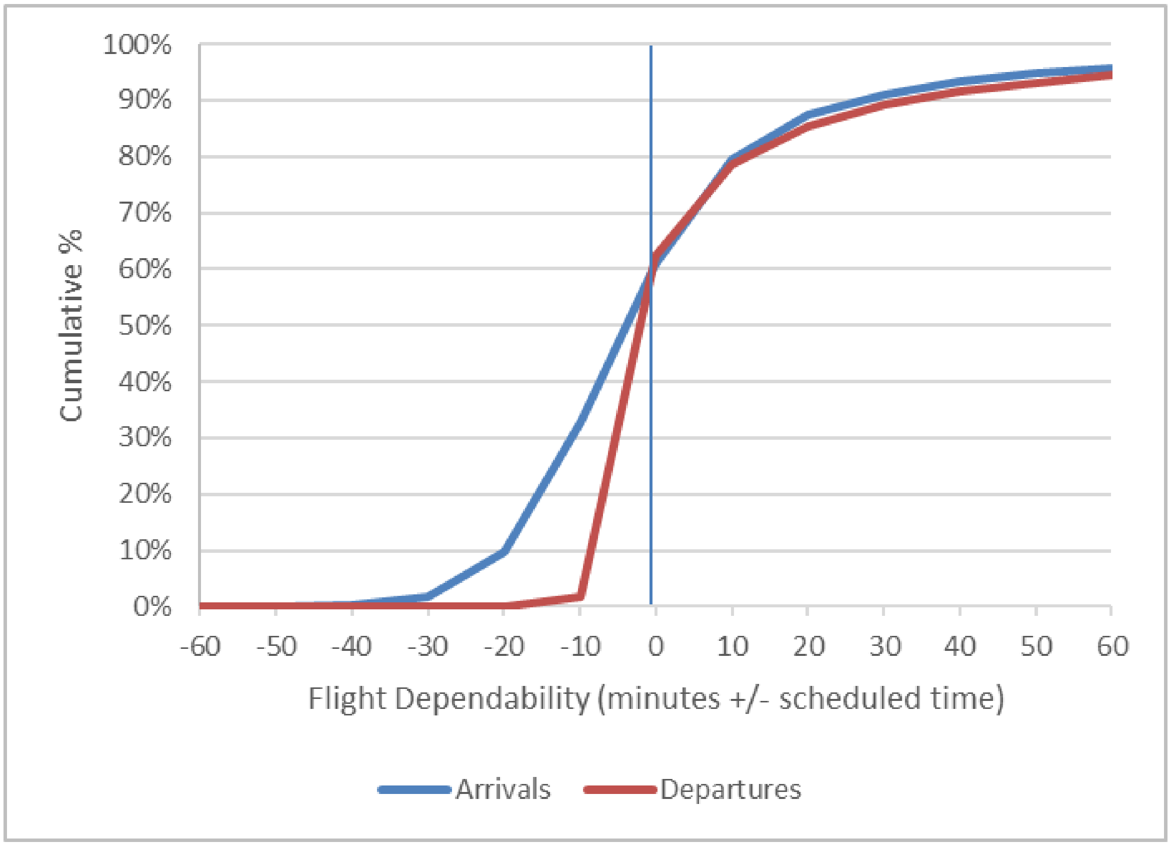
Source: TransSolutions analysis of ACEP and observations

2.15 Flight Dependability

The probability that a flight arrives/departs earlier or later than scheduled is applied in the SIMMOD model to create a realistic arrival and departure profile. Negative values indicate flights that arrive or depart prior to their scheduled time, while positive values indicate flights that arrive or depart after their scheduled time.

Flight dependability varied for both arrivals and departures by 30 minutes (60 minutes in North IMC configuration) in the ACEP. The Existing Conditions and future No-Action Baseline used the data analyzed from Aerobahn®, shown in **Figure 2-11**, since this provided more detailed information.

Figure 2-11 Earliness/Lateness Distributions



Source: Aerobahn®, January 2015 – April 2017

2.16 Model Calibration

A necessary step in any simulation analysis is to ensure that the simulation model is an accurate representation of the actual operations. SIMMOD model calibration is accomplished by comparing results of the simulation to actual data for the same traffic demand. Typically, simulation results should be within 10 percent of the actual data for the SIMMOD model to be calibrated.

Calibration was performed for both the North Flow and South Flow models with the 2016 traffic demand in VMC. The simulation model was calibrated to reflect current operational conditions of the following elements:

- 90 percent maximum hourly runway throughput for arrivals and departures.[18]

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[18] According to the *Airport Capacity Enhancement Plan* (Pg. 6-54), the DORA stakeholder group recommended that all throughput and capacity results from the ACEP simulation modeling analysis be weighted using the 90th percentile methodology, which yields a more conservative and sustainable runway throughput rate than the maximum throughput rate. In some calibration comparisons, both 90th and 95th percentile are presented to show the complete range of related values.

- Hourly airport throughput for arrivals and departures.
- Average arrival taxi-in times.
- Average departure taxi-out times.

Runway and airport throughput was also calibrated for both North Flow and South Flow in IMC. The IMC calibration did not include taxi time comparisons due to the variety of weather conditions at both CLT and other airports in IMC that can affect taxi times.

2.16.1 VMC Calibration

The first calibration comparison presented is hourly runway throughput. Aerobahn® data provided by CLT was analyzed for the peak month of May 2016 to obtain the hourly runway throughput on the major arrival and departure runways. The 90th-percentile hourly throughputs from Aerobahn® were compared to the simulation model's 90th-percentile hourly runway throughput. **Table 2-13** summarizes the calibrated major arrival and departure runway throughput of the simulation model in VMC. The simulation model produced runway throughputs within 10 percent of the actual data from Aerobahn®, thus demonstrating that the runway throughput of the simulation model was appropriately calibrated.

Table 2-13 Hourly Runway Throughput Calibration in VMC

Flow	Operations	Main Runway	Aerobahn®*	Simulation
South	Arrivals	18R	33	33
	Departures	18C	32	31
	Departures	18L	38	35
North	Arrivals	36L	35	32
	Departures	36C	38	37
	Departures	36R	29	28

* Analysis of Aerobahn® data, May 2016

In addition, the simulated throughputs for both South- and North-flow operations were compared to the FAA called rates and to the overall hourly traffic counts, analyzed for calendar years 2016 and 2017. The FAA called rates, or facility reported rates, provide an indication of CLT's ability to accommodate that number of hourly flights as the rates are used by FAA in traffic flow and metering. The analysis of ASPM data is presented in **Table 2-14** when the same configuration was operational:

- South: Arriving 18R, 23, 18C and 18L | Departing 18L and 18C
- North: Arriving 36L, 36R, and 36C | Departing 36C and 36R

Note: a variety of called rate values were found in ASPM for a particular runway configuration. The most frequent called rate for each configuration is included in the table. For comparison purposes, the ACEP throughputs are also provided.

Table 2-14 VMC Hourly Throughput Calibration by Operation Type

		ASPM[1]		Simulation[2]		ACEP[3]	
Flow	**Operations**	**Called Rate***	**Maximum Operations***	**95th% Operations***	**Maximum Operations**	**95th% Operations**	**Peak Hour**
South	Arrivals	92	78	66	77	69	71
	Departures	82	81	70	78	66	73
North	Arrivals	92	79	67	73	66	72
	Departures	69	82	71	78	67	73

1 Analysis of ASPM data, 2016-2017
2 Simulation single day of 2016
3 ACEP Table 3-11 on page 3-34

The FAA's acceptance or called arrival rates are much higher than actual hourly counts. The hourly throughput of the simulated single day is very similar to the ASPM hourly counts, especially for the 95th percentiles.

Overall, the simulated hourly airport throughput for arrivals and departures together is presented in **Table 2-15** for the 90th percentile.

Table 2-15 VMC Hourly Throughput Calibration – Total Operations

ASPM 90th %	**Simulation 90th %**
121	121
121	118

Note: Analysis of ASPM data, 2016-2017

Another primary calibration comparison in VMC is taxi-in and taxi-out times. While the simulation model produces unimpeded travel times, taxi delays and departure queue delays, the only operational statistic for comparison is the overall taxi times, which include all delays encountered taxiing between the gate and the runway. For CLT, the taxi times compare favorably, within ten percent of the actual taxi times from Aerobahn®. **Table 2-16** summarizes the comparison of the calibrated taxi times of the simulation model in VMC.

Table 2-16 2017 Average Taxi Times

Flow	Operation	Aerobahn®[1] (min)	Simulation (min)
South	Arrival	11.0	10.3
	Departure	12.5	13.6
North	Arrival	10.5	10.2
	Departure	13.7	14.8

[1] Analysis of Aerobahn® data, May 2016

2.16.2 IMC Calibration

The IMC calibration includes both hourly runway throughput and overall hourly airport throughput. The runway throughput is obtained from Aerobahn® for the January - August 2016 to obtain the hourly runway throughput on the major arrival and departure runways: arrivals on Runway 18R-36L, and departures on Runways 18C-36C and 18L-36R. Note that additional months were analyzed to obtain adequate amount of IMC hours for comparing to the simulation. The 90th-percentile hourly throughputs from Aerobahn® were compared to the simulation model's 90th-percentile hourly runway throughput in **Table 2-17**.

Table 2-17 Hourly Runway Throughput Calibration in IMC

Flow	Operations	Main Runway	Aerobahn®[1]	Simulation
South	Arrivals	18R	34	35
	Departures	18C	28	29
	Departures	18L	32	34
North	Arrivals	36L	35	32
	Departures	36C	35	35
	Departures	36R	27	26

[1] Analysis of Aerobahn® data, January - August 2016

The simulated throughputs for both South Flow and North Flow operations IMC were compared to the FAA called rates and to the overall hourly traffic counts, analyzed for calendar years 2016 and 2017. Analysis is presented in **Table 2-18** of ASPM data when the same configuration was operational as is being simulated:

- South: Arriving 18R, 18C and 18L | Departing 18L and 18C
- North: Arriving 36L, 36R, and 36C | Departing 36C and 36R

While several called rate values are found in ASPM for a particular runway configuration, the most frequent called rate for each configuration is presented below. In addition to maximum counts, the 95th percentile is also provided for 0700 – 2200 local time. For comparison purposes, the ACEP throughputs are also provided. The hourly throughput of the simulated single day is very similar to the ASPM hourly counts, especially for the 95th percentiles.

Table 2-18 IMC Hourly Throughput Calibration by Operation Type

		ASPM[1]			Simulation[2]		ACEP[3]
Flow	**Operations**	**Called Rate***	**Maximum Operations***	**95th% Operations***	**Maximum Operations**	**95th% Operations**	**Peak Hour**
South	Arrivals	75	77	68	74	66	65
	Departures	65	74	64	68	62	68
North	Arrivals	75	76	68	73	66	65
	Departures	65	79	66	68	61	65

1 Analysis of ASPM data, 2016-2017
2 Simulation single day of 2016
3 ACEP Table 3-11 on page 3-34

The simulated hourly airport throughput for arrivals and departures combined is presented in **Table 2-19** for the 90th percentile.

Table 2-19 IMC Hourly Throughput Calibration – Total Operations

	ASPM	Simulation
Flow	**90th %**	**90th %**
South	112	114
North	114	116

Note: Analysis of ASPM data, 2016-2017

All simulation outputs compared for the 2016 calibration are within 10 to 11 percent of the actual data analyzed from FAA ASPM and Aerobahn for all four runway configurations: South Flow VMC, North Flow VMC, South Flow IMC and North Flow IMC.

3

Simulation Findings

3.1 Introduction

This section documents the findings of the airfield capacity/delay analysis for the Existing Conditions and future No-Action alternatives. This is followed by analysis of the simulation results for the current and anticipated demand for the Environmental Impact Statement (EIS) requirement for current and future conditions. The analysis years considered are the 2016 baseline year (Existing Conditions) for which a full year of data is available, 2028 when the project elements will be in place, and 2033, which is five years after the full implementation of the Project. This simulation estimates what the future would be like, without the proposed projects, and will ultimately serve as a comparison to the proposed project alternatives.

The primary simulation metrics used in an airfield capacity/delay analysis are the following.

- **Airfield/Runway throughput**: Hourly throughput reports the maximum number of arrivals and departures that use the runways in a given hour. Sustainable hourly capacity is the 90th percentile of the maximum hourly throughputs.
- **Arrival airspace delay**: Delay is measured as the difference in the amount of time an aircraft actually lands on the runway and the time it would have taken to land on the runway if it were able to move unimpeded through the airspace. The majority of the arrival delay occurs when aircraft must maintain separations and merge onto final approach.
- Taxi times:
    - Arrival taxi-in time (“on-to-in”) – Taxi-in time measures the time from when the aircraft lands on the runway until it taxies into its gate or ramp. It includes runway landing roll time, airfield taxi time, and any taxiway or ramp delays.
    - Departure taxi-out time (“out-to-off”) – Taxi-out time measures the time from when the aircraft departs its gate or ramp until it leaves the runway. It includes the time for push-back from the gate, airfield taxi time, departure queue wait time, and runway takeoff roll time.
- **Airfield delays**: Taxi delay is measured as the difference between the time an aircraft taxis between the runway and gate compared to the time it would have taken if it were able to move unimpeded on its airfield taxiing path. Departure ground delay includes the time in departure queue awaiting clearance to take-off. (Note that this airfield delay measure is included in the taxi times above.)

- **Ramp delays waiting for gates**: Ramp delay measures the amount of time an aircraft waits on the airfield for its assigned gate to become available. This indicates that additional gates are required to meet the traffic demand being simulated. (Note that this ramp or gate waiting delay measure is included in the airfield delays above.)

3.2 Existing Conditions and Future No-Action Modeling Analysis

In South Flow operations, arrivals primarily land on Runways 18R and Runway 23, adhering to the Converging Runway Operations (CRO) procedures with the required Arrival-Departure Window (ADW) for departures on Runway 18C. During peak arrival times, more arrival capacity is needed than can actually be achieved during CRO, in this case the Charlotte Douglas International Airport (CLT) air traffic controllers move to an all-parallel runway configuration to achieve more efficiency. The Runway 23 arrivals then are assigned to other runways so that both arrivals and departures can be accommodated on Runway 18C. As the traffic demand grows in the forecast flight schedules, there are limited opportunities to arrive on Runway 23 since the three simultaneous runway procedures are needed more frequently throughout the day. **Table 3-1** summarizes the average South Flow Visual Meteorological Conditions (VMC) airspace delays and taxi times for the current and future demands.

Table 3-1 South Flow VMC Average Delay and Taxi Times (in minutes)

	Arrival		Departure	
Year	Average Airspace Delay	Average Taxi-In Time	Average Ground Delay	Average Taxi-Out Time
2016	2.2	10.3	4.5	13.6
2028	3.3	12.8	4.5	13.4
2033	4.5	15.4	5.4	14.8

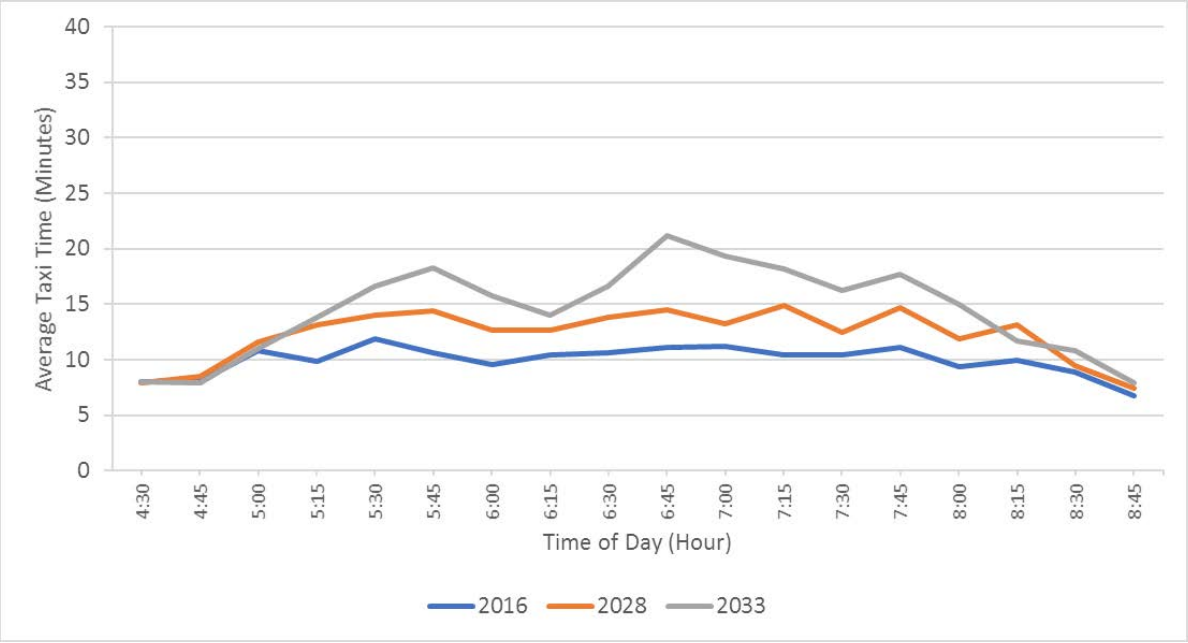
Source: TransSolutions, LLC; *Simmod PLUS!*

The arrival airspace delay increases by 50 percent from 2016 to 2028 and doubles from 2016 to 2033, increasing from 2.2 minutes in 2016 to 4.5 minutes in 2033.

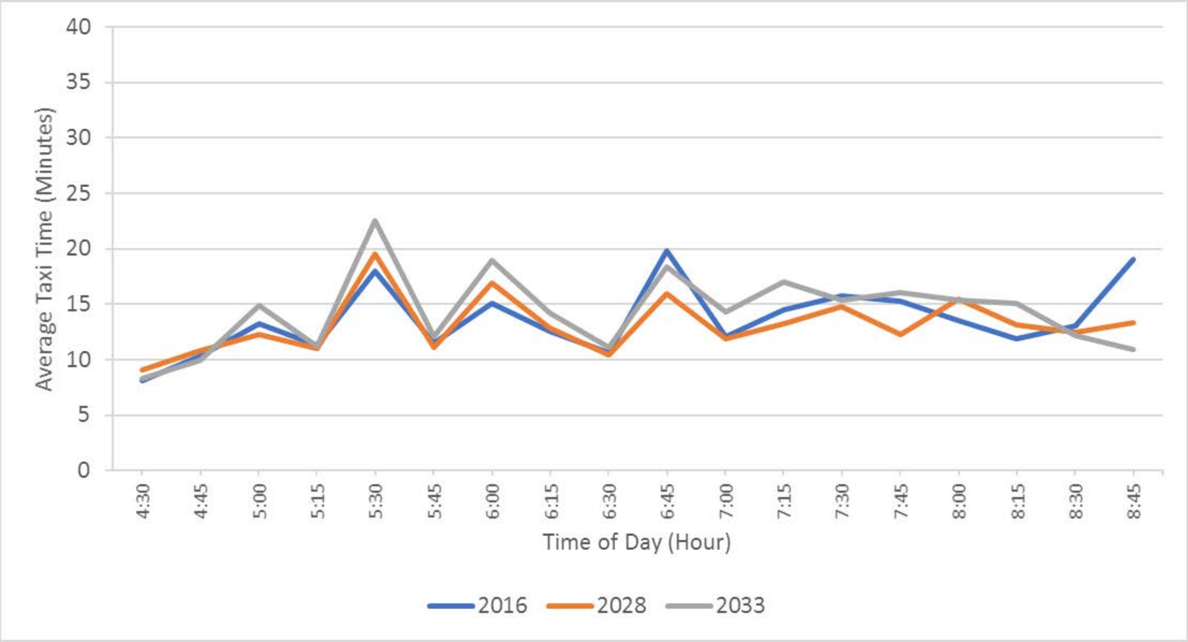
Taxi times increase with higher demand from 2016 to 2033: average taxi-in time increases by 50 percent, while taxi-out time increases by 9 percent.

Figure 3-1 illustrates the average taxi times in hourly increments for South Flow VMC.

1 **Figure 3-1 South Flow VMC Hourly Average Taxi Times**



Taxi-In



Taxi-Out

2 Source: TransSolutions, LLC; *Simmod PLUS!*

3

3.2.1 South Flow Instrument Meteorological Conditions (IMC)

During Instrument Meteorological Conditions (IMC) operations, Runway 23 is not used in South Flow. **Table 3-2** summarizes the average South Flow IMC airspace delays and taxi times for the current and future demands.

Table 3-2 South Flow IMC Average Delay and Taxi Times (in minutes)

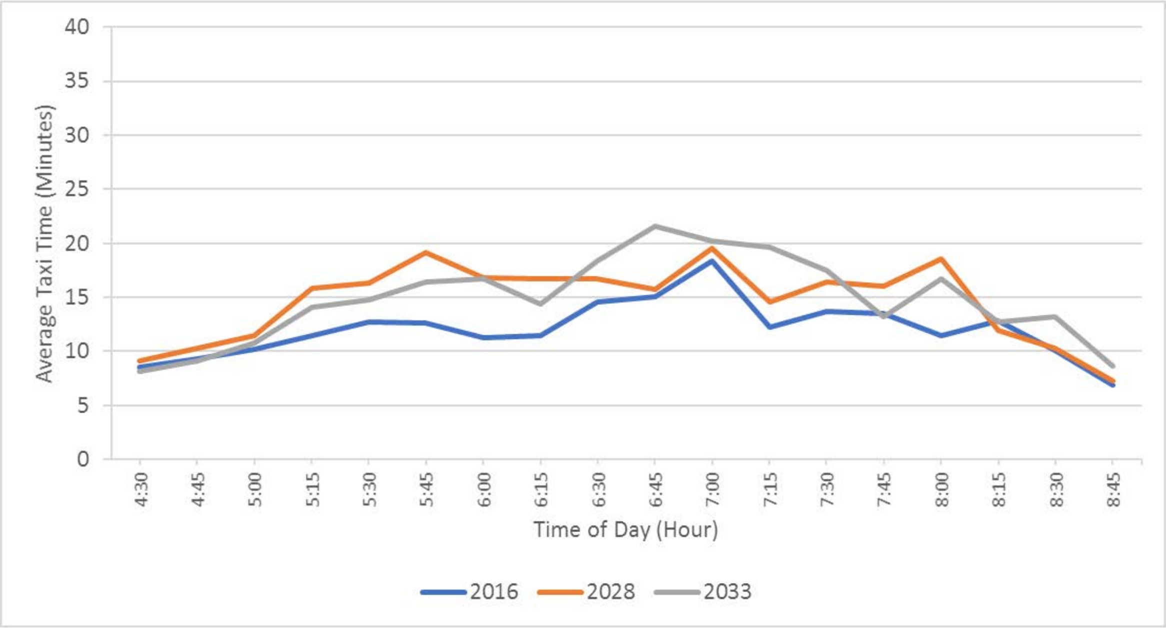
	Arrival		Departure	
Year	Average Airspace Delay	Average Taxi-In Time	Average Ground Delay	Average Taxi-Out Time
2016	4.3	12.4	8.3	17.7
2028	7.3	15.2	8.6	17.9
2033	12.6	15.4	13.1	23.4

Source: TransSolutions, LLC; *Simmod PLUS!*

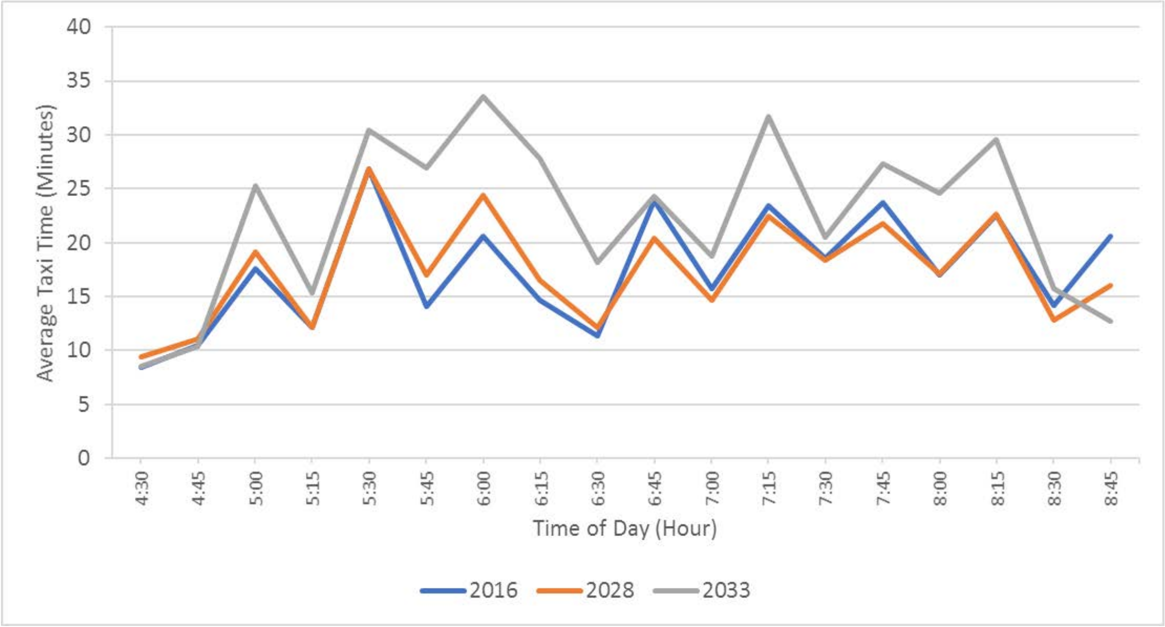
Arrival airspace delay is nearly three times higher in 2033 than in 2016. Average taxi-in time increases by 24 percent and average taxi-out time increases by nearly 32 percent from 2016 to 2033. The average departure ground delays increase 4 percent from 2016 to 2028, and another 52 percent from 2028 to 2033.

Figure 3-2 illustrates the average taxi times in hourly increments for South Flow IMC.

Figure 3-2 South Flow IMC Quarter-Hour Average Taxi Times



Taxi-In



Taxi-Out

Source: TransSolutions, LLC; *Simmod PLUS!*

3.2.2 North Flow VMC

In North Flow operations, the arrivals and departures use only the parallel runways so that Runway 5 is used as a taxiway. Often, departure aircraft taxi from their gates to Runway 36C on Runway 5. **Table 3-3** summarizes the average North Flow VMC average air delay and taxi times for the current and future demands.

Table 3-3 North Flow VMC Average Delay and Taxi Times (in minutes)

	Arrival		Departure	
Year	Average Airspace Delay	Average Taxi-In Time	Average Ground Delay	Average Taxi-Out Time
2016	3.8	10.2	4.4	14.8
2028	7.8	13.9	4.1	14.6
2033	10.9	14.9	4.8	15.4

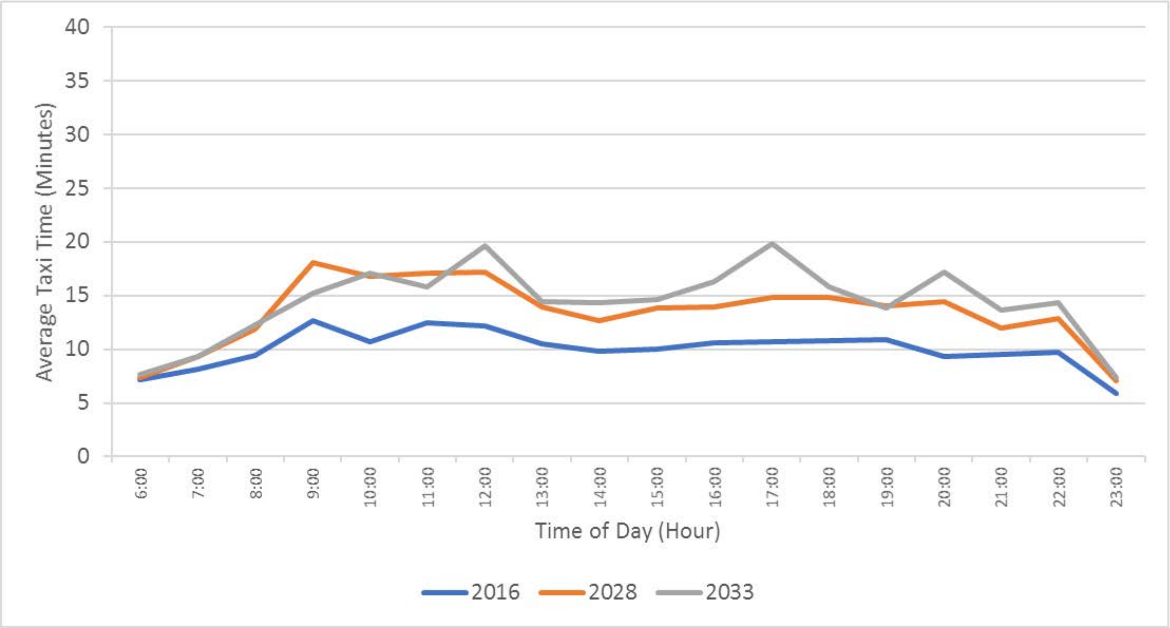
Source: TransSolutions, LLC; *Simmod PLUS!*

In general, taxi-in times are similar to South Flow but taxi-out times are longer because the departure runway ends are further from the terminals. In North Flow VMC:

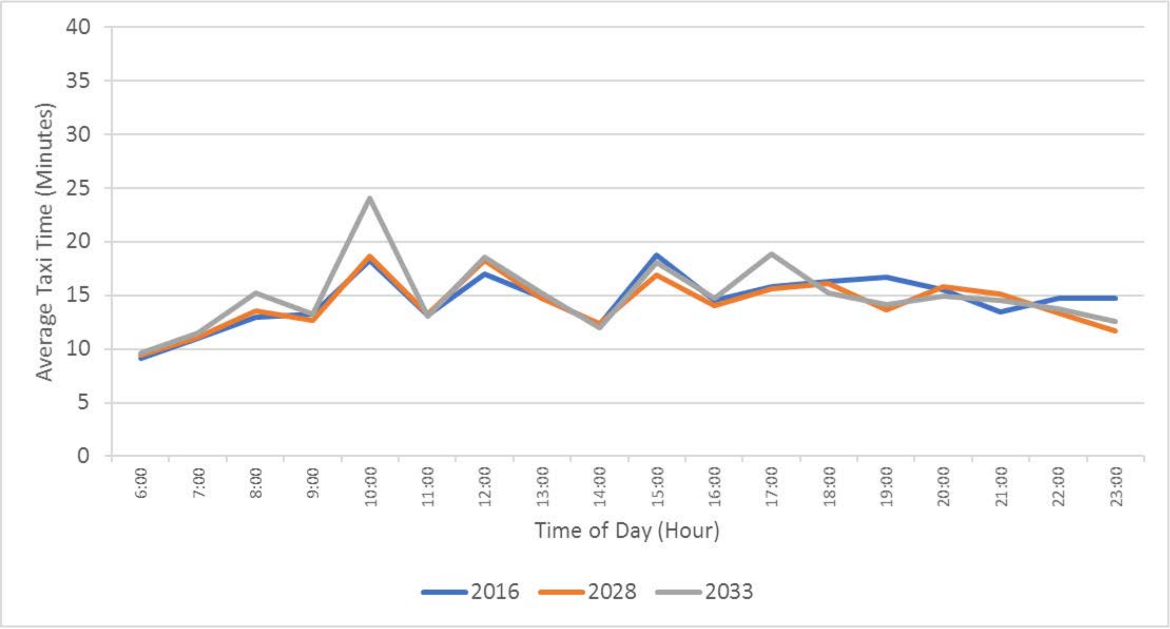
- Average airspace delays nearly double from 2016 to 2028 and nearly triple from 2016 to 2033.
- Average taxi-in time increases by 46 percent from 2016 to 2033.
- Average taxi-out time increases by 4 percent from 2016 to 2033.
- Average departure ground delays decreased by 7 percent from 2016 to 2028 as next generation (FAA NextGen) equipment is assumed to be in place by 2028, reducing the required departure separations. However, average departure ground delays increased by 17 percent from 2028 to 2033 due to the increase in traffic demand.

Figure 3-3 illustrates the average taxi times in hourly increments for North Flow VMC.

Figure 3-3 North Flow VMC Hourly Average Taxi Times



Taxi-In



Taxi-Out

Source: TransSolutions, LLC; *Simmod PLUS!*

3.2.3 North Flow IMC

North Flow IMC delay and taxi times are summarized in **Table 3-4** for the current and future demands.

Table 3-4 North Flow IMC Average Delays and Taxi Times (in minutes)

	Arrival		Departure	
Year	**Average Airspace Delay**	**Average Taxi-In Time**	**Average Ground Delay**	**Average Taxi-Out Time**
2016	3.9	11.1	7.3	18.6
2028	8.6	12.3	11.5	23.2
2033	12.0	12.5	15.0	26.6

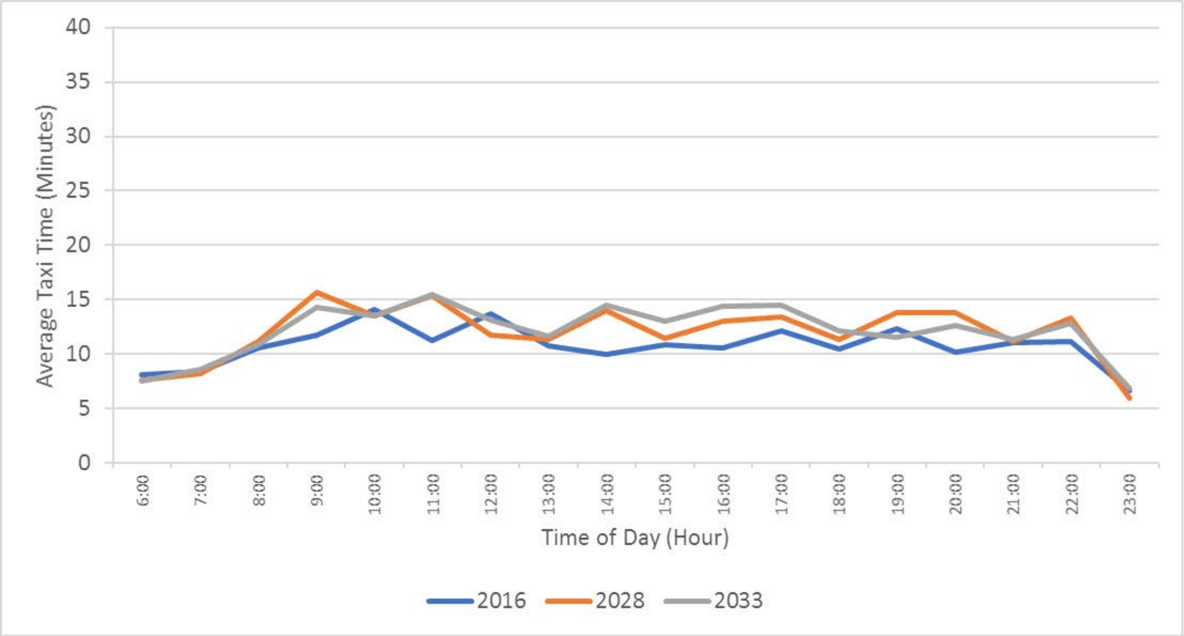
Source: TransSolutions, LLC; *Simmod PLUS!*

In North Flow IMC operations:

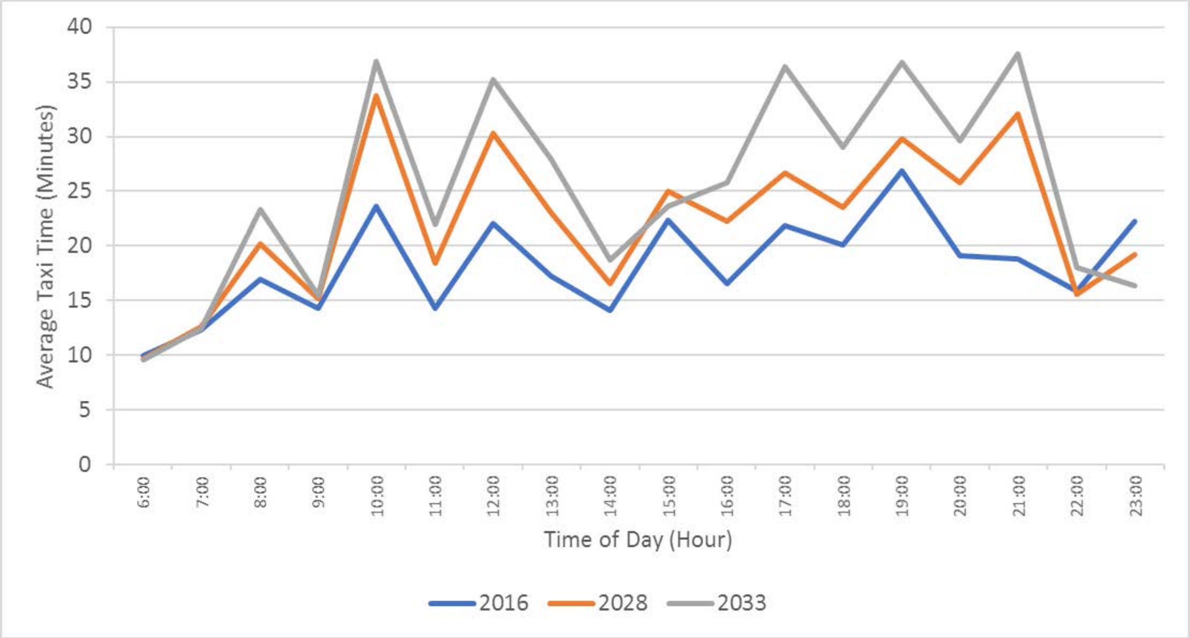
- Average airspace delay doubles from 2016 to 2028, and triples from 2016 to 2033.
- Average departure ground delay doubles from 2016 to 2033.
- Average taxi-out time increases by 25 percent from 2016 to 2028, and by 43 percent from 2016 to 2033.

Figure 3-4 illustrates the average taxi times in hourly increments for North Flow IMC. Note that the y-scale of the graphs is increased to 40 minutes to display the quarter-hour average taxi-out times.

Figure 3-4 **North Flow IMC Hourly Average Taxi Times**



Taxi-In



Taxi-Out

Source: TransSolutions, LLC; *Simmod PLUS!*

3.3 Hourly Airport Capacity (Peak Hour Throughput)

The simulation results were analyzed to obtain rolling hour airport throughput for individual days (iterations) in each wind/weather configuration. This analysis used the highest demand level (2033) in the simulation since it will likely have the highest throughput. The maximum hourly throughput is achievable under specific circumstances, but is not a good indication of the capacity that can be sustained for several hours. Thus the 90th percentile is often used as the measure of capacity. In **Table 3-5**, the hourly throughput for each wind/weather configuration is summarized by arrivals only, departures only and all operations, with 90th percentile calculated for 7:00 AM to 10:00 PM local time.

Table 3-5 Airport Peak Hour Throughput

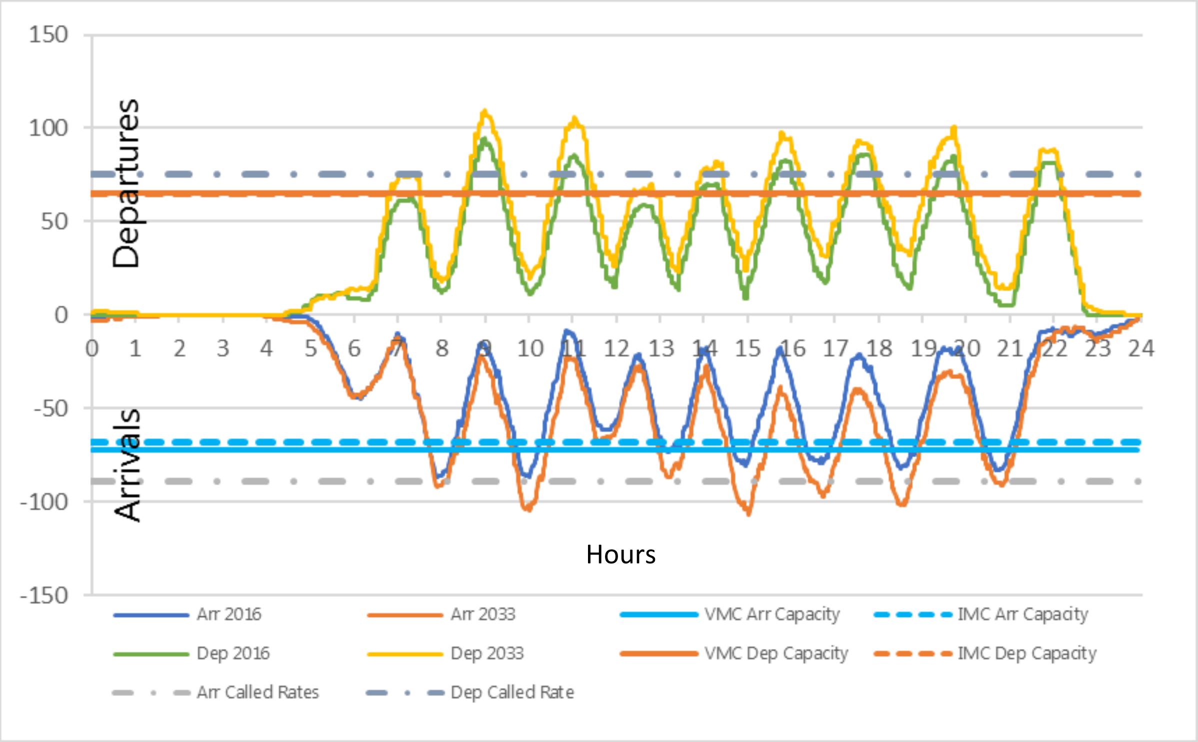
Flow / Weather	Arrivals		Departures		Total Operations	
	Maximum	**Capacity**	**Maximum**	**Capacity**	**Maximum**	**Capacity**
South VMC	84	72	78	65	141	130
South IMC	74	68	69	66	134	130
North VMC	77	68	78	65	138	131
North IMC	76	68	68	63	137	127

Source: TransSolutions, LLC; *Simmod PLUS!*

- In VMC, the simulated overall capacity is approximately 130 operations, with 130 operations in South Flow and 131 in North Flow.
- In IMC, the simulated overall capacity is 126-130 operations.

These hourly capacity estimates are depicted with the rolling-hour flight schedule in **Figure 3-5** below. Both arrival and departure capacity is already exceeded during peak departure times; by 2033, the capacity will be exceeded during most of the airline banks.

Figure 3-5 Rolling Hour Flight Schedule



Source: TransSolutions, LLC

3.4 Arrival Gate and Ramp Delays

The simulations in this analysis were run with the gate expansions currently under construction incorporated, including an additional pier at Concourse A and a few more parking positions for American Eagle. With all the domestic non-American flights parking at Concourse A, these airlines were allowed to park at any Concourse A gate.

While the simulations ran without any additional gates, more aircraft wait for an available gate as the traffic demand increases from 2016 through 2033. **Table 3-6** summarizes the number of flights and amount of time spent waiting for an open gate after landing for each simulated scenario.

Table 3-6 Arrival Aircraft Waiting on Ramp for an Available Gate

Operational Configuration	Year	95th Percentile Waiting Time for a Gate (minutes)	Total Time Waiting for a Gate Each Day (minutes)	Average Number of Daily Flights that Wait for Gate
South Flow VMC	2016	5.9	470.1	327
	2028	8.0	1093.1	453
	2033	12.7	1862.7	519
South Flow IMC	2016	6.1	424.6	239
	2028	5.4	1095.1	472
	2033	6.7	1202.7	582
North Flow VMC	2016	6.0	636.1	292
	2028	6.4	940.8	453
	2033	5.4	1423.6	562
North Flow IMC	2016	5.6	577.9	260
	2028	6.2	993.6	434
	2033	6.2	1423.7	517

Source: TransSolutions, LLC; *Simmod PLUS!*

Note that with aircraft arriving on Runway 23 in South Flow, the gate waiting time increases significantly, compared to all other scenarios with only the parallel runways in use. The arrival runway throughput is higher when Runway 23 is used so that more arrivals get to the ramp and must wait for a gate.

With the current number of gates, there is not enough ramp space for the arrival flights to wait for an open gate. If the ramp is full of aircraft waiting for a gate, additional arriving flights will wait on the taxiways and may back-up to the runways, indicating that ramp capacity is being exceeded.

3.5 Summary of Simulated Results

The results from all simulation scenarios are analyzed together to provide a summary of the overall CLT operations. **Figure 3-6** illustrates the average taxi times for all operational scenarios. While taxi-in times increase rather steadily from 2016 to 2033, the most notable increase occurs from 2028 to 2033 in south VMC. In general, taxi-out times increase faster from 2028 to 2033 compared with the increase from 2016 to 2028.

Annualized average times are calculated to succinctly analyze the delays and taxi times for each demand level. The FAA Aviation System Performance Metrics (ASPM) data was analyzed for 14 years, 2003 through 2017. The data excludes the hours when only the crosswind Runway 5-23 is used, North Flow is used for 44 percent of the operations and South Flow for 56 percent of the operations. IMC is used during approximately 21 percent of the operations, almost equally split between North and South Flow. **Table 3-7** summarizes the percentage of the operations, 2003 through 2017, that occurred in each particular configuration (excluding the time when only the crosswind Runway 5-23 is used).

Table 3-7 Annual Use of Runway Configurations

Flow	Weather	Percent of Operations[19]
North	IMC	10.7%
	VMC	33.3%
South	IMC	10.4%
	VMC	45.7%

Source: ASPM, analyzed by TransSolutions

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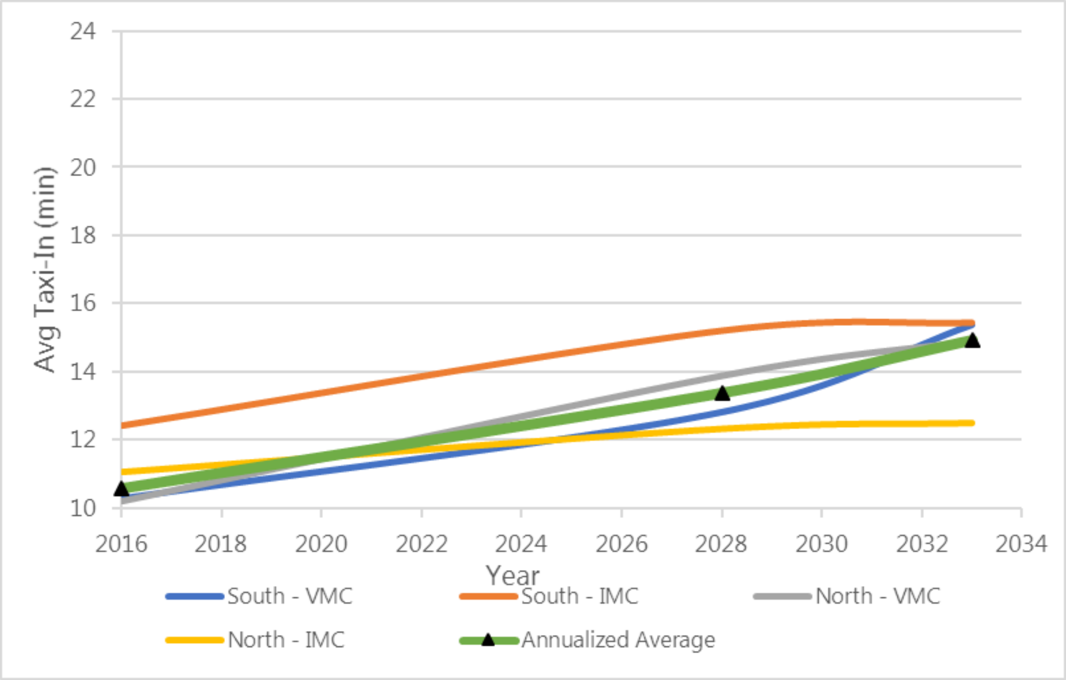
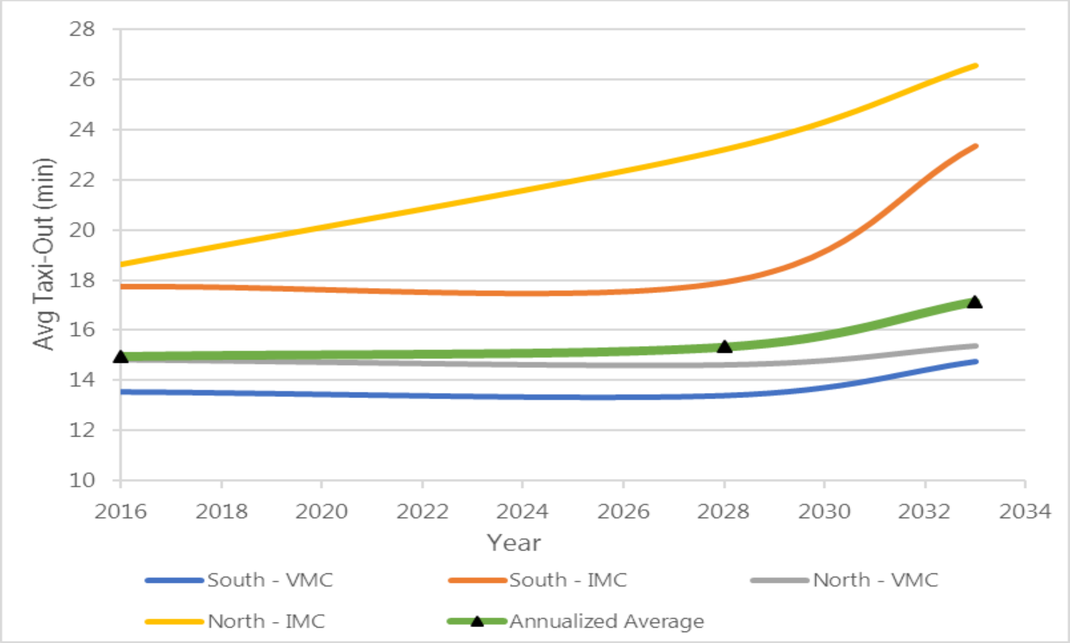
[19] Note that ACEP included configuration use for 2013 only, resulting in slightly different percentage use.

1 **Figure 3-6 Average Taxi Times**



2 Taxi-In

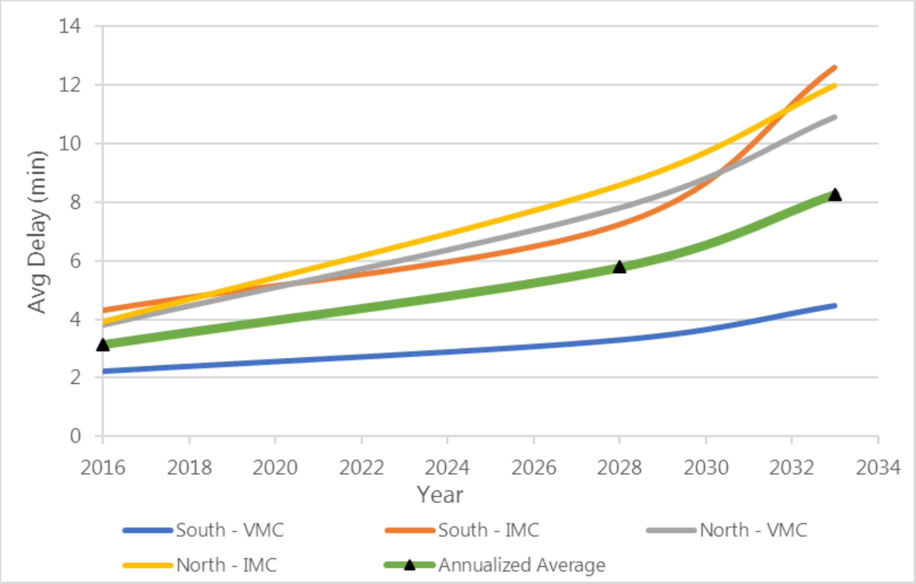


3 Taxi-Out

4 Source: TransSolutions, LLC; *Simmod PLUS*!

Figure 3-7 illustrates the average airspace delays for all operational scenarios. The lowest airspace delays are experienced in South Flow VMC. Similar to the taxi-out times, the arrival airspace delays increase faster from 2028 to 2033 compared with the delays increase from 2016 to 2028.

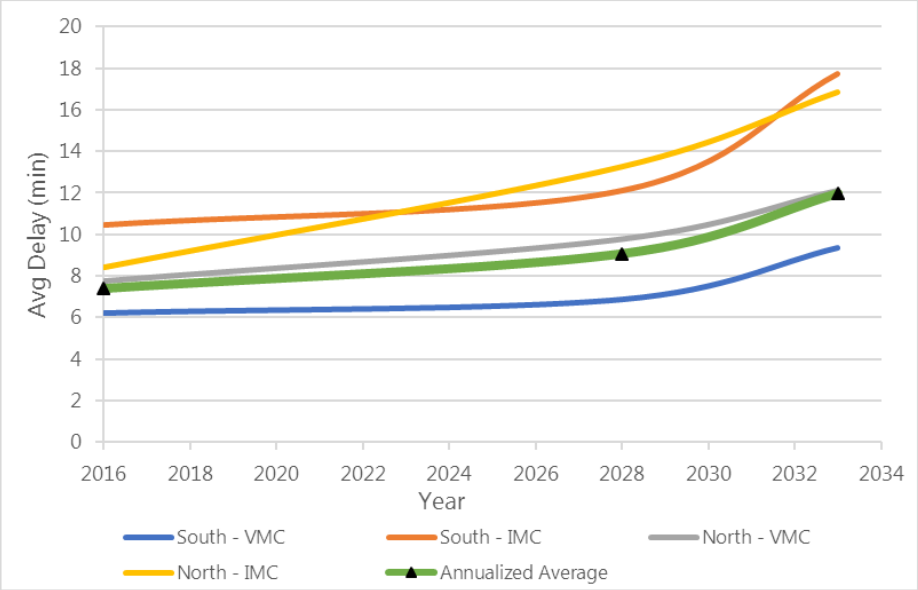
Figure 3-7 Average Airspace Delays



Source: TransSolutions, LLC; *Simmod PLUS!*

The average delay per operation is illustrated in **Figure 3-8** for each operational scenario modeled.

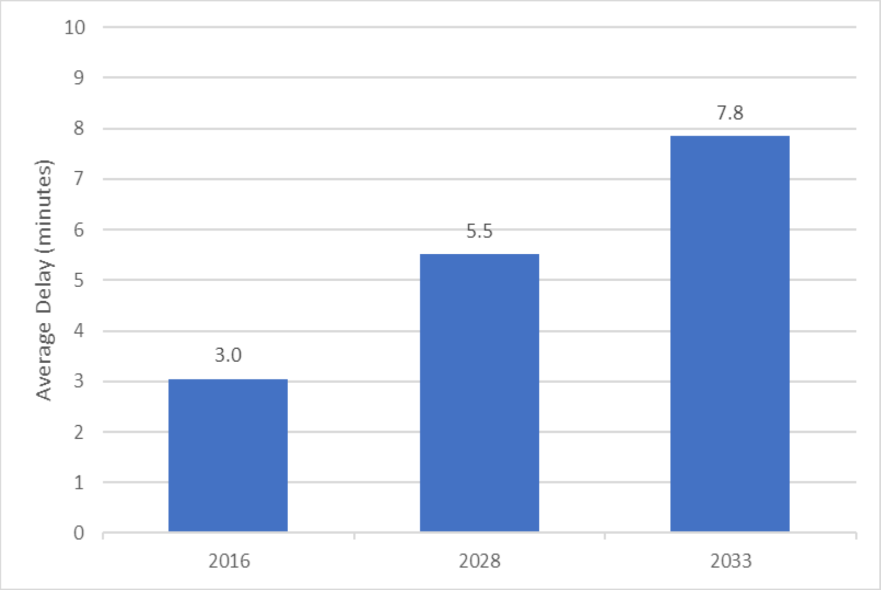
Figure 3-8 Average Delay per Operation (in minutes)



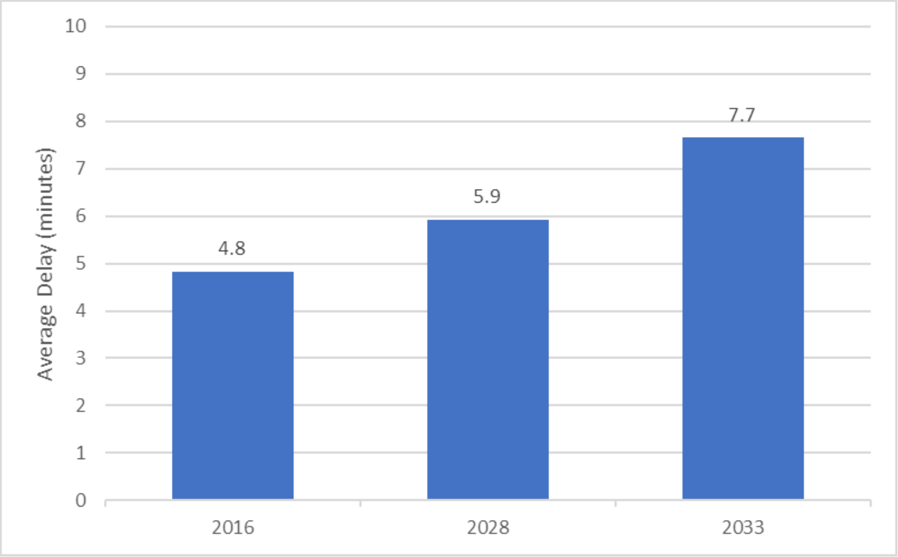
Source: TransSolutions, LLC; *Simmod PLUS!*

Applying the annual use of each runway configuration, a weighted average is calculated for the arrival airspace delays and for the overall taxi delays, as depicted in **Figure 3-9**.

Figure 3-9 Annualized Average Airspace and Ground Delays



Average Arrival Airspace Delay

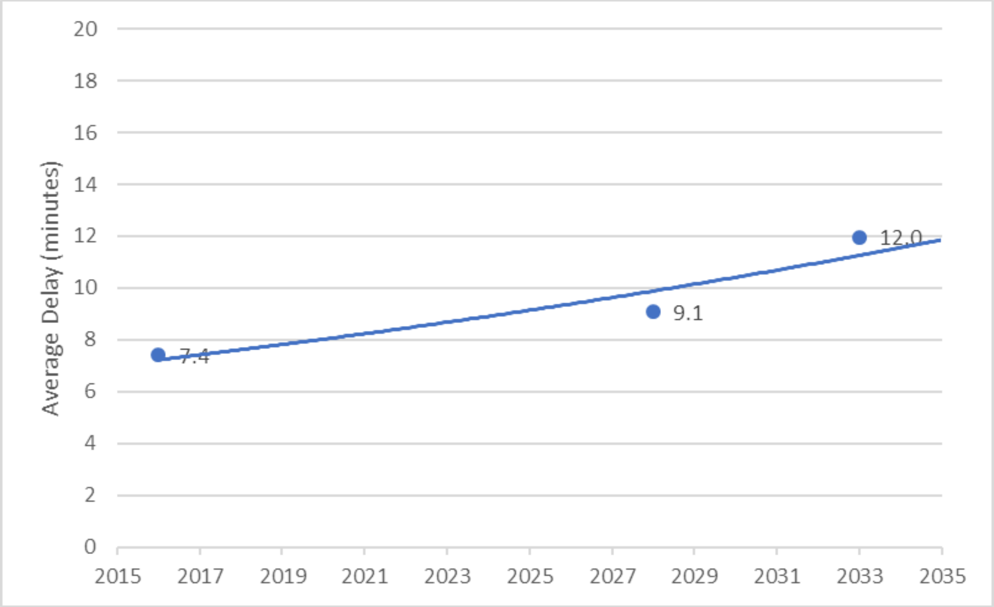


Average Taxi Delays

Source: TransSolutions, LLC; *Simmod PLUS*!

The annualized average delays per operation, depicted in **Figure 3-10**, increase over 60 percent from 2016 to 2033.

Figure 3-10 **Annualized Average Delay per Operation (in minutes)**



Source: TransSolutions, LLC; *Simmod PLUS!*

These average delays per operation result in the following daily total delays for the average day peak month:

- 2016 – 1,582 operations with a total of 11,725 minutes of delay per day.
- 2028 – 1,857 operations with a total of 16,854 minutes of delay per day.
- 2033 – 1,968 operations with a total of 23,529 minutes of delay per day.

4

Conclusions

Based on the Existing Conditions and future No-Action simulation analyses and findings detailed in this Technical Memorandum, the following conclusions can be made:

- Hourly capacity of the airfield system is regularly exceeded by the arrival and departure demand of the airline hub banking periods.
- During Visual Meteorological Conditions (VMC), taxi-in times (including ramp delays due to aircraft waiting for a gate) increase more rapidly than in Instrument Meteorological Conditions (IMC), since arrival runway operations exceed gate/ramp capacity, which in turn cause more ramp congestion.
- Imbalance of arrival runway capacity and aircraft gate capacity, particularly during the predominant operational configuration of the airport (South flow VMC), results in high taxi-in delays (due to aircraft waiting on the ramp for a gate).

Based on the modeling results and other information, the Consultant Team will develop a Purpose & Need Technical Report. The Technical Report will compare the capacity (annual and hourly) of the airfield system at Charlotte Douglas International Airport (CLT) with existing and forecast demand, and will also describe the delay analysis results in the context of the National Environmental Policy Act (NEPA) requirements for Purpose & Need.

Proposed Capacity Enhancements at Charlotte Douglas International Airport

National Environmental Policy Act Environmental Assessment

AirTOp Simulation Report

August 2021

PREPARED FOR
Charlotte Douglas International
Airport

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1 Introduction

Charlotte Douglas International Airport (CLT or Airport) is the sixth busiest airport in the US in terms of aircraft operations and the tenth busiest in terms of passenger enplanements,[1] making it an integral part of the National Airspace System (NAS). CLT is the second busiest hub operation for American Airlines. In 2016, the airline connected approximately 58,000 passengers per day through CLT on a normal day; 67,000 passengers on a typical busy day, and even more during peak travel days.[2] Given this level of connecting passengers, American Airlines (AA) personnel have indicated that schedule reliability is critical to maintaining minimum connection times for passengers that range from 25 to 35 minutes.

The City of Charlotte (Sponsor) completed an Airport Capacity Enhancement Program (ACEP) and Master Plan Update in February 2016. The ACEP utilized a comprehensive approach to understand the demand for and capacity of runways, taxiways, aircraft gates, ramp, and passenger processing facilities. The ACEP identified a number of deficiencies that exist at CLT. These included insufficient runway capacity, gate capacity, and ramp space to accommodate the existing and future demand. The Sponsor is now undertaking an Environmental Assessment (EA) that analyzes proposed solutions for those deficiencies.

As part of the EA, a simulation modeling analysis has been conducted to simulate the existing and future airfield and airspace improvements at the Airport. The simulation was conducted using the Air Traffic Optimization (AirTOp) model, a rule-based, fast-time simulation tool. AirTOp computes aircraft travel times and delay statistics which are used as evaluation metrics to determine differences between various simulated alternatives.

The simulation modeling began with an analysis of CLT for the base year of 2016. The EA has a base year of 2016 because this was the latest calendar year with a full year of available data when the National Environmental Policy Act (NEPA) process began.

The simulation analysis involved the following steps and is described in the sections that follow:

- Develop design day flight schedules
- Define 2016 existing conditions and modeling assumptions
- Calibrate model to actual 2016 results
- Model 2019 Baseline experiments
- Model No Action experiments
- Model Airfield Alternatives experiments

1.1 Direction, Oversight, Review, and Agreement (DORA) Process

The EA utilized the DORA process to obtain the necessary operational input from stakeholders and the Federal Aviation Administration (FAA). The DORA Work Group was comprised of representatives from the FAA, CLT Airport, airlines, and consultants. The meetings provided FAA controller input on air traffic control operations and the viability of proposed alternatives, which were crucial components of analyzing and screening the airfield alternatives. The airlines, as users of the airport's infrastructure, were active in providing their operational perspectives, including linkages to network hub operations

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[1] 2017 Airports Council International-North America Traffic Report

[2] *Purpose and Need Working Paper*, Charlotte Douglas International Airport, Environmental Impact Statement, prepared by VHB Engineering NC, P.C. in association with Parish and Partners, Inc. and TransSolutions, July 31, 2018.

and ramp control. FAA provided their perspective and expectations regarding data and simulation analysis, as well as unique knowledge about the efficacy of ways to enhance operational efficiency. Four meetings during the EA were conducted with the stakeholder group, which builds on prior DORA coordination conducted during the Environmental Impact Statement (EIS) and ACEP.

This process has ensured that the appropriate operational expertise and experience has informed the design, analysis and decision-making for the CLT EA effort.

2 Design Day Flight Schedules

The first step in building the simulation models was to select the design day flight schedule. The schedule for the calibration year of 2016 and future years of 2028 and 2033 were developed by VHB and InterVISTAS as part of the CLT EIS.[3] Subsequent to the creation of those schedules, Runway 23 ceased being a primary arrival runway during South Flow operations. To ensure that the models accurately reflect airport operations without the use of Runway 23, a 2019 Baseline demand level was added to the simulation study.

The schedule for the Baseline year of 2019 was developed by Landrum & Brown using the Average Busy Weekday, Peak Month methodology. This methodology was used in the previous ACEP study. Weekends were excluded from the selection process due to the low number of operations compared to weekdays. The selected design day would also have to meet the following criteria:

- South flow runway configuration (all day)
- Visual Meteorological Conditions weather conditions (all day)
- No runway closures or other anomalies in the normal daily operation

Based on the FAA Aviation System Performance Metrics (ASPM) database, October was the peak month of operations for 2019. However, no suitable day in October met all of the selection criteria. May was the second busiest month for 2019. Applying the criteria above, May 30, 2019, with 1,628 daily operations was the nearest demand level to the average busy weekday for May (1,638 daily ops) so May 30, 2019 was chosen as the 2019 design day.

The operation levels of the four demand schedules are compared in **Table 2-1**.

Table 2-1, Total Daily Operations

YEAR	DAILY OPERATIONS
2016	1,563
2019	1,628
2028	1,860
2033	1,978

Source: Landrum & Brown analysis, 2021

The rolling hour arrival and departure demand for each schedule is shown on **Exhibit 2-1**. CLT has a typical hub airline schedule, with distinct arrival and departure banks throughout the day. The 2016 schedule exceeds 80 arrivals in five hours of the day and is at or above 80 departures in six hours of the day. The peak arrival period at the Airport occurs in the 10:00 a.m. hour. From 2016 to 2033, peak hour arrival demand increases from 88 to 104 operations. The peak departure period at the Airport occurs in the 09:00 a.m. hour. From 2016 to 2033, demand increases from 93 to 110 operations in the peak departure period.

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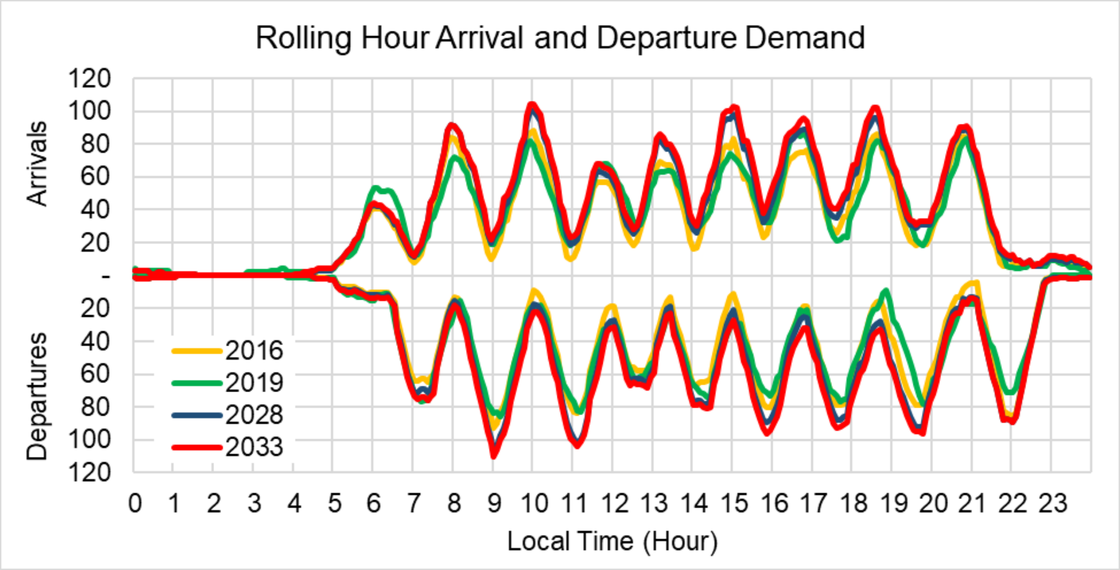
[3] *Forecast Technical Memorandum*, Charlotte Douglas International Airport Environmental Impact Statement, VHB in association with InterVISTAS, November 10, 2017

Exhibit 2-1, Rolling Hour Arrival and Departure Profiles



Source: Landrum & Brown analysis, 2020

Table 2-2 and **Table 2-3** provides a summary of the aircraft fleet mix by flight type and FAA Airplane Design Group (ADG). The tables summarize the number of aircraft by group and as a percentage of total operations.

Table 2-2, Fleet Mix by Flight Type

Flight Type	2016		2019		2028		2033	
	Number of Ops	% of Total Ops	Number of Ops	% of Total Ops	Number of Ops	% of Total Ops	Number of Ops	% of Total Ops
Passenger	1470	94%	1506	93%	1760	95%	1874	95%
General Aviation	81	5%	108	7%	84	5%	86	4%
Cargo	10	1%	14	1%	14	1%	16	1%
Military	2	0%	0	0%	2	0%	2	0%
Total	**1563**	**100%**	**1628**	**100%**	**1860**	**100%**	**1978**	**100%**

Source: Landrum & Brown analysis, 2020

Table 2-3, Fleet Mix by Design Group

FAA ADG	2016		2019		2028		2033	
	Number of Ops	% of Total Ops	Number of Ops	% of Total Ops	Number of Ops	% of Total Ops	Number of Ops	% of Total Ops
I	19	1%	16	1%	20	1%	21	1%
II	372	24%	474	29%	494	27%	495	25%
III	1139	73%	1102	68%	1309	70%	1421	72%
IV	14	1%	16	1%	16	1%	18	1%
V	19	1%	20	1%	21	1%	23	1%
Total	**1563**	**100%**	**1628**	**100%**	**1860**	**100%**	**1978**	**100%**

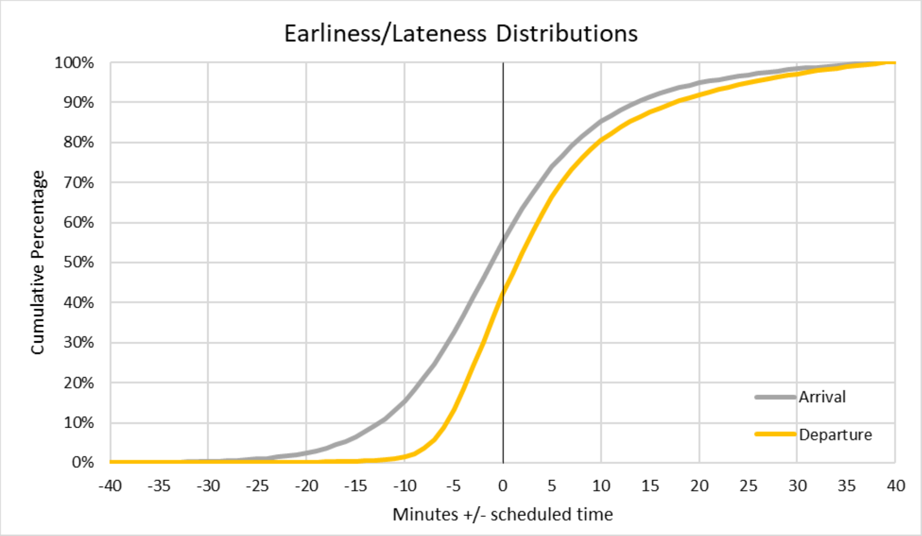
Source: Landrum & Brown analysis, 2020

2.1 Flight Dependability

A probability distribution is applied to flight times in the simulation models to mimic variation in flight arrival/departure times. Flights that arrive or depart early are indicated by negative values, while flights that arrive or depart late are indicated by positive values.

The distributions, shown in **Exhibit 2-2**, are based on data analyzed from Aerobahn.[4] Arrivals tend to have more variability than departures and are more likely to be early.

Exhibit 2-2, Flight Earliness/Lateness Distributions



Source: Aerobahn May 2016- Apr 2017, Landrum & Brown analysis, 2020

3 2016 Airport Operating Assumptions

The first objective of this simulation analysis was to develop an AirTOp simulation model that is an appropriate representation of the actual operations at CLT. Once it has been confirmed that the simulation model reflects existing operating conditions, the model can be adjusted using various control parameters and demand levels to evaluate changes in the operation. This chapter describes the assumptions that were used to develop and calibrate the AirTOp models.

3.1 Airfield and Aircraft Apron Layouts

CLT has three parallel runways oriented in the 18/36 direction and one crosswind runway oriented in the 5/23 direction. **Exhibit 3-1** depicts the airfield as it existed in 2016. The 2016 apron areas for the passenger airlines, cargo carriers (FedEx and UPS), general aviation, and military aircraft are shown on **Exhibit 3-2**. The passenger airlines park at Concourses A through E, which are located on the north side of the Airport between Runway 18C/36C and Runway 18L/36R. The passenger airline gating assignments are shown in **Table 3-1**. The table also summarizes the number of gates in each concourse. The count is based on the number of regional and narrowbody gates. For Multiple Apron Ramp System (MARS) gates, which accommodate one widebody or two narrowbody aircraft, only the narrowbody gates are counted to avoid double counting. The cargo facilities are located to the south of the passenger terminal and Runway 5/23. The general aviation and Air National Guard aprons are located to the east of Runway 18L/36R.

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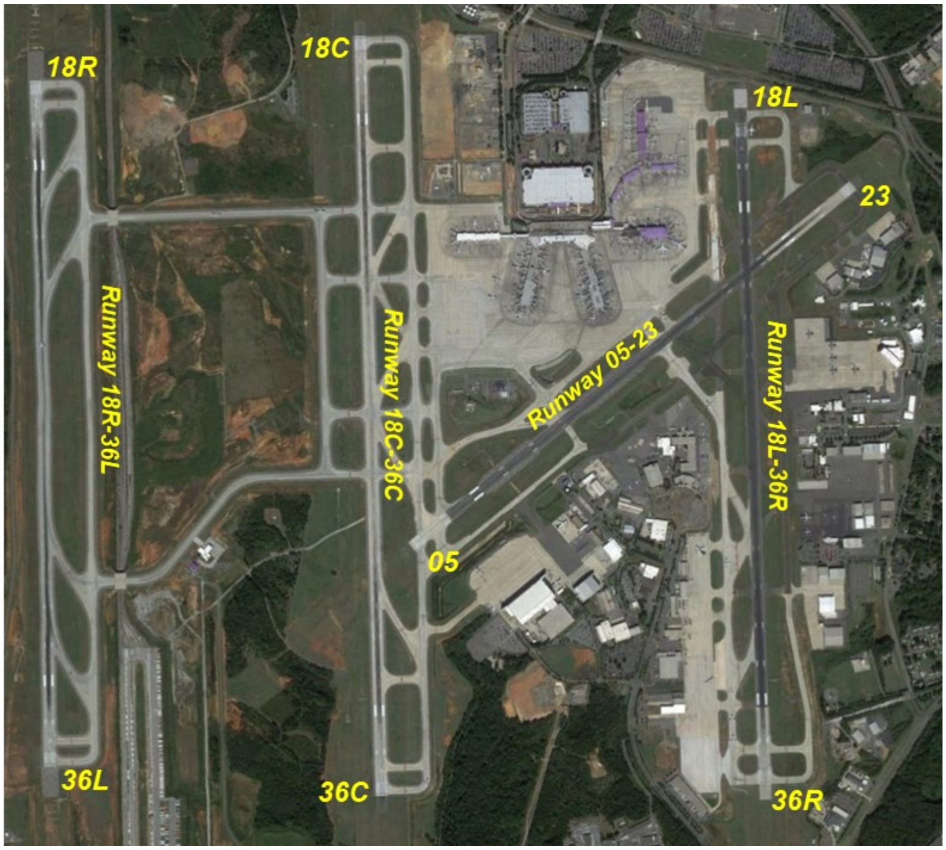
[4] Aerobahn® tracks and reports aircraft ground movements to provide a comprehensive view of airport surface operations.

Exhibit 3-1, 2016 CLT Airfield



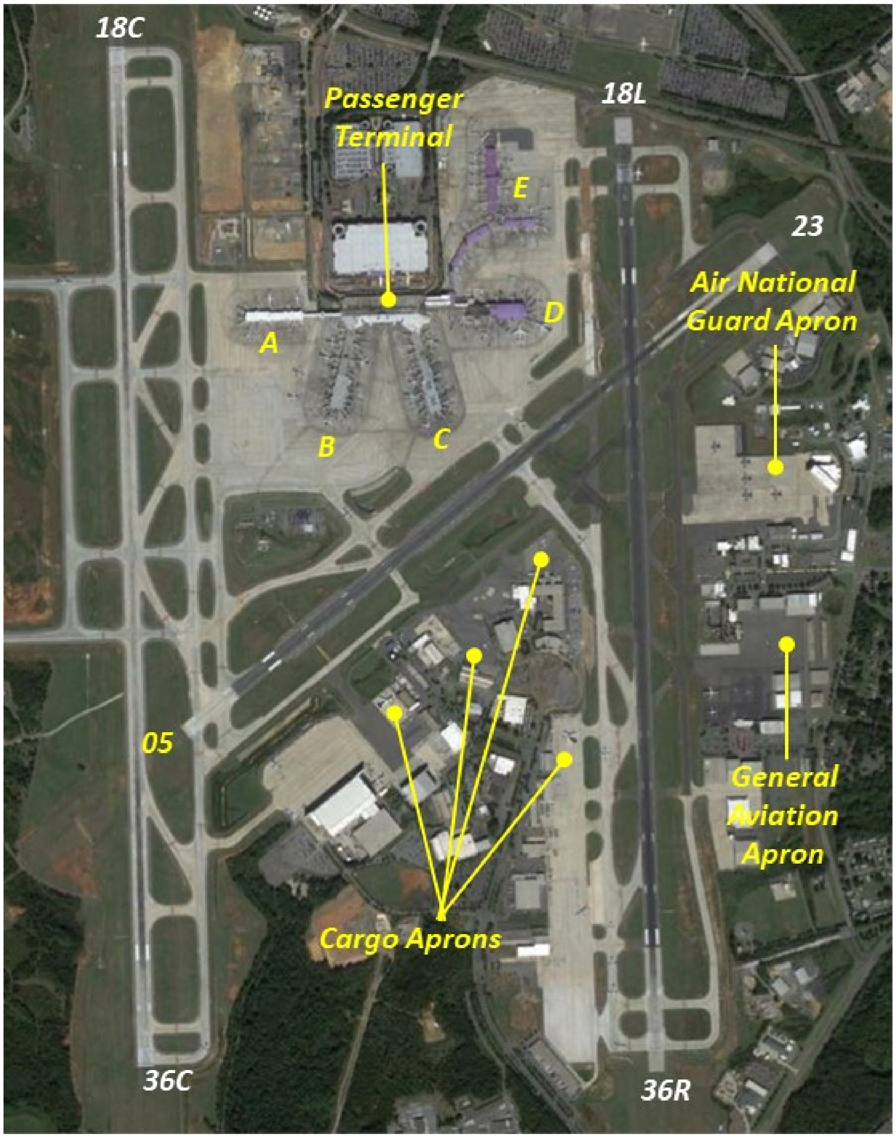
Source: ESRI ArcMap aerial imagery

Table 3-1, 2016 Airline Gating Assignment Assumptions

Concourse	Airline	Number of Gates
A	American, Air Canada, JetBlue, Delta, Frontier, United, Southwest	13
B	American Mainline	16
C	American Mainline	18
D	American Mainline, Lufthansa	13
E	American Regional	44

Source: CLT airport and Landrum & Brown analysis, 2020

Exhibit 3-2, 2016 CLT Aircraft Parking Aprons

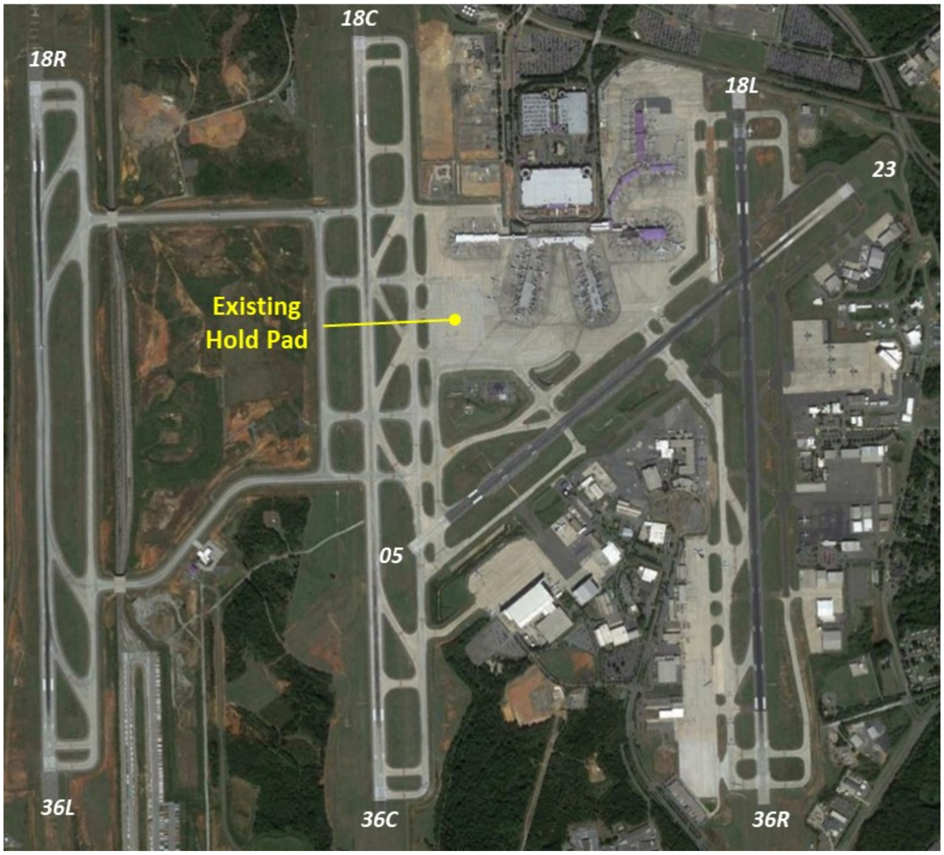


Source: ESRI ArcMap aerial imagery

3.2 Airfield Hold Pad Usage

CLT has one hold pad that is used to accommodate arrivals waiting for an available gate, remain overnight (RON) operations, towed aircraft, and departures waiting for a spot in the queue. This hold pad is located south of Concourse A and west of Concourse B as shown on **Exhibit 3-3**.

Exhibit 3-3, 2016 Airfield Hold Pad



Source: ESRI ArcMap aerial imagery

3.3 Runway Operating Configurations

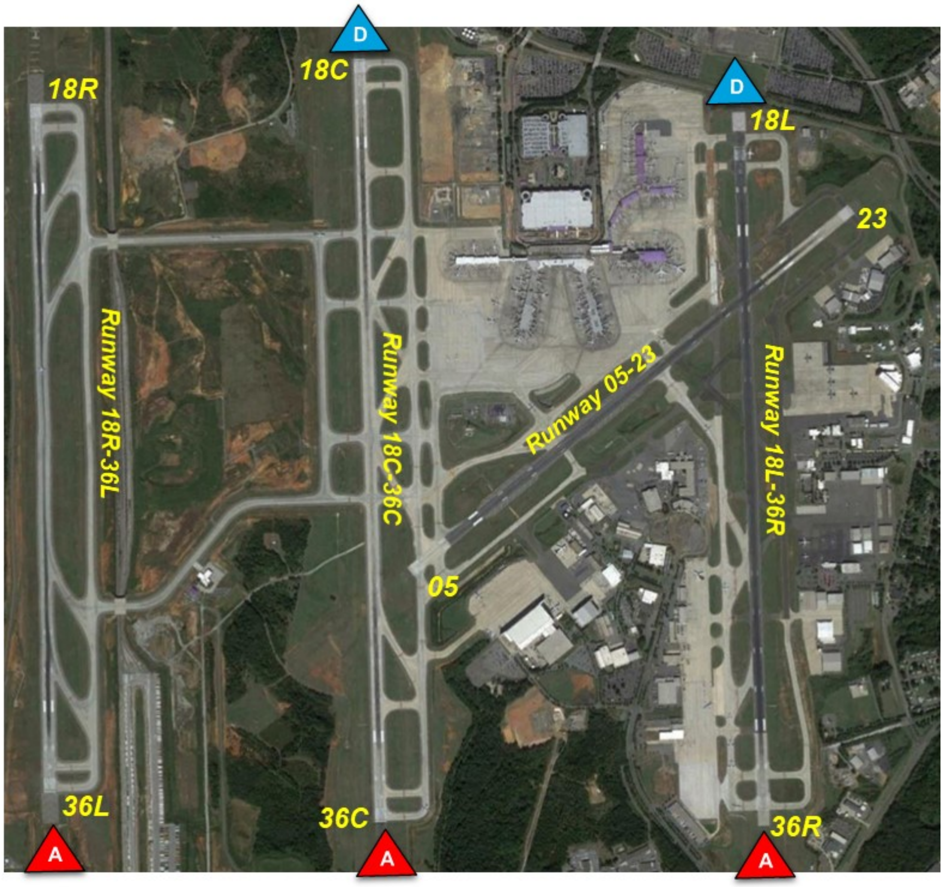
Runway use at an airport is typically dictated by the origin/destination city, wind direction, and weather conditions. Runway use changes as demand for flights arriving from specific standard terminal arrival routes (STAR) or departing to standard instrument departure (SID) routes changes. The four primary (most often used) runway operating configurations at CLT were modeled for the EA:

- North Flow Visual Meteorological Conditions (VMC)
- North Flow Instrument Meteorological Conditions (IMC)
- South Flow VMC
- South Flow IMC

3.3.1 North Flow VMC and IMC Operating Configurations

The basic runway usage in a North Flow configuration (VMC and IMC) consists of arrivals on Runways 36L and 36R. Runway 36C is used in conjunction with Runways 36L and 36R to provide triple parallel approach capability during periods of high arrival demand. The primary departure runways are Runways 36C and 36R in both VMC and IMC. The allocation of departing aircraft to these runways is based on the destination of the flight. Runway 36C is used by aircraft departing to northbound and westbound destinations. Runway 36C is also used by international heavy aircraft heading east. Runway 36R is used by southbound and eastbound departures. **Exhibit 3-4** depicts the North Flow runway usage. There is a single jet departure heading in North Flow (no fanning permitted). However, prop aircraft can turn immediately after becoming airborne.

Exhibit 3-4, 2016 North Flow VMC/IMC Runway Configuration

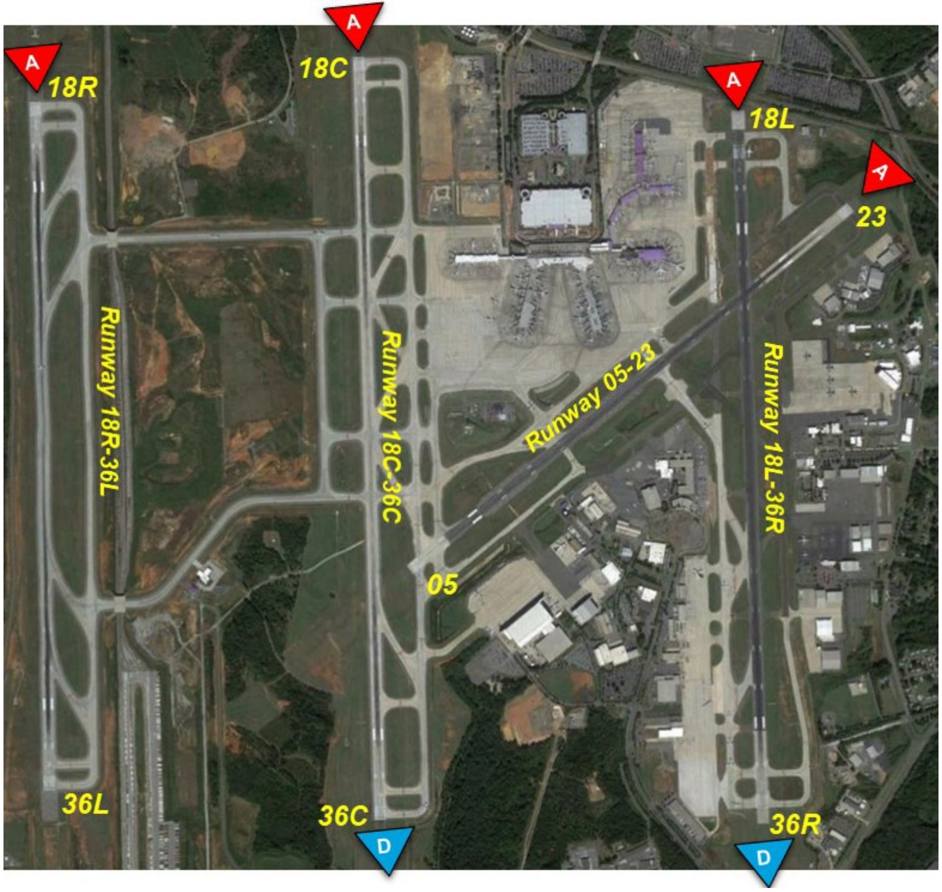


Source: ESRI ArcMap aerial imagery; Landrum & Brown, 2020

3.3.2 South Flow VMC and IMC Operating Configurations

The basic runway usage in a South Flow VMC configuration consists of arrivals on Runways 23 and 18R, with Runway 18L used in lieu of Runway 23 during peak departure times[5]. In IMC, Runways 18L and 18R are used for arrivals; Runway 23 is used as a taxiway, not a runway in South Flow IMC. Runway 18C is used in conjunction with Runways 18L and 18R to provide triple parallel approach capability during periods of high arrival demand. The primary departure runways are Runways 18C and 18L in both VMC and IMC. The allocation of departing aircraft to these runways is based on the destination of the flight. Runway 18C is used by aircraft departing to northbound and westbound destinations. Runway 18C is also used by international heavy aircraft heading east. Runway 18L is used by southbound and eastbound departures. **Exhibit 3-5** depicts the South Flow runway usage.

Exhibit 3-5, 2016 South Flow VMC/IMC Runway Configuration



Source: ESRI ArcMap aerial imagery; Landrum & Brown, 2020

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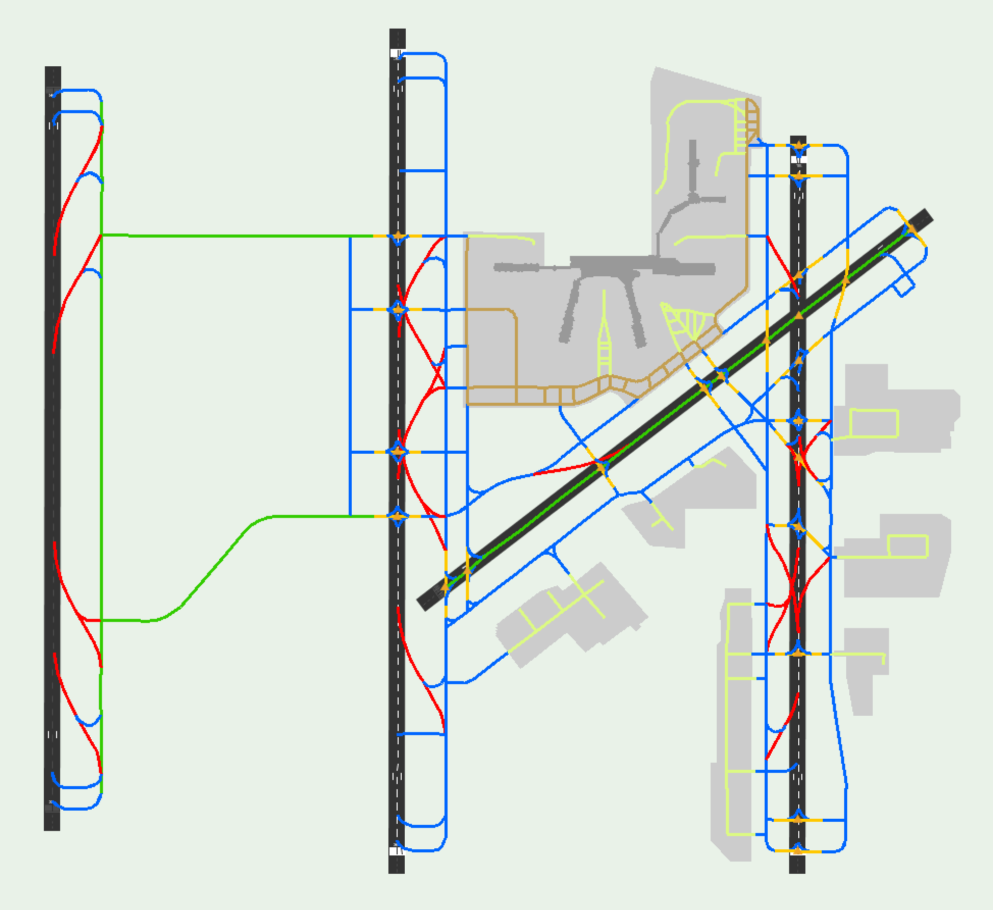
[5] This was the standard arrival configuration in 2016. Since that time, Runway 23 is no longer a primary arrival runway.

3.4 Airfield Ground Speeds

For accurate simulation, the aircraft taxi speeds within the AirTOp model should replicate the actual taxi speeds at the Airport. **Exhibit 3-6** shows the average taxi speeds used in the model.

Exhibit 3-6, 2016 Airfield Ground Speed Assumptions



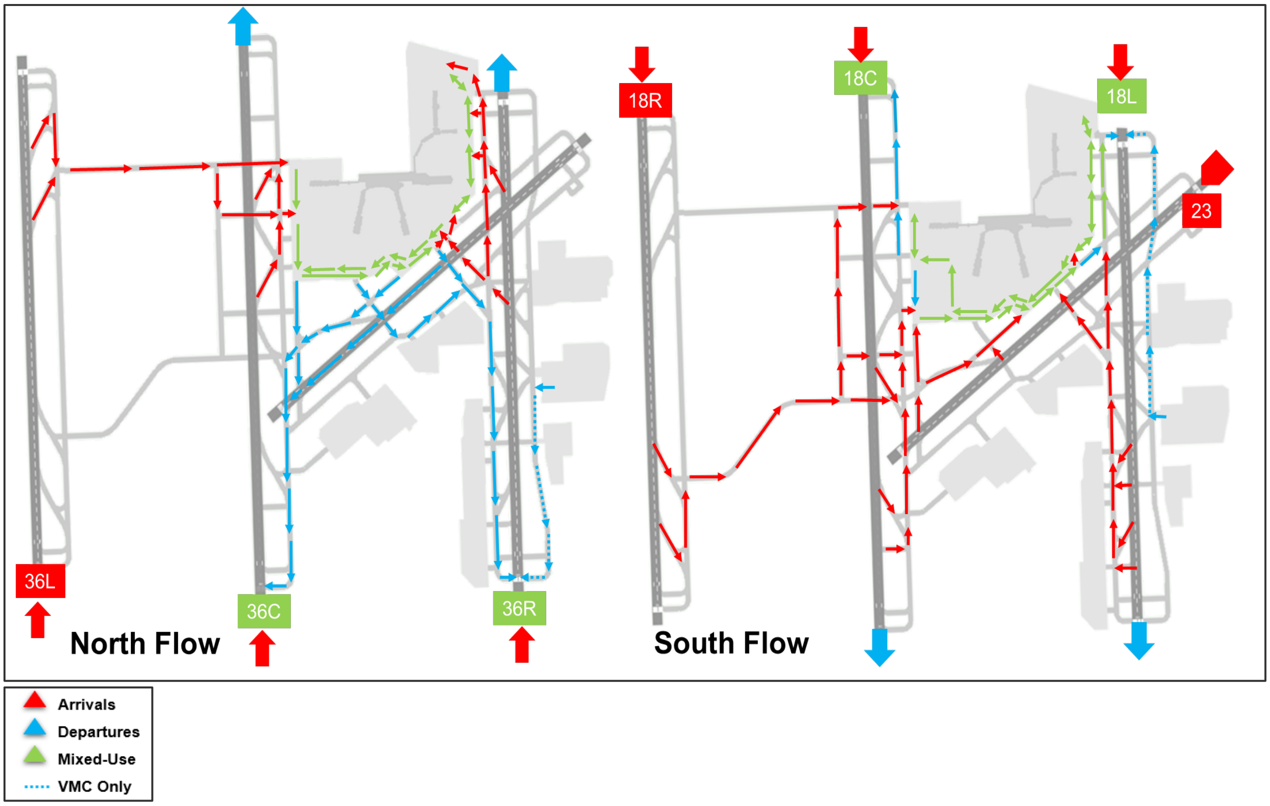
High Speed Exits	🟥	32 knots
Outer Perimeter Taxiways	🟩	20 knots
Runway Crossings	🟧	18 knots
Taxiways	🟦	15 knots
Ramp Area Taxiways	🟫	12 knots
Ramp Area Taxilanes	🟨	10 knots

Source: ACEP, EIS, and Landrum & Brown analysis, 2020

3.5 Airfield Taxi Flows

For accurate simulation, the aircraft movements within the AirTOp model should replicate the actual taxi flows at the Airport. The standard taxi routes are shown on **Exhibit 3-7.**

Exhibit 3-7, 2016 Taxi Routes



Source: Tower observations and ATCT feedback

3.6 Aircraft Separations

It is important to reflect the actual aircraft-to-aircraft separations in the AirTOp model because these separations have a large effect on the operating capacity of the Airport. The aircraft separation data, which is measured as the space between consecutive aircraft operations, is presented in terms of distance (nautical miles) for arrivals and in terms of time (seconds) for departures. **Table 3-2** presents the simulated minimum VMC and IMC in-trail separation distances for arrivals based on actual radar data. **Table 3-3** presents the simulated minimum VMC and IMC in-trail separation times for departures based on actual radar data from January 2013 to December 2013.

Table 3-2, Simulated Arrival In-trail Separations

Aircraft Category	In-trail Separations (in nautical miles)				
	Upper Heavy (A332, B777)	Lower Heavy (B763)	Upper Medium (A320, E190)	Lower Medium (AT72, CRJ9)	Small (GA Prop)
Upper Heavy	3.3/3.8[1]	4.3	5.3	5.3	7.3
Lower Heavy	3.3/3.8[1]	3.3/3.8[1]	3.8	3.8	6.3
Upper Medium	3.3/3.8[1]	3.3/3.8[1]	3.3/3.8[1]	3.3/3.8[1]	4.3
Lower Medium	3.3/3.8[1]	3.3/3.8[1]	3.3/3.8[1]	3.3/3.8[1]	3.3/3.8[1]
Small	3.3/3.8[1]	3.3/3.8[1]	3.3/3.8[1]	3.3/3.8[1]	3.3/3.8[1]

[1] VMC/IMC in-trail separations

Notes: 1. Arrival separations include a 0.3 nautical mile buffer. 2. Lead-to-trail arrival separation compression on final approach allows for minimum separation below 3.3/3.8 nautical miles.

Source: ACEP; Landrum & Brown analysis, 2020

Table 3-3, Simulated Departure In-trail Separations

Aircraft Category	In-trail Separations (in seconds)				
	Upper Heavy (A332, B777)	Lower Heavy (B763)	Upper Medium (A320, E190)	Lower Medium (AT72, CRJ9)	Small (GA Prop)
Upper Heavy	90	120	120	120	120
Lower Heavy	90	90	90	120	120
Upper Medium	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]
Lower Medium	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]
Small	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]

[1] VMC/IMC in-trail separations

Source: ACEP; Landrum & Brown analysis, 2020

In addition to the above separations, the following in-trail separations were applied for CLT:

- Six nautical mile in-trail separations were applied at the arrival corner post fixes for transition from the center airspace to the terminal environment.
- During mixed arrival/departure operations:
  - Arrivals block departures 2.3 nautical miles from the runway threshold.
  - On the east runway, a minimum of 4.5 nautical miles arrival in-trail separation is maintained to ensure one departure between every arrival.
  - On the center runway, a minimum of 8.0 nautical miles arrival in-trail separation is maintained to allow for one departure and runway crossings between every arrival.

Vertical separation between aircraft on approaches to parallel runways is also important until the aircraft are established on the approach. Parallel approaches were assumed to be vertically separated by 1,000 feet when turning onto final approach.

3.7 Airspace Structure

The airspace route structure is a key part of the simulation model development. The CLT Metroplex terminal airspace was simulated in the AirTOp model, which represents an approximate 40-mile radius around the Airport. To create the simulation model's airspace structure, January 2015 to April 2017 Aerobahn data was analyzed and used to determine origin and destination city pair airspace fix assignments for input into the simulation flight schedule. May 2019 area navigation (RNAV) arrival and departure procedures were analyzed and used as the basis for constructing the simulation airspace.

3.7.1 Arrival Airspace

Table 3-4 provides a summary of the arrival routes and sample origin airports they serve.

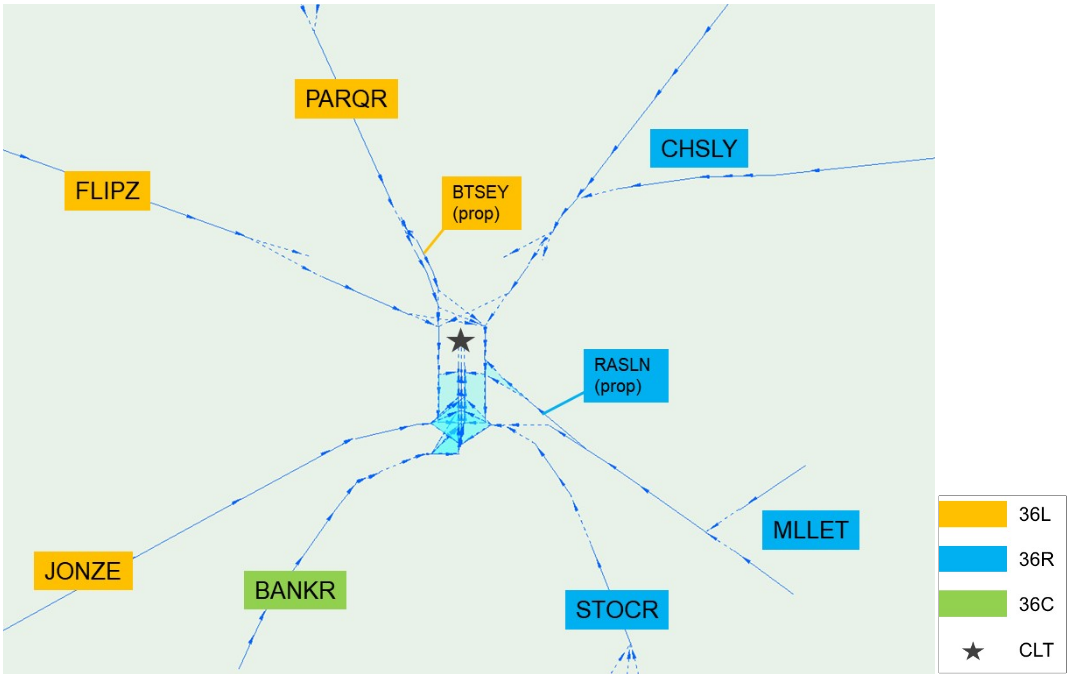
Table 3-4, Sample Origins by Arrival Routing

Arrival Route	Origin Direction	Origin Examples
PARQR	North	Midway and O'Hare (Chicago), Cleveland, Minneapolis, Seattle
CHSLY	East	Boston, Newark, New York City, Frankfurt, London Heathrow
MLLET	East	Coastal Carolina Regional, Ellis (Jacksonville NC), Florence SC
STOCR	South	Palm Beach, Southwest Florida, Fort Lauderdale
BANKR	South	Jacksonville, Miami
JONZE	West	Atlanta, Houston, Mexico City
FLIPZ	West	Denver, Dallas, Los Angeles, Phoenix, San Francisco

Note: Origin examples listing is not all-inclusive.
Source: EIS and Landrum & Brown analysis, 2020

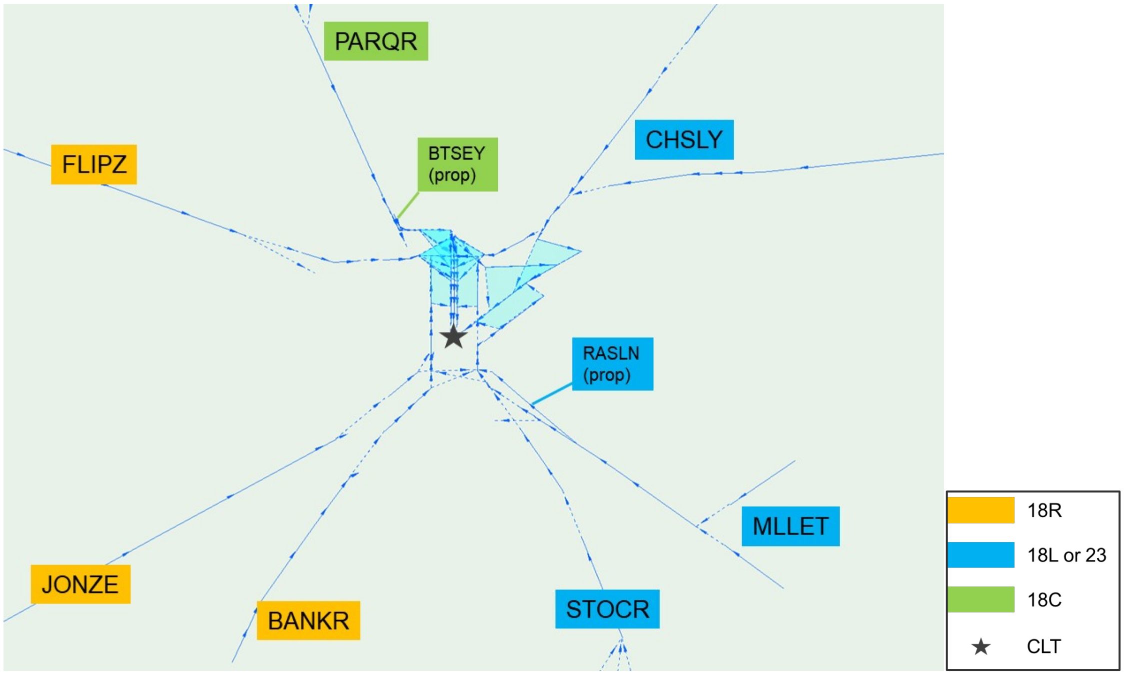
Exhibit 3-8 and **Exhibit 3-9** depict the arrival route structure for both North and South Flows. The exhibit shows the primary allocation of the arrival routes to an arrival runway. The routes that primarily feed Runway 18R/36L are shown in orange, Runway 18L/36R and Runway 23 routes are shown in blue, and the Runway 18C/36C routes are shown in green. While the primary route-runway allocations are depicted on the exhibit, arrivals were offloaded to a different runway than is shown as needed based on demand. For example, triple simultaneous approaches were simulated during various peak arrival pushes throughout the day. During these times, Runway 18C/36C served as the mixed-use offload runway.

Exhibit 3-8, 2016 North Flow Simulation Arrival Route Structure



Note: Arrivals can be offloaded to runways other than those shown on exhibit during busy periods.
Source: FAA terminal procedures

Exhibit 3-9, 2016 South Flow Simulation Arrival Route Structure



Note: Arrivals can be offloaded to runways other than those shown on exhibit during busy periods.
Source: FAA terminal procedures

3.7.2 Departure Airspace

Table 3-5 provides a summary of the departure routes and sample destination airports they serve.

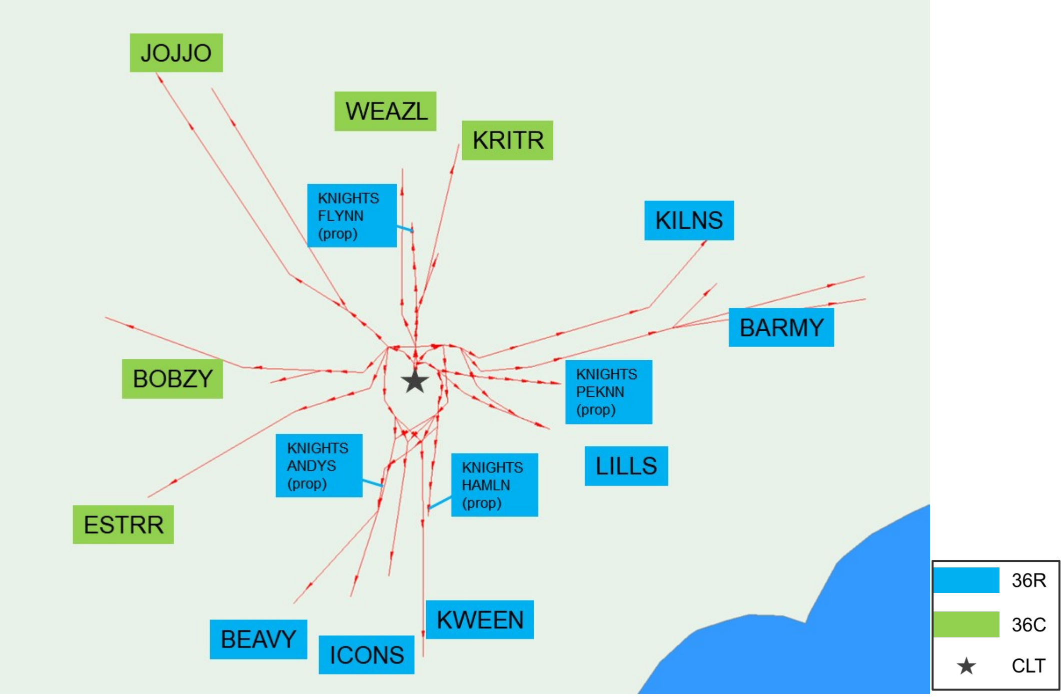
Table 3-5, Sample Destinations by Departure Routing

Departure Route	Destination Direction	Destination Examples
JOJJO	North	Midway and O'Hare (Chicago), Portland, Seattle
WEAZL	North	Minneapolis, Cleveland, Detroit
KRITR	North	Buffalo, Pittsburgh, Toronto
KILNS	East	Baltimore, Dulles (Washington DC), Newark, Philadelphia
BARMY	East	Boston, Frankfurt, LaGuardia (New York City)
LILLS	East	Raleigh–Durham, Ellis (Jacksonville NC)
KWEEN	South	Myrtle Beach, Charleston
ICONS	South	Jacksonville, Miami
BEAVY	South	Cancun, Tallahassee
ESTRR	West	Austin, Dallas, Houston, Mexico City
BOBYZ	West	Denver, Dallas, Los Angeles, Phoenix, San Francisco

Note: Destination examples listing is not all-inclusive.
Source: EIS and Landrum & Brown analysis, 2020

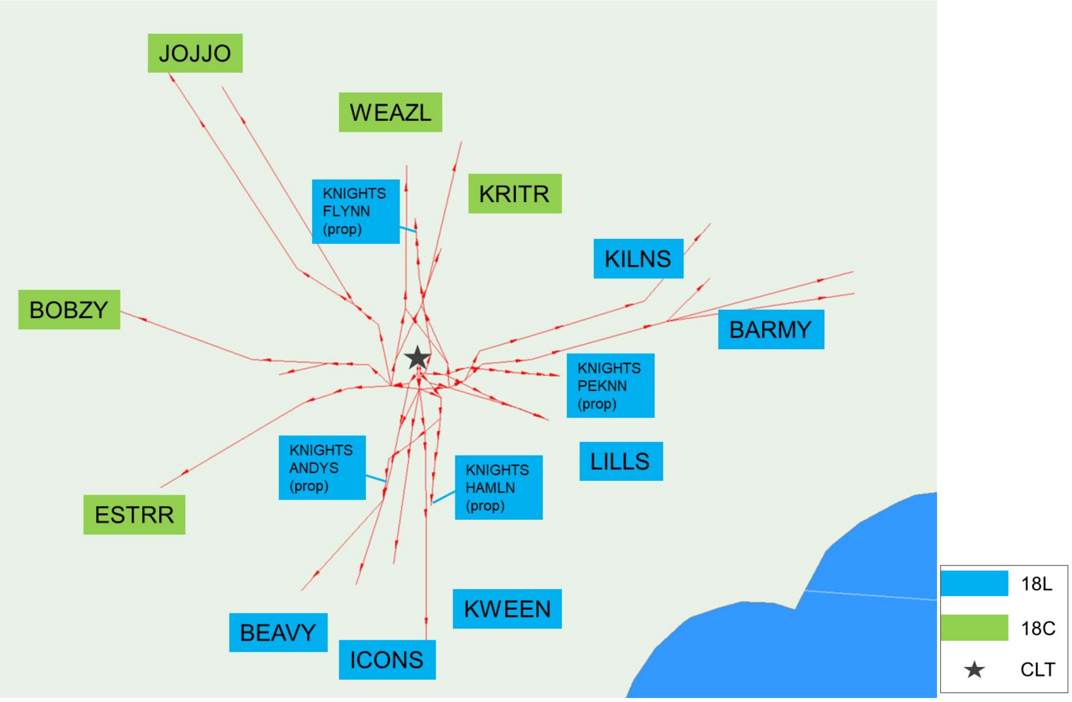
Exhibit 3-10 and **Exhibit 3-11** depict the departure route structure for both North and South Flows. The exhibit shows the primary allocation of the departure routes to a departure runway. The routes that primarily use Runway 18L/36R are shown in blue, whereas the routes that primarily use Runway 18C/36C are shown in green. In addition to the routings shown, BEAVY, ICONS, and KWEEN departures were allowed to offload to Runway 36C in North Flow. In South Flow, KRITR departures were offloaded to Runway 18L during busy periods.

Exhibit 3-10, 2016 North Flow Simulation Departure Route Structure



Note: BEAVY, ICONS, and KWEEN departures can be offloaded to Runway 36C during busy periods.
Source: FAA terminal procedures

Exhibit 3-11, 2016 South Flow Simulation Departure Route Structure



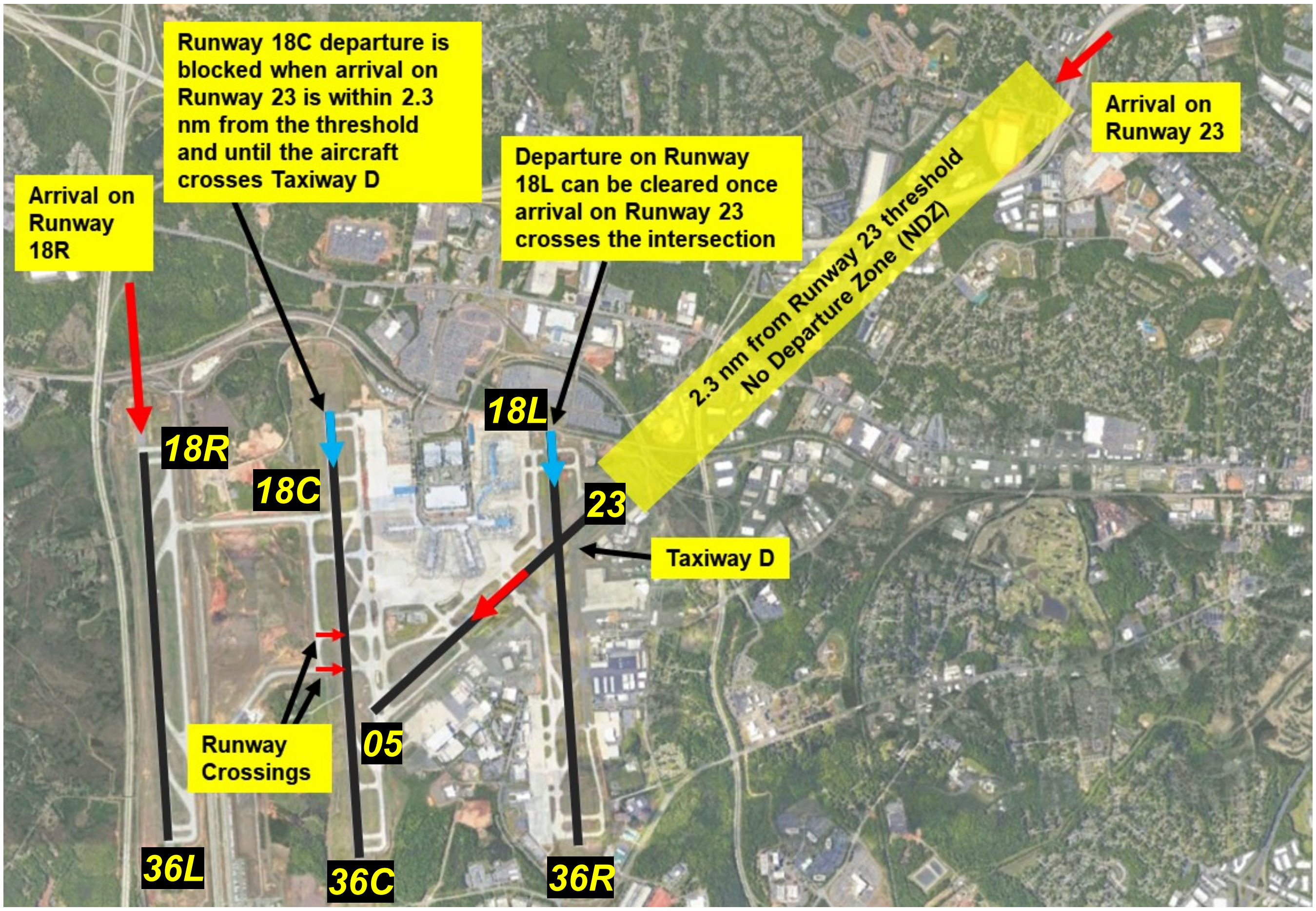
Note: KRITR departures can be offloaded to Runway 18L during busy periods.
Source: FAA terminal procedures

3.7.3 Converging Runway Operation (CRO) with Arrival Departure Window (ADW)

Runway 5/23 intersects Runway 18L/36R and its flight paths intersect with Runway 18C/36C and Runway 18R/36L. As a result, operations on these runways must be coordinated when Runway 23 is being used for arrivals, as shown on **Exhibit 3-12**. This coordination involves:

- Arrivals on Runway 23 block departures on Runway 18C/36C and Runway 18L/36R when the arrival is 2.3 nautical miles or less from the Runway 23 threshold.
- Runway 18L departure cannot take off until Runway 23 arrival crosses the Runway 18L/36R intersection.
- Runway 18C cannot take off until Runway 23 arrival crosses Taxiway D.

Exhibit 3-12, Converging Runway Operation with ADW



Source: Landrum & Brown, 2020

4 Simulation Model Calibration

Calibration of a simulation model is an important step in any airside simulation analysis. The calibration process ensures that the model accurately reflects airport operations under different conditions. The ability of the model to simulate actual conditions is significant because the resulting statistics are used to assess operational performance and to determine the need for airside improvements and additional facilities. The AirTOp calibration is an update of the CLT EIS calibration, which analyzed the 2016 conditions using the SIMMOD simulation model.

Each simulation was run a minimum of ten iterations. Each of the iterations is intended to produce differing results. Probability distributions were input into the simulation model to produce random variations within the simulation so that no iteration is identical. The results of the calibration analysis presented in this chapter are based on the average of ten simulation iterations.

The following metrics were calibrated for CLT:

- Throughput rates
- Average total taxi times

4.1 Throughput Rates

A key metric in the calibration analysis is throughput rates. Throughput rates were calibrated to 2016-2017 FAA Aviation System Performance Metrics (ASPM) data or CLT's Aerobahn system data. The throughput rates were also compared to the EIS calibration effort to ensure consistency in the results.

The 90th percentile throughput was used as a measure of sustained, repeatable capacity in the calibration analysis. The maximum throughput was not used because it is not considered a reliable measure of sustained, repeatable capacity, based on FAA input and the DORA stakeholder group recommendations from the ACEP study and the first EA DORA meeting.

The simulated total operations throughput for the four calibration cases (North Flow VMC, North Flow IMC, South Flow VMC, and South Flow IMC) is compared to ASPM data and the EIS results in **Table 4-1**.

Table 4-1, Calibration Total Operations Throughput Comparison

Case	90th Percentile Airport Throughput		
	ASPM	EIS	AirTOp
North VMC	121	118	117
North IMC	114	116	114
South VMC	121	121	117
South IMC	112	116	115

Sources: Capacity/Delay Analysis and Airfield Modeling Technical Memorandum, CLT EIS; ASPM data, 2016-2017; Landrum & Brown analysis, 2020

The simulated 90th percentile throughputs are within 10 percent of the ASPM rates and the EIS simulation results. The simulation schedule has less variation than actual operations over the 2016-2017 period. Lower variation leads to fewer instances of overlapping arrival and departure peaks, which results in a lower total operations peak for the simulated throughput versus the 2016-2017 actual data. The Airport is more stressed by demand in IMC as compared to VMC. This difference occurs because the separations required between aircraft are higher in IMC than in VMC. As a result, there are less pronounced peaks in IMC than in VMC.

The simulated arrival and departure throughputs are compared to the ASPM data and the EIS results for the maximum rates and the 90th percentile rates in **Table 4-2**. The simulated arrival and departure hourly throughputs match closely with ASPM and the EIS simulation results. The FAA's Capacity Airport Rates (called rates) are also shown; the arrival called rates are much higher than actual hourly counts, so they are not considered a reliable indication of actual throughput.

Table 4-2, Calibration Arrival and Departure Throughput Comparison

Case	Type of Operation	Arrival and Departure Throughput					
		ASPM Called Rate[1]	ASPM Max	ASPM 90th	EIS Max[2]	AirTOp Max	AirTOp 90th
North VMC	Arrival	92	79	63	73	76	67
	Departure	69	82	67	78	82	63
North IMC	Arrival	75	76	64	73	72	64
	Departure	65	79	62	68	78	59
South VMC	Arrival	92	78	63	77	77	68
	Departure	82	81	66	78	83	64
South IMC	Arrival	75	77	64	74	77	66
	Departure	65	74	58	68	79	61

[1] A variety of called rates were found in ASPM for each particular runway configuration; the most frequent called rate is shown in the table.

[2] The EIS did not include 90th percentile data for arrival and departure throughput.

Source: Capacity/Delay Analysis and Airfield Modeling Technical Memorandum, CLT EIS; ASPM data, 2016-2017; Landrum & Brown analysis, 2020

The hourly throughput rate for the main operation on each runway was compared to the actual runway throughput. The simulated runway throughputs are shown with the Aerobahn data and the EIS results for the 90th percentile rates in **Table 4-3**. The simulated runway throughputs match closely with Aerobahn and the EIS simulation results.

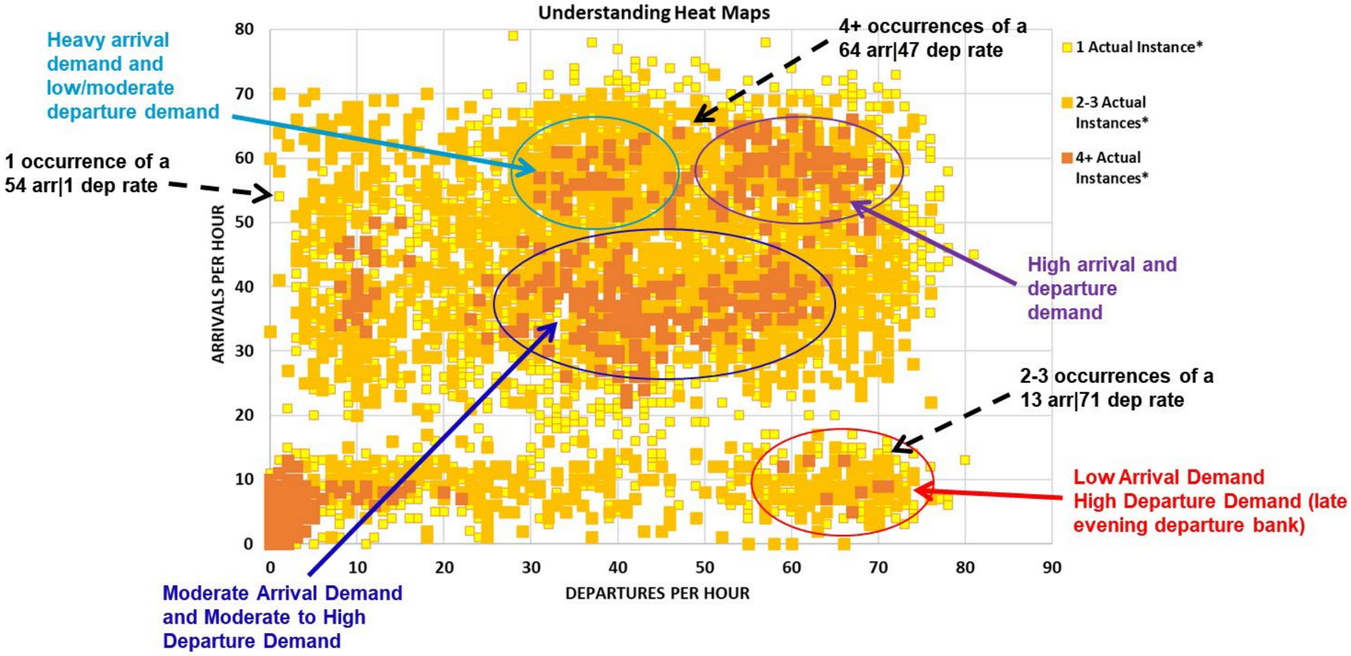
Table 4-3, Calibration Runway Throughput Comparison

	Operation	Runway	Aerobahn – 90th	EIS - 90th	AirTOp – 90th
North VMC	Arrival	36L	35	32	34
	Departure	36C	38	37	39
	Departure	36R	29	28	27
North IMC	Arrival	36L	35	32	32
	Departure	36C	35	35	36
	Departure	36R	27	26	26
South VMC	Arrival	18R	33	33	33
	Departure	18C	32	31	32
	Departure	18L	38	35	37
South IMC	Arrival	18R	34	35	33
	Departure	18C	28	29	31
	Departure	18L	32	34	32

Source: Capacity/Delay Analysis and Airfield Modeling Technical Memorandum, CLT EIS; Aerobahn data, May 2016 for VMC, Jan-Aug 2016 for IMC; Landrum & Brown analysis, 2020

Simulated throughputs can also be compared to actual rates using a heat map. A heat map plots the number of hourly arrivals against the number of hourly departures. The frequency of occurrence of a particular arrival-departure rate in the data sample defines the color (heat) of the data point. This technique enables the visual differentiation of commonly occurring throughput rates from outlier throughput rates. **Exhibit 4-1** shows how heat maps work.

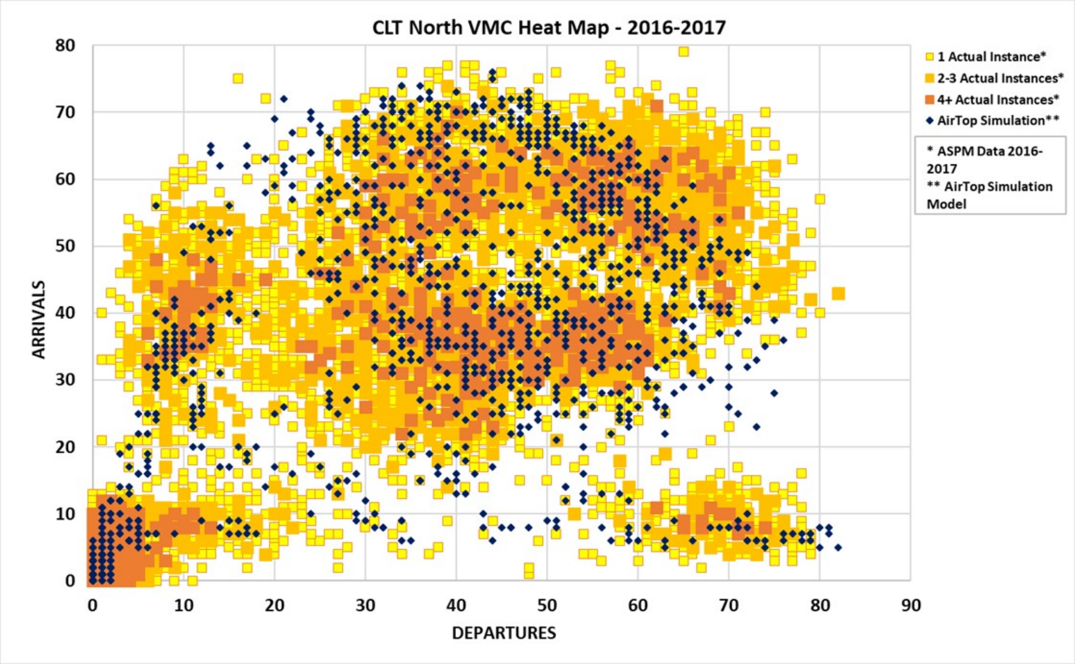
Exhibit 4-1, Heat Map Example



Source: Landrum & Brown analysis, 2020

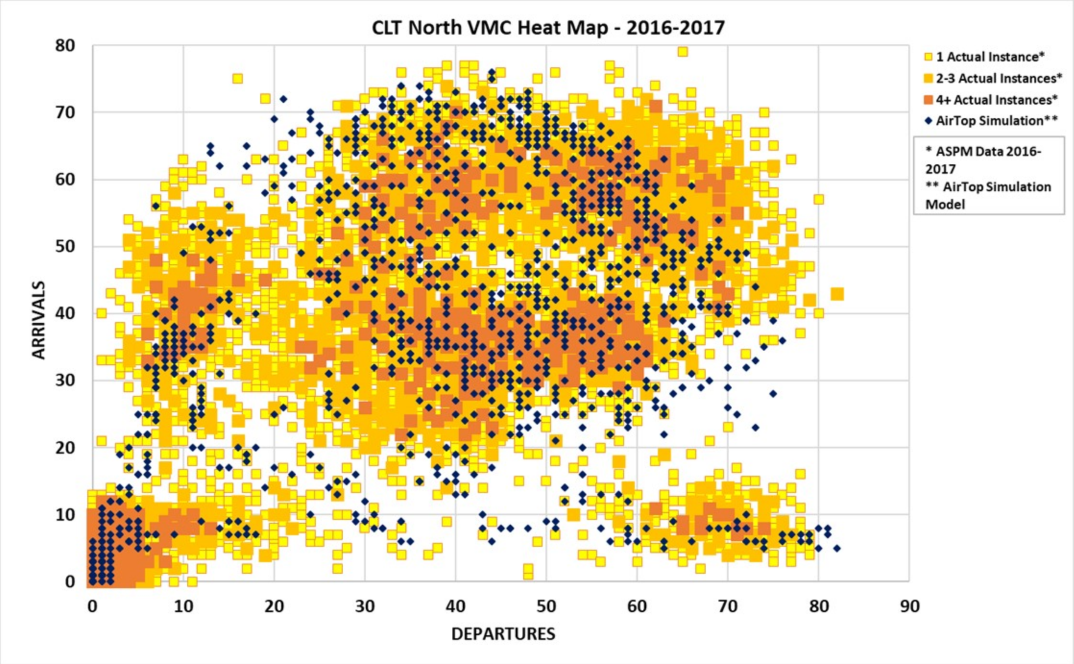
Exhibit 4-2 and **Exhibit 4-3** present the throughput rate heat map based on 2016-2017 ASPM data for the North Flow VMC and South Flow VMC operation respectively. In both flows, the simulated throughputs correlate well to the actual data.

Exhibit 4-2, Calibration North Flow VMC Throughput Heat Map – Actual Data



Source: ASPM data, 2016-2017; Landrum & Brown analysis, 2020

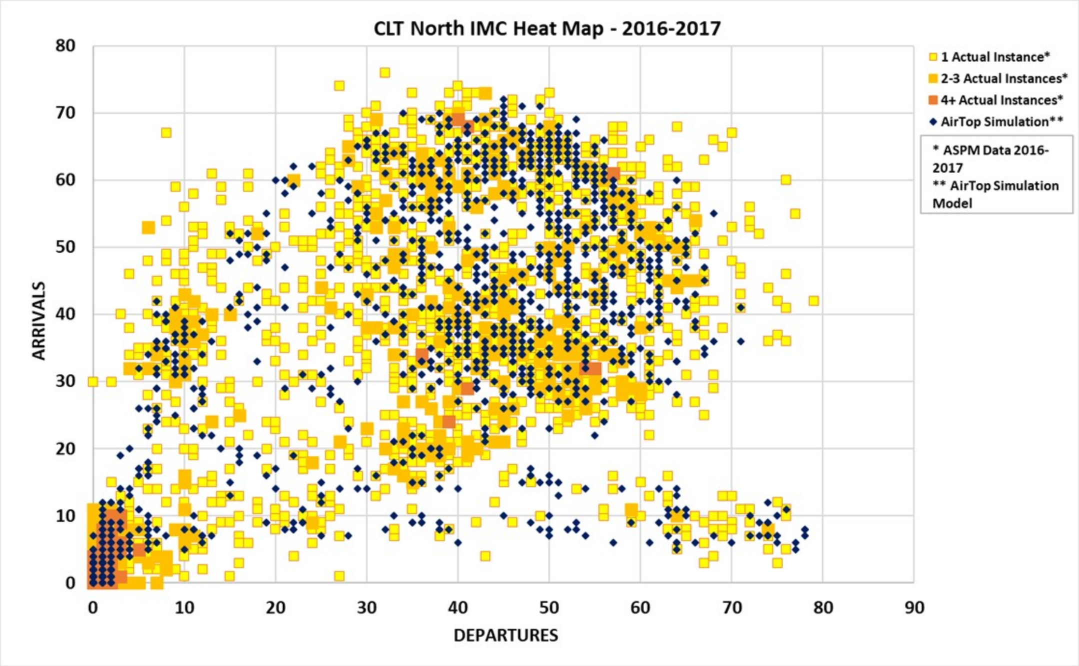
Exhibit 4-3, Calibration South Flow VMC Throughput Heat Map – Actual Data



Source: ASPM data, 2016-2017; Landrum & Brown analysis, 2020

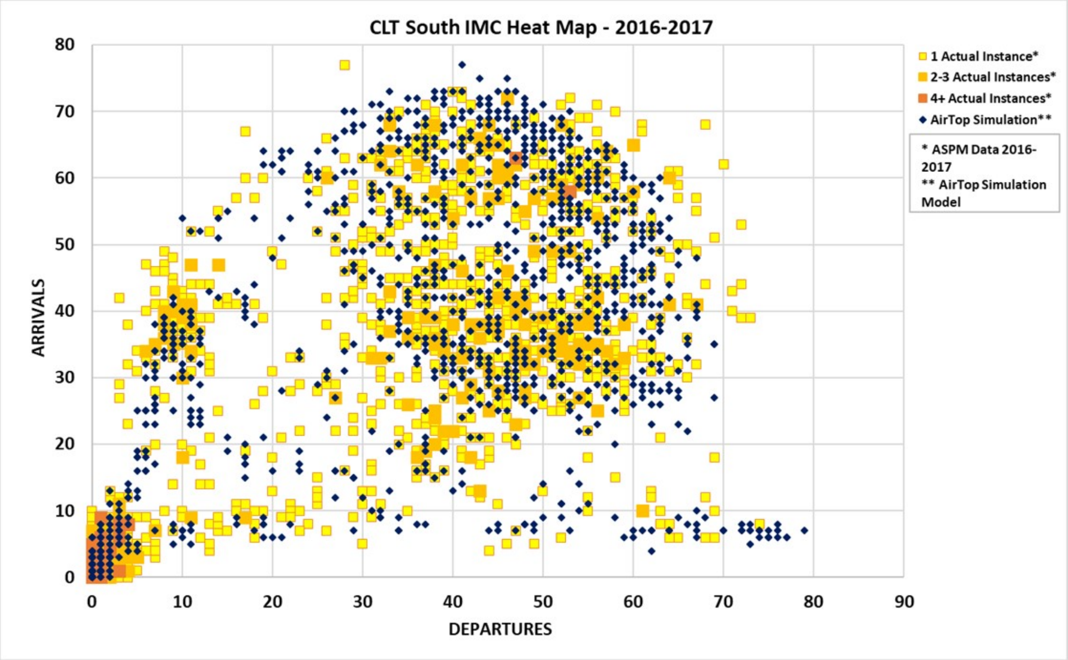
Exhibit 4-4 and **Exhibit 4-5** present the throughput rate heat map based on 2016-2017 ASPM data for the North Flow VMC and South Flow IMC operation respectively. In both flows, the simulated throughputs correlate well to the actual data.

Exhibit 4-4, Calibration North Flow IMC Throughput Heat Map – Actual Data



Source: ASPM data, 2016-2017; Landrum & Brown analysis, 2020

Exhibit 4-5, Calibration South Flow IMC Throughput Heat Map – Actual Data



Source: ASPM data, 2016-2017; Landrum & Brown analysis, 2020

4.2 Aircraft Taxi Times

Aircraft ground taxi times are a key metric in the simulation model calibration process. The AirTOp simulated taxi times were calibrated to 2016 FAA ASPM data to ensure model accuracy. **Table 4-4** provides a comparison of the average taxi times for the 2016 ASPM data versus the North Flow and South Flow VMC simulated times. IMC taxi times were assumed to be the same as the VMC taxi times so they were not compared. It is important to note that the FAA database provides the taxi times for most of the major US carriers, however not all aircraft operations are accounted for (i.e., cargo, general aviation, non-major commercial carriers). The simulation average taxi times represent the averages for all airlines and flights which were simulated in 10 iterations. The primary goal of calibrating to actual taxi times is to achieve taxi in and out times which are representative of the actual average taxi times at the Airport.

Table 4-4, Calibration Taxi Time Comparison

Case	Taxi Times (in minutes)	
	Arrival	Departure
North Flow ASPM	11.0	20.3
North Flow VMC AirTOp	11.9	20.2
South Flow ASPM	12.4	19.5
South Flow VMC AirTOp	11.6	17.6

Source: ASPM data, 2016; Landrum & Brown analysis, 2020

4.3 Calibration Summary

The results of the calibration analysis for the North Flow VMC, South Flow VMC, North Flow IMC and South Flow IMC operations demonstrate that the models can successfully generate arrival and departure throughput rates and ground travel times which coincide well with actual operations. **Table 4-5** presents a summary of the final taxi time and delay metrics for the four calibrated simulation models. These results are based on the average of ten iterations of simulation runs.

Table 4-5, Calibration Results Summary

Metric	Minutes per Operation				
	North VMC	North IMC	South VMC	South IMC	All-Weather Annualization
Runway Use[1]	44.8%	9.9%	38.8%	6.5%	***100.0%***
Avg. Arrival Taxi Time	11.9	13.1	11.6	12.2	***11.9***
Avg. Dep. Taxi Time	20.2	22.3	17.6	20.6	***19.4***
Avg. Arrival Air Delay	6.1	7.5	5.1	5.6	***5.8***
Avg. Arrival Delay	11.3	13.8	9.6	10.8	***10.9***
Avg. Dep. Taxi Delay	7.0	9.1	6.8	9.5	***7.3***
Avg. Dep. Delay	8.8	11.3	8.9	11.5	***9.2***
Average Delay	10.1	12.5	9.2	11.2	***10.1***

[1] Based on ASPM configurations and ATC called rates in 2016.

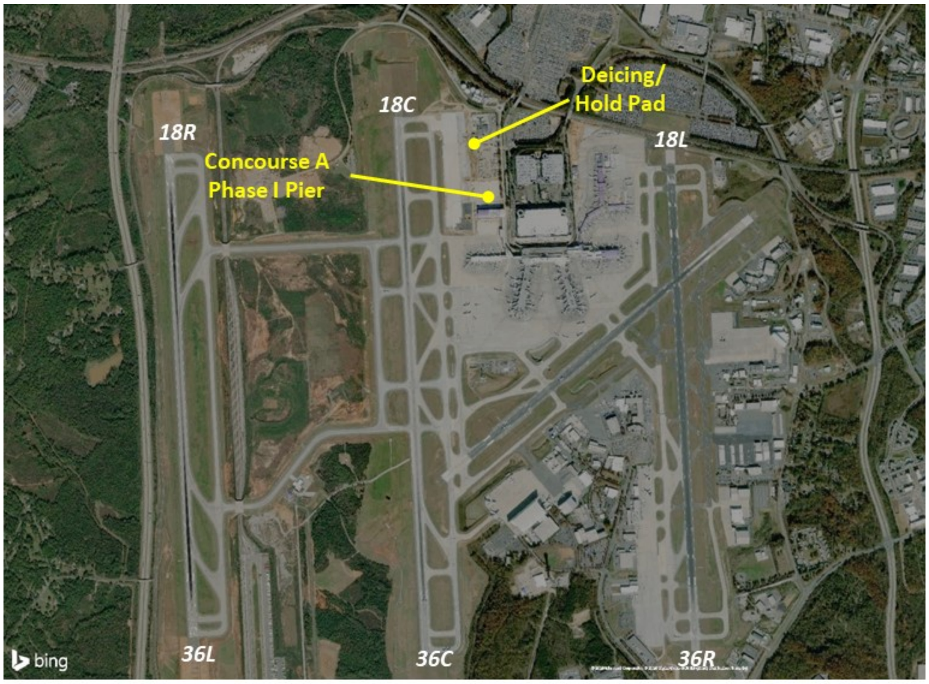
Source: AirTOp simulations; ASPM data, 2016; Landrum & Brown analysis, 2020

5 2019 Baseline Operating Assumptions

Since the 2016 calibration, Runway 23 is no longer a primary arrival runway, therefore subsequent South Flow models were revised to reflect the new runway usage. To ensure that the models accurately reflect airport operations under the updated conditions, the 2019 Baseline simulation results were used to validate the models. North Flow models were not modeled for 2019 because runway usage remained the same as 2016.

The Baseline condition represents existing airside conditions (airfield, airspace, and terminal) in 2019 as shown on **Exhibit 5-1**. The primary differences between the 2016 calibrated condition and the 2019 condition are the addition of (1) the Concourse A Phase 1 Pier and (2) a deicing/hold pad to the north of the new pier. The 2019 Baseline condition was simulated with the 2019 flight schedule.

Exhibit 5-1, 2019 Baseline Airfield Layout



Source: 2020 Bing Maps imagery; Landrum & Brown, 2020

For purposes of the EA, the following 2019 Baseline modeling experiments were run:

- 2019 South Flow VMC
- 2019 South Flow IMC

5.1 Airfield and Aircraft Apron Layouts

The apron areas for the cargo carriers, general aviation, and military aircraft remain the same as in 2016. The 2019 Baseline includes the addition of the new Concourse A Phase I Pier as compared to the 2016 condition. In addition, airline usage of gates has changed since 2016. In 2019, American and Delta occupied the original Concourse A pier, while OALs moved to the Concourse A Phase I Extension Pier. The updated passenger airline gating assignments are shown in **Table 5-1**. The table also summarizes the number of gates in each concourse.

Table 5-1, 2019 Baseline Airline Gating Assignment Assumptions

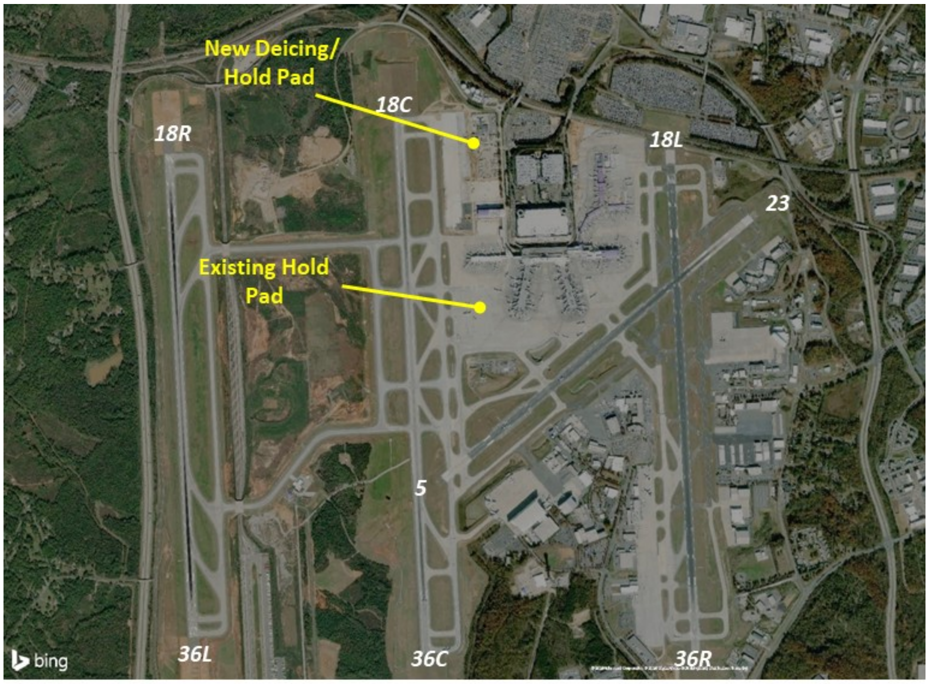
Concourse	Airline Assignments	Number of Gates
A	American, Delta	13
A Phase I Pier	Other Airlines (OALs)	9
B	American Mainline	16
C	American Mainline	18
D	American Mainline, Lufthansa	13
E	American Regional	44

Source: CLT airport and Landrum & Brown analysis, 2020

5.2 Hold Pad Usage

As with the 2016 condition, airfield deicing/hold pads were used to accommodate arrivals waiting for an available gate, RON operations, towed aircraft, and departures waiting for a spot in the queue. In the Baseline condition, the new deicing/hold pad located at the Runway 18C end can be used in addition to the existing hold pad between Concourses B and C, as shown on **Exhibit 5-2**.

Exhibit 5-2, 2019 Baseline Deicing/Hold Pads



Source: 2020 Bing Maps imagery; Landrum & Brown, 2020

5.3 Runway Operating Configurations

In South Flow, Runway 23 is no longer used for arrivals in the 2019 Baseline; Runway 5/23 is used as a taxiway instead. The basic runway usage in a South Flow configuration therefore consists of arrivals on Runways 18L and 18R, Runway 18C is used in conjunction with Runways 18L and 18R to provide triple parallel approach capability during periods of high arrival demand. The primary departure runways are Runways 18C and 18L in both VMC and IMC. The allocation of departing aircraft to these runways is based on the destination of the flight. Runway 18C is used by aircraft departing to northbound and westbound destinations. Runway 18C is also used by international heavy aircraft heading east. Runway 18L is used by southbound and eastbound departures. **Exhibit 5-3** depicts the South Flow runway usage.

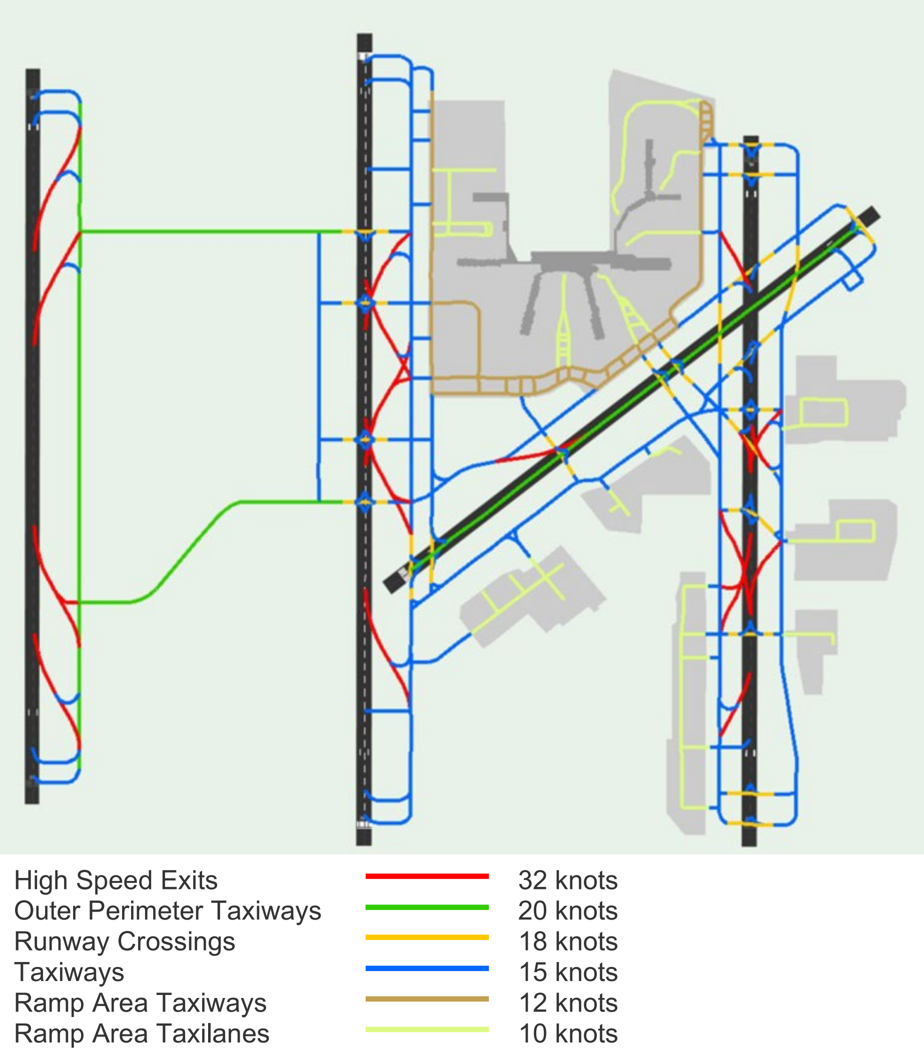
Exhibit 5-3, 2019 Baseline South Flow VMC/IMC Runway Configuration

Source: 2020 Bing Maps imagery; Landrum & Brown, 2020

5.4 Airfield Ground Speeds

The overall ground speed assumptions remain the same as in 2016. **Exhibit 5-4** shows the 2019 Baseline speeds with the Concourse A pier expansion and deicing/hold pad included.

Exhibit 5-4, 2019 Baseline Airfield Ground Speed Assumptions

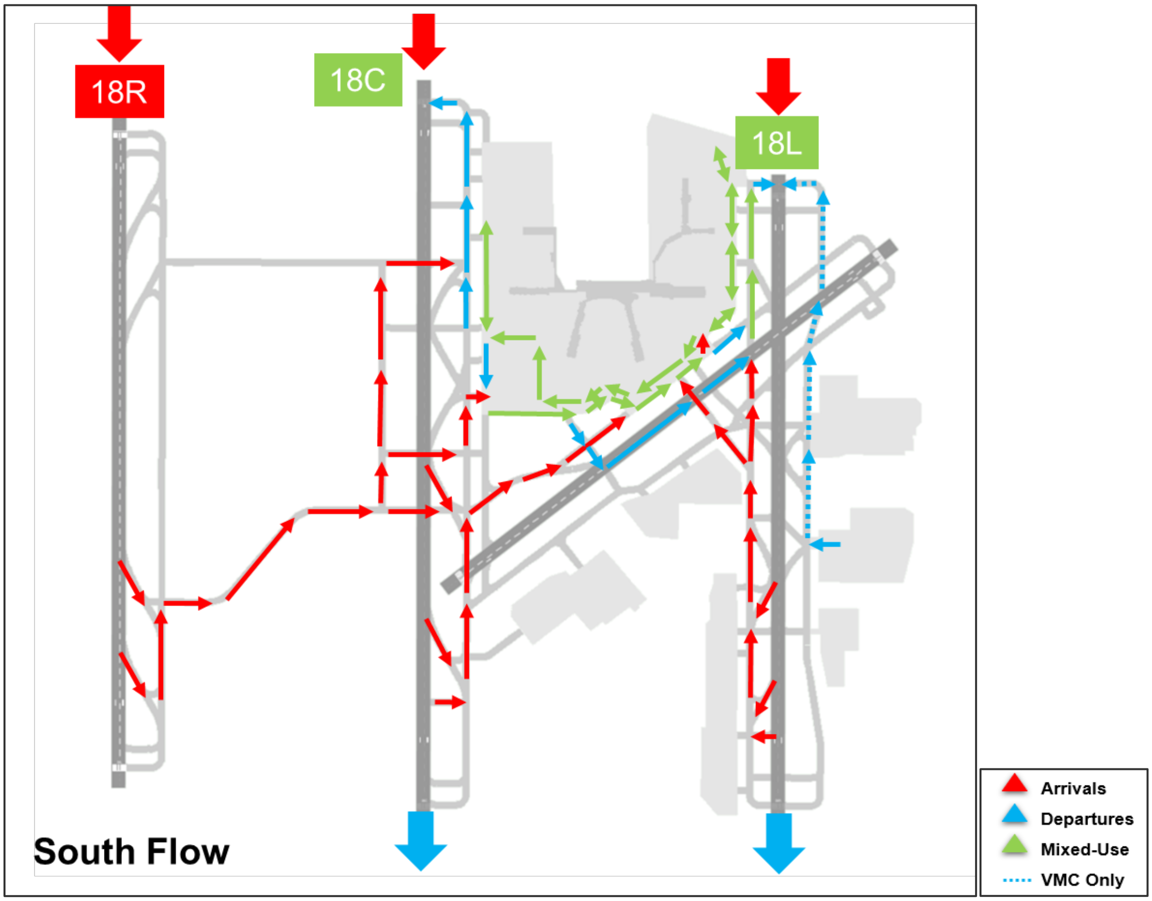


Source: ACEP, EIS, and Landrum & Brown analysis, 2020

5.5 Airfield Taxi Flows

Exhibit 5-5 shows the South Flow taxi routes with the Baseline improvements. Runway 23 is used as a taxiway.

Exhibit 5-5, 2019 Baseline Taxi Routes



Source: Tower observations and ATCT feedback

5.6 Airspace Assumptions

The 2019 Baseline conditions were modeled with the same aircraft separation and airspace structure assumptions as were used for the 2016 modeling and calibration effort.

6 2019 Baseline Modeling Results

The results of the 2019 Baseline simulation models are presented in this chapter. The following metrics were validated for the South VMC and IMC models:

- Throughput rates
- Average total taxi times

6.1 Throughput Rates

A key metric in the calibration analysis is throughput rates. Throughput rates were calibrated to 2019 FAA ASPM data or CLT's Aerobahn system data. The simulated total operations throughput is compared to ASPM data in **Table 6-1**. The simulated 90th percentile throughputs are within 10 percent of the ASPM rates.

Table 6-1, 2019 Baseline Total Operations Throughput Comparison

Case	90th Percentile Airport Throughput	
	ASPM	AirTOp
South VMC	117	118
South IMC	111	116

Sources: ASPM data, 2019; Landrum & Brown analysis, 2020

The simulated arrival and departure throughputs are compared to the ASPM data for the maximum rates and the 90th percentile rates in **Table 6-2.** The simulated arrival and departure hourly throughputs match closely with ASPM data. The FAA's Capacity Airport Rates (called rates) are also shown; the arrival called rates are much higher than actual hourly counts, so they are not considered a reliable indication of actual throughput. The called rates also heavily prioritize arrivals over departures, with the arrival hourly called rate being much higher than the departure rate. However, in actual operations, arrivals and departures are more balanced, with the peak departure rates slightly higher than arrival rates. The simulation takes a similar balanced approach to optimize delays.

Since the separation requirements between aircraft are higher in IMC than in VMC, the throughput is generally lower in IMC that it is in VMC. However, some IMC rates are slightly higher than VMC rates. The 2019 demand level does not constantly stress the airport during VMC as most operations are completed within the hour. During IMC, demand often spills over to the next hour, causing a backup that increases the throughput rate.

Table 6-2, 2019 Baseline Arrival and Departure Throughput Comparison

Case	Type of Operation	Arrival and Departure Throughput				
		ATC Called Rate[1]	ASPM Max	ASPM 90th	AirTOp Max	AirTOp 90th
South VMC	Arrival	87	73	60	68	62
	Departure	69	77	63	74	64
South IMC	Arrival	80	71	60	71	63
	Departure	69	69	57	72	59

[1] A variety of called rates were found in ASPM for each runway configuration; the most frequent called rate is shown in the table.

Source: ASPM data, 2019; Landrum & Brown analysis, 2020

The hourly throughput rate for the main operation on each runway was compared to the actual runway throughput determined from Aerobahn data. The simulated runway throughputs are shown with the Aerobahn data for the 90th percentile rates in **Table 6-3**. The simulated runway throughputs match closely with the observed data.

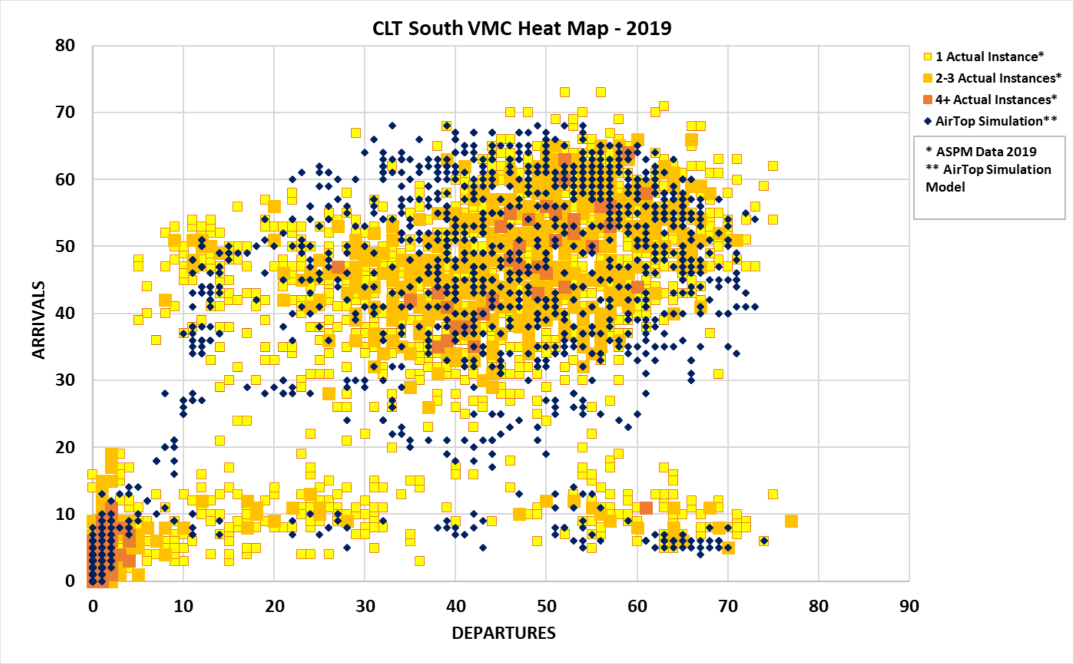
Table 6-3, 2019 Baseline Runway Throughput Comparison

Case	Operation	Runway	Aerobahn – 90th	AirTOp – 90th
South VMC	Arrival	18R	34	34
	Departure	18C	34	36
	Departure	18L	30	30
South IMC	Arrival	18R	32	33
	Departure	18C	32	33
	Departure	18L	27	29

Source: Aerobahn data, January-April 2019; Landrum & Brown analysis, 2020

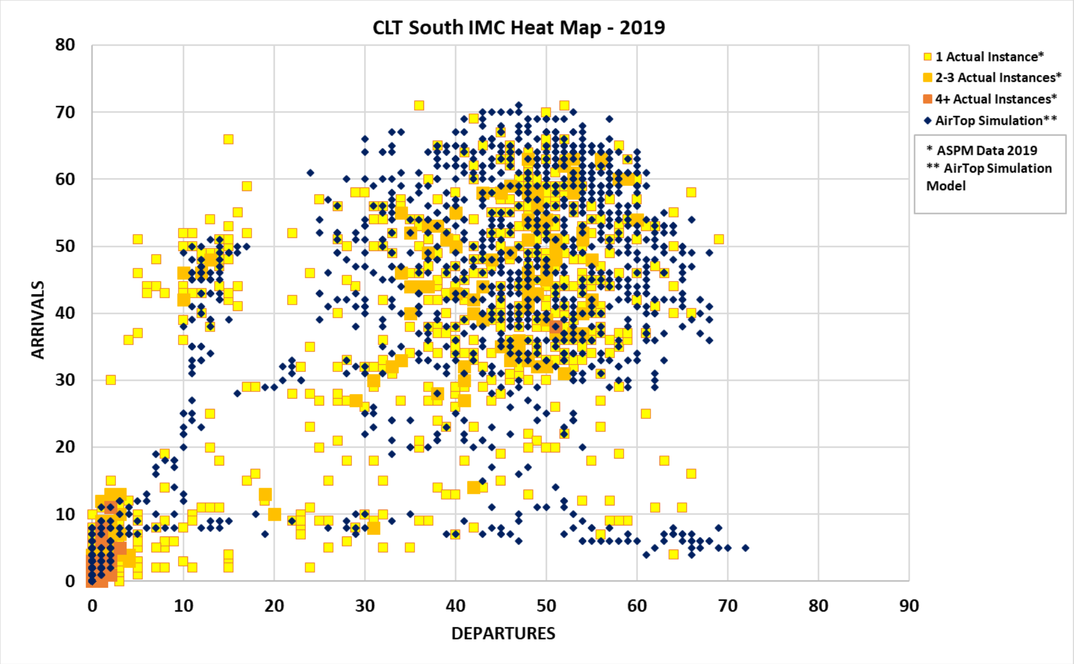
Simulated throughputs can also be compared to actual rates using a heat map. **Exhibit 6-1** and **Exhibit 6-2** present the throughput rate heat map based on 2019 ASPM data for the South Flow VMC and South Flow IMC operation respectively. In both flows, the simulated throughputs correlate well to the actual data.

Exhibit 6-1, 2019 Baseline South Flow VMC Throughput Heat Map – Actual Data



Source: ASPM data, 2019; Landrum & Brown analysis, 2020

Exhibit 6-2, 2019 Baseline South Flow IMC Throughput Heat Map – Actual Data



Source: ASPM data, 2019; Landrum & Brown analysis, 2020

6.2 Aircraft Taxi Times

Aircraft ground taxi times are a key metric in the simulation model calibration process. The AirTOp simulated taxi times were calibrated to 2019 FAA ASPM data to validate model accuracy. **Table 6-4** provides a comparison of the 2019 ASPM data versus the simulated average taxi times. The comparison is only made for the VMC because the IMC and VMC taxi times were assumed to be the same. It is important to note that the FAA database provides the taxi times for most of the major US carriers, but not all aircraft operations are accounted for (i.e., cargo, general aviation, non-major commercial carriers).

Table 6-4, 2019 Baseline Taxi Time Comparison

Case	Taxi Times (in minutes)	
	Arrival	Departure
South Flow ASPM	13.1	19.6
South Flow VMC AirTOp	12.6	17.5

Source: ASPM data, 2019; Landrum & Brown analysis, 2020

6.3 Baseline Summary

The results of the validation analysis for the South Flow VMC and South Flow IMC operations demonstrate that the models can successfully produce arrival and departure throughput rates and ground travel times which coincide well with actual operations.

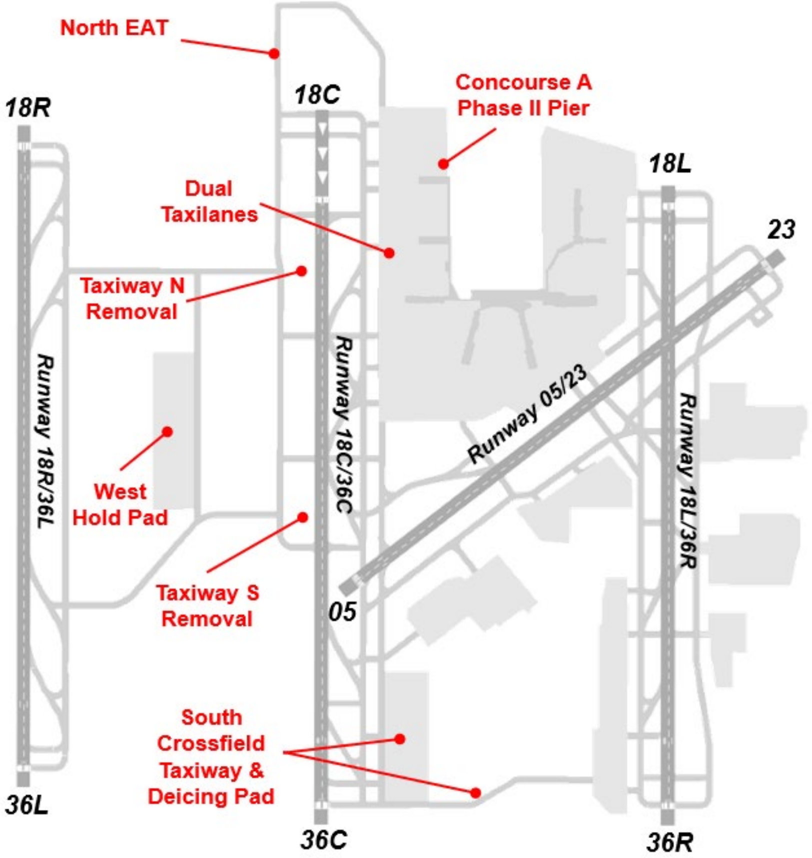
7 No Action Operating Assumptions

With the 2016 and 2019 simulation models calibrated to reflect airport conditions, the models can be adjusted using various control parameters and demand levels to evaluate future changes in the operation. The No Action experiment reflects the existing airside system along with improvements that are expected to be in place by 2028, as shown on **Exhibit 7-1**. These include:

- Concourse A Phase II Pier
- North End Around Taxiway (EAT) on the Runway 18C end
- Dual taxilanes for Concourse A
- Taxiway N removal
- West hold pad between Runways 18C/36C and 18R/36L
- Taxiway S removal
- South crossfield taxiway and deicing pad

The No Action cases were simulated with the 2028 and 2033 flight schedules.

Exhibit 7-1, 2028/2033 Future No Action Airfield Layout



Source: CLT airport and Landrum & Brown, 2020

For purposes of the EA, the following No Action modeling experiments were run:

- 2028 North Flow VMC
- 2028 North Flow IMC
- 2028 South Flow VMC
- 2028 South Flow IMC
- 2033 North Flow VMC
- 2033 North Flow IMC
- 2033 South Flow VMC
- 2033 South Flow IMC

7.1 Airfield and Aircraft Apron Layouts

The apron areas for the cargo carriers, general aviation, and military aircraft remain the same as in 2016 and 2019. The No Action conditions include the addition of Concourse A Phase II Pier as compared to the 2019 condition. The updated passenger airline gating assignments are shown in **Table 7-1**. The table also summarizes the number of gates in each concourse.

Table 7-1, No Action Airline Gating Assignment Assumptions

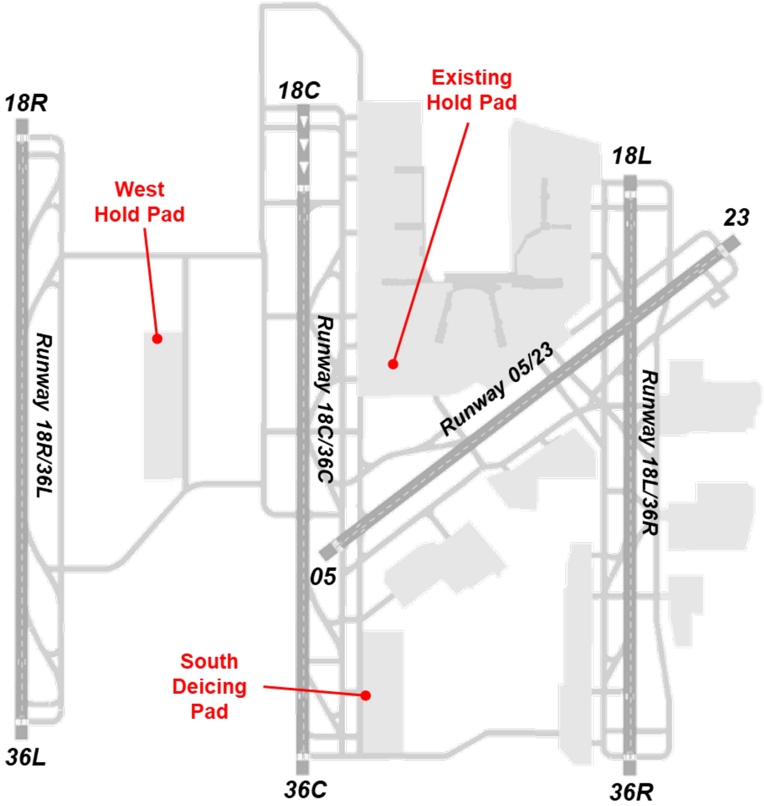
Concourse	No Action Airline Assignments	Number of Gates
A	American	9
A Phase I Pier	Other Airlines (OALs)	9
A Phase II Pier	Other Airlines (OALs)	10
B	American Mainline	16
C	American Mainline	18
D	American Mainline, Lufthansa	13
E	American Regional	44

Source: CLT airport and Landrum & Brown analysis, 2020

7.2 Hold Pad Usage

Airfield deicing/hold pads were used to accommodate arrivals waiting for an available gate, RON operations, and towed aircraft. In the No Action condition, the South Deicing Pad and West Hold Pad can be used in addition to the existing hold pad between Concourses B and C (see **Exhibit 7-2**).

Exhibit 7-2, No Action Deicing/Hold Pads



Source: CLT airport and Landrum & Brown, 2020

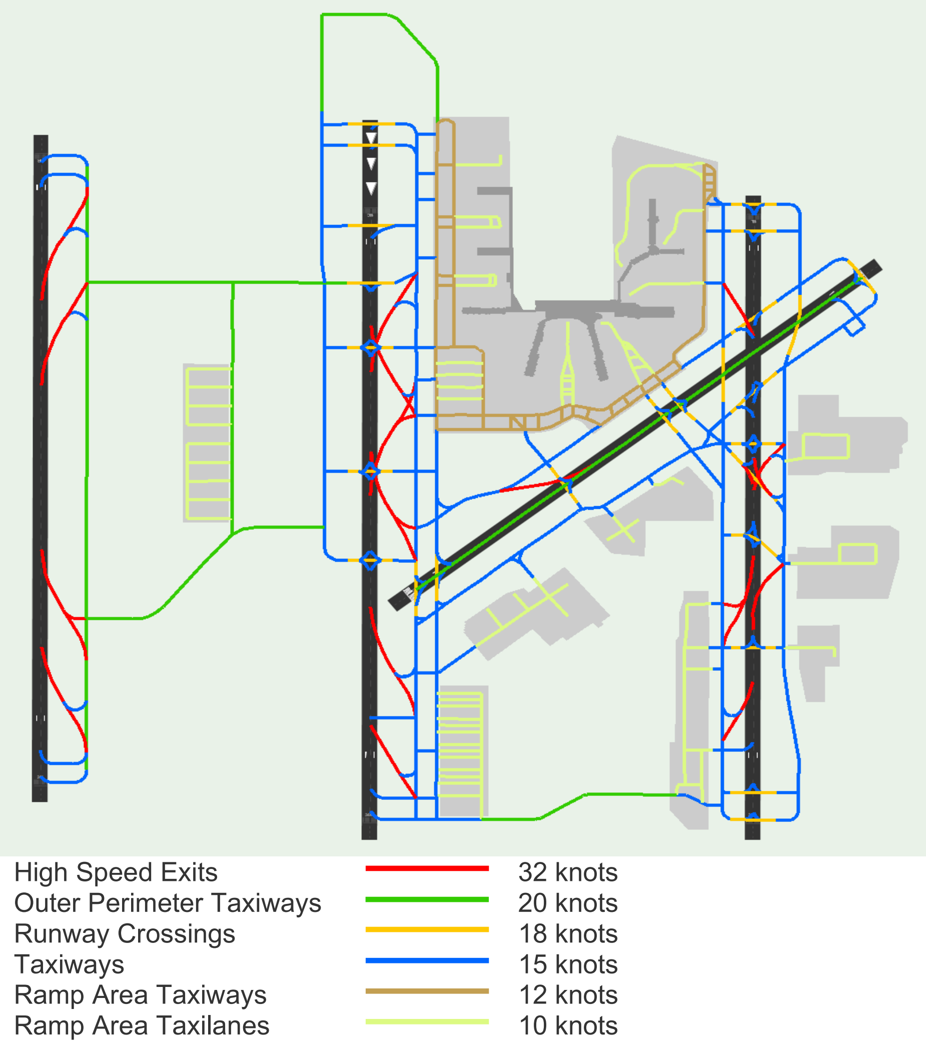
7.3 Runway Operating Configurations

For North Flow, the No Action experiments were modeled with the same runway operating configurations as the 2016 Calibration modeling effort. For South Flow, the No Action experiments were modeled with the same runway operating configurations as the 2019 Baseline modeling effort.

7.4 Airfield Ground Speeds

The overall ground speed assumptions remain the same as in 2016 and 2019. **Exhibit 7-3, *No Action Airfield Ground Speed Assumptions***, shows the 2028 and 2033 No Action speeds with the No Action additions, such as the Concourse A pier and the North EAT, included.

Exhibit 7-3, No Action Airfield Ground Speed Assumptions

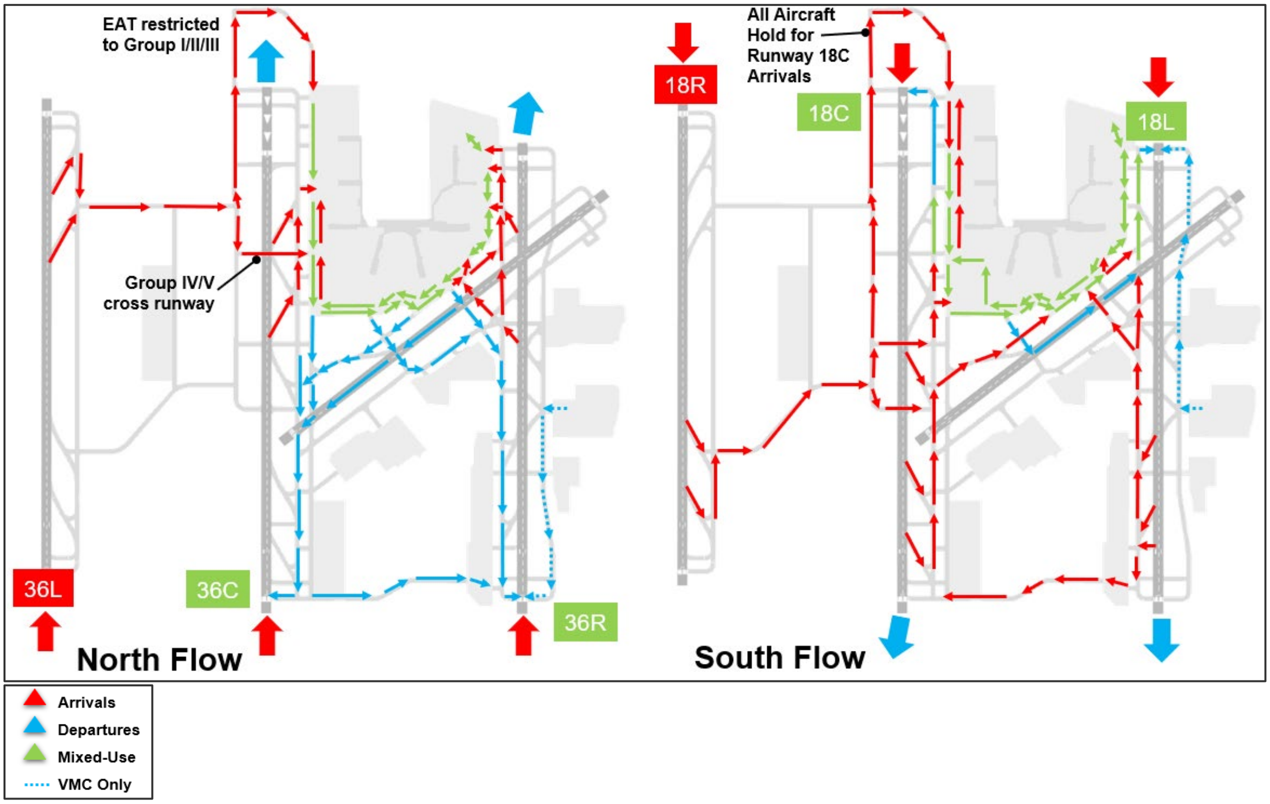


Source: ACEP, EIS, and Landrum & Brown analysis, 2020

7.5 Airfield Taxi Flows

Exhibit 7-4 shows the taxi routes in the No Action with additional projects implemented. Both North Flow and South Flow reflect the use of the new North EAT and the new dual taxilanes along Concourse A. In addition, in South Flow, Runway 23 is not used for arrivals as it was in 2016; instead Runway 5/23 is used as a taxiway.

Exhibit 7-4, No Action Taxi Routes



Source: Tower observations and ATCT feedback

7.6 Airspace Assumptions

Based on discussion with the FAA during the DORA process,[6] the No Action and alternative simulations assumed a final approach in-trail separation of 2.5 nautical miles due to average runway occupancy time of less than 50 seconds. This separation allows arrivals to fully utilize runway capacity at higher demand levels.

With the implementation of the NASA Airspace Technology Demonstration 2 (ATD-2) system, a predecessor to the FAA Terminal Flight Data Manager (TFDM), the miles-in-trail (MIT) constraints that would have otherwise been added for northern destinations from CLT are no longer necessary. Prior to ATD-2, it was normal practice for MIT restrictions to be implemented, even during VMC, due to overhead enroute congestion. With ATD-2, flights going to the north are assigned a takeoff time prior to pushback from the gate to meter the departures into the airspace. Further improved enroute flows are anticipated with the Atlantic Coast Reroute Project.

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[6] DORA #3 follow up meeting with FAA, July 8, 2020

In addition, wake turbulence separations were updated according to Consolidated Wake Turbulence (CWT) Separation Standards issued in September 2019. **Table 7-2** lists the different aircraft types in each new category. **Table 7-3** presents the simulated minimum VMC and IMC in-trail separation distances for arrivals. **Table 7-3** presents the simulated minimum VMC and IMC in-trail separation times for departures.

Table 7-2, CWT Categories

A	B	C	D		E	F		G		H	I
Super	**Upper Heavy**	**Lower Heavy**	**Non-Pairwise Heavy**		**B757**	**Upper Large**		**Lower Large**		**Upper Small**	**Lower Small**
A388	A332	A306	A124	DC85	B752	A318	C130	AT43	E170	ASTR	BE10
	A333	A30B	A339	DC86	B753	A319	C30J	AT72	E45X	B190	BE20
	A343	A310	A342	DC87		A320	CVLT	CL60	E75L	BE40	BE58
	A345	B762	A3ST	E3CF		A321	DC93	CRJ1	E75S	B350	BE99
	A346	B763	A400	E3TF		B712	DC95	CRJ2	F16	C560	C208
	A359	B764	A50	E6		B721	DH8D	CRJ7	F18H	C56X	C210
	B742	DC10	AN22	E767		B722	E190	CRJ9	F18S	C680	C25A
	B744	K35R	B1	IL62		B732	GL5T	CRJX	F900	C750	C25B
	B748	MD11	B2	IL76		B733	GLEX	DC91	FA7X	CL30	C402
	B772		B52	IL86		B734	GLF5	DH8A	GLF2	E120	C441
	B773		B703	IL96		B735	GLF6	DH8B	GLF3	F2TH	C525
	B77L		B741	K35E		B736	MD82	DH8C	GLF4	FA50	C550
	B77W		B743	KE3		B737	MD83	E135	SB20	GALX	P180
	B788		B74D	L101		B738	MD87	E145	SF34	H25B	PAY2
	B789		B74R	MYA4		B739	MD88			LJ31	PA31
	C5		B74S	R135			MD90			LJ35	PC12
	C5M		B78X	T144						LJ45	SR22
			BLCF	T160						LJ55	SW3
			BSCA	TU95						LJ60	
			C135	VMT						SH36	

Source: JO 7110.126A - Consolidated Wake Turbulence (CWT) Separation Standards. Effective Date: September 28, 2019

Table 7-3, CWT Arrival In-trail Separations

In-trail Separations (nautical miles)		Trailing Aircraft								
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Leading Aircraft	**A**	2.5/3.8[1]	4.8	6.3	6.3	7.3	7.3	7.3	7.3	8.3
	B	2.5/3.8[1]	3.3	4.3	4.3	5.3	5.3	5.3	5.3	6.3
	C	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	3.8	3.8	3.8	5.3	6.3
	D	2.5/3.8[1]	3.3	4.3	4.3	5.3	5.3	5.3	6.3	6.3
	E	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	4.3
	F	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	4.3
	G	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]
	H	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]
	I	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]	2.5/3.8[1]

[1] VMC/IMC in-trail separations

Note: Arrival separations include a 0.3 nautical mile buffer

Source: JO 7110.126A - Consolidated Wake Turbulence (CWT) Separation Standards. Effective Date: September 28, 2019. Landrum & Brown analysis with FAA feedback, 2020

Table 7-4, CWT Departure In-trail Separations

In-trail Separations (seconds)		Trailing Aircraft								
		A	B	C	D	E	F	G	H	I
Leading Aircraft	A	60/72[1]	180	180	180	180	180	180	180	180
	B	60/72[1]	120	120	120	120	120	120	120	120
	C	60/72[1]	60/72[1]	60/72[1]	60/72[1]	120	120	120	120	120
	D	60/72[1]	120	120	120	120	120	120	120	120
	E	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]	120
	F	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]
	G	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]
	H	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]
	I	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]	60/72[1]

[1] VMC/IMC in-trail separations

Source: JO 7110.126A - Consolidated Wake Turbulence (CWT) Separation Standards. Effective Date: September 28, 2019. Landrum & Brown analysis with FAA feedback, 2020

Table 7-5 summarizes the existing and forecasted fleet mix sorted by the new wake classes.

Table 7-5, Fleet Mix by CWT Category

CWT Category	2016		2019		2028		2033	
	Number of Ops	% of Total Ops	Number of Ops	% of Total Ops	Number of Ops	% of Total Ops	Number of Ops	% of Total Ops
A	0	0%	0	0%	0	0%	0	0%
B	19	1%	20	1%	21	1%	23	1%
C	10	1%	12	1%	14	1%	16	1%
D	0	0%	0	0%	0	0%	0	0%
E	2	0%	4	0%	0	0%	0	0%
F	770	49%	683	42%	779	42%	865	44%
G	708	45%	843	52%	991	53%	1017	51%
H	40	3%	55	3%	40	2%	42	2%
I	14	1%	11	1%	15	1%	15	1%
Total	**1563**	**100%**	**1628**	**100%**	**1860**	**100%**	**1978**	**100%**

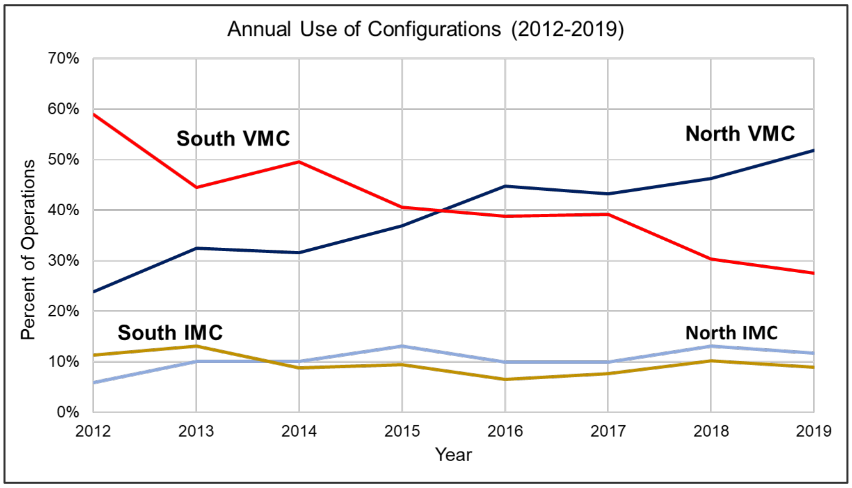
Source: Landrum & Brown analysis, 2020

8 No Action Modeling Results

The results of the No Action simulation models are presented in this chapter. Throughput, taxi times, and delay data are presented for the 2028 (1,860 daily operations) and the 2033 (1,978 daily operations) demand levels. Each of the simulation modeling experiments was run a minimum of ten iterations to incorporate random variation in the modeling in order to produce statistically significant results.

To summarize the results for each demand level, annualized averages were calculated for each of the simulation metrics. The annualized data was calculated by averaging the results of the four flow and weather configurations, weighted by the percent of time each configuration was observed. FAA ASPM runway usage/weather data from 2012 to 2019 were analyzed to determine the frequency of each configuration, as shown in **Exhibit 8-1**. The data show a clear trend in the increase of North Flow operations and decrease of South Flow operations over this time period. Based on conversations with local Air Traffic, North Flow is favored over South Flow due to factors such as North Flow having more departure queue space. An average of 2012 to 2019 configuration shares would likely undercount North Flow percentages at future demand levels, therefore the 2028 and 2033 simulation results were weighted solely on the 2019 shares.

Exhibit 8-1, Annual Use of Airport Configurations



Source: ASPM data, 2012-2019

8.1 Throughput Rates

In order to evaluate the No Action airfield's ability to manage the increase in demand, rolling hour throughput rates were calculated from the simulations. As recommended by the DORA stakeholder group, the 90th percentile throughput is used in this analysis rather than the maximum throughput. The 90th percentile methodology presents an achievable runway throughput rate, while the maximum hourly rate may not be sustainable[7] on a recurring basis.

Exhibit 8-2 shows the 90th percentile hourly throughput rate for arrivals, departures, and overall airport operations. The 2016 calibration throughput rates are included for reference. The 2016 rates are annualized based on the shares of 2016 runway configurations, while the 2028 and 2033 rates are annualized based on the 2019 runway configurations. At the higher No Action demand levels, airfield improvements such as the addition of the North EAT and the compression of arrival separations to 2.5nm allow for the increase in throughput as compared to the 2016 Calibration.

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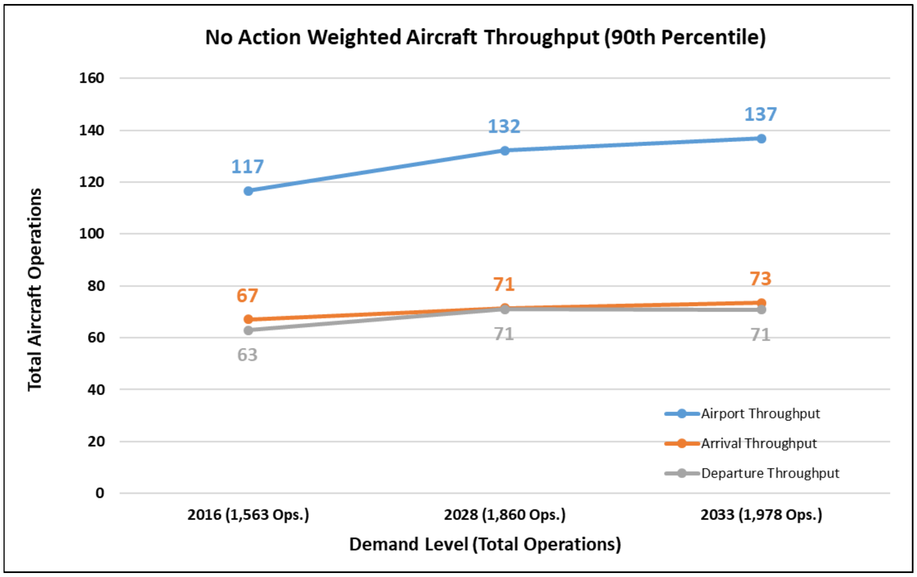
[7] Although the focus of the analysis was on the 90th percentile sustained throughput rate, the maximum 15-minute simulation throughput was verified with and matches the Airport Capacity Profile modeled rates for CLT.

Exhibit 8-2, No Action Weighted Aircraft Throughput



Source: Landrum & Brown analysis, 2020

Table 8-1 presents the 90th percentile hourly throughput rates for each of the four weather and flow configurations. In addition to the overall airport, arrival, and departure rates, the throughput rates for the main operation on each runway is listed. The departure rate on Runway 18L/36R is lower than Runway 18C/36C because Runway 18L/36R is a mixed-use runway.

Table 8-1, No Action Aircraft Throughput by Flow

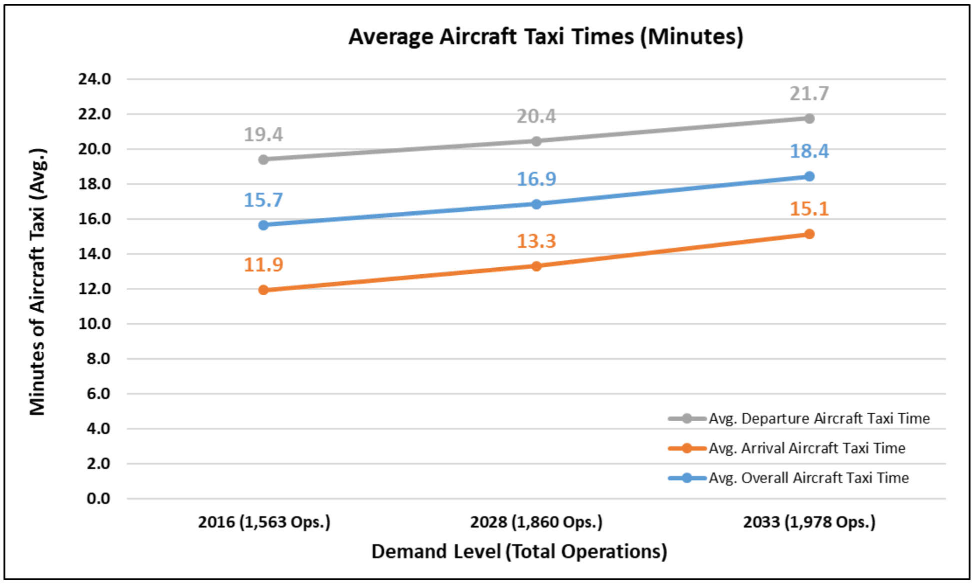
90th Percentile Simulated Throughput	2028 Future No Action				2033 Future No Action			
	North VMC	North IMC	South VMC	South IMC	North VMC	North IMC	South VMC	South IMC
Airport	134	128	132	128	139	131	137	132
Arrival	73	70	70	69	75	72	72	71
Departure	72	65	73	67	71	67	73	68
18R/36L Arrival	41	34	40	35	42	35	41	36
18C/36C Departure	44	42	44	40	45	43	45	42
18L/36R Departure	30	27	31	29	30	27	31	28

Source: Landrum & Brown analysis, 2020

8.2 Aircraft Taxi Times and Delay

To assess the impact of the increased operations on the performance of the No Action airfield, average taxi times and delay were generated from the simulation. **Exhibit 8-3** depicts the average aircraft taxi times including delays for arrivals, departures and overall airport operations. Taxi times increased as compared to the 2016 Calibration due to increased delay and the longer taxi distances when aircraft use the North EAT.

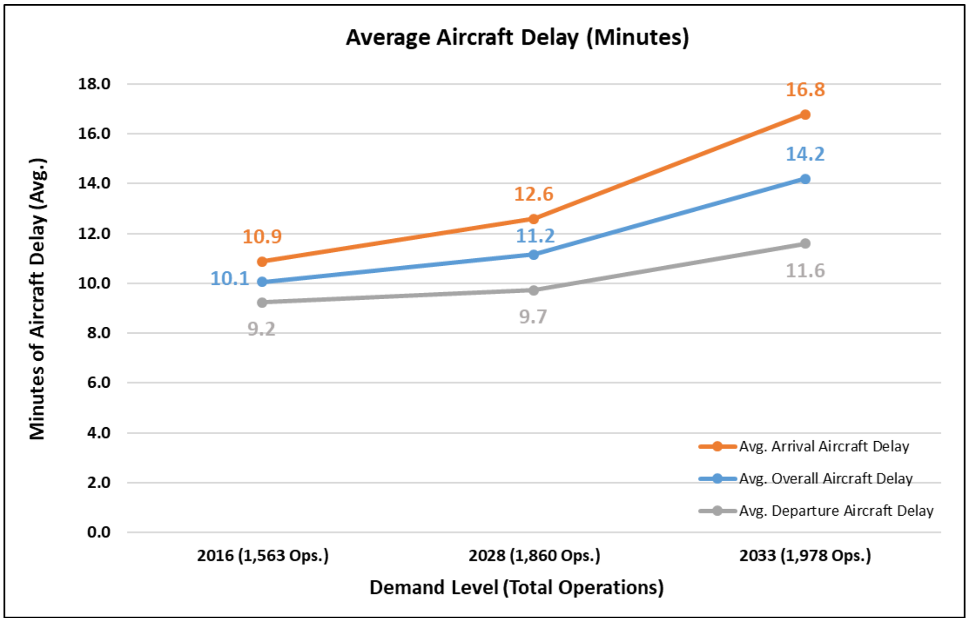
Exhibit 8-3, No Action Weighted Average Taxi Times



Source:	Landrum & Brown analysis, 2020

Exhibit 8-4 shows the average aircraft delays for arrivals, departures and overall airport operations. Arrival delays include air, taxi, and gate wait delays. Departure delays include taxi and gate holding delays. Delays increased when compared to the 2016 Calibration due to constraints in runway capacity, taxiway and ramp congestion, as well as gate shortages. One major bottleneck is located near the tip of Concourse C, where the flow of aircraft traffic on the taxilanes and Taxiway M is severely constricted due to the single taxilane access to Concourse E.

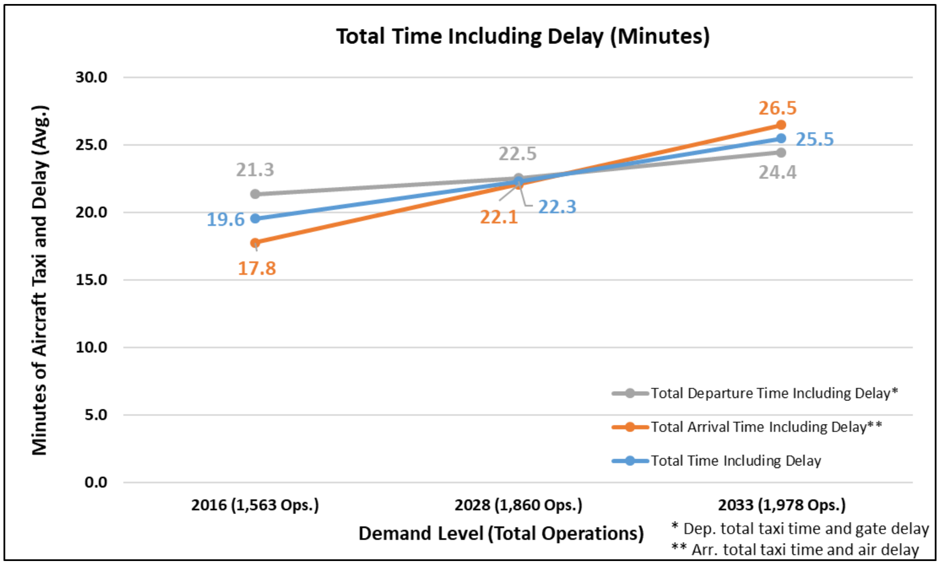
Exhibit 8-4, No Action Weighted Average Delay



Source:	Landrum & Brown analysis, 2020

Exhibit 8-5 shows the total aircraft times including delays for arrivals, departures and overall airport operations. Arrival total times include air delays, taxi times, taxi delays, and gate wait delays. Departure total times include gate holding delays, taxi times, and taxi delays. The total time provides a more well-rounded measure of airport performance than taxi times and delay could separately.

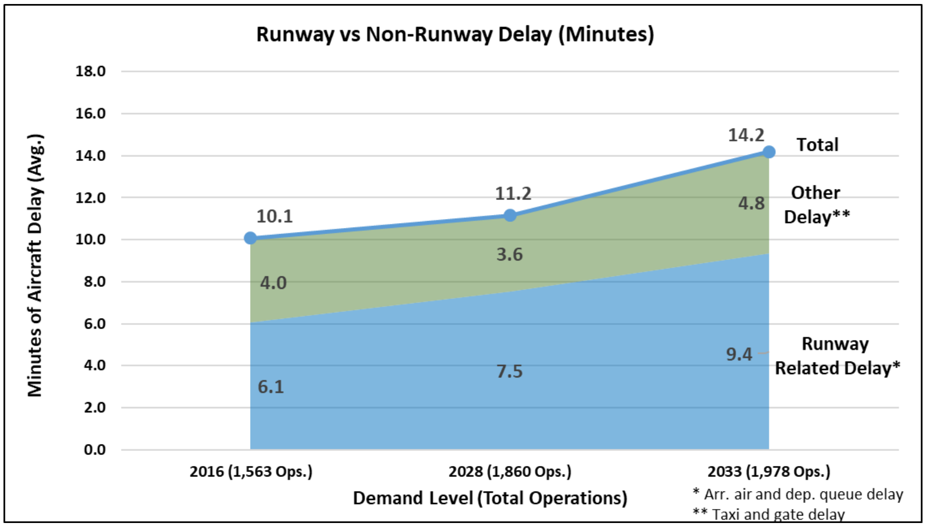
Exhibit 8-5, No Action Total Time Including Delay



Source: Landrum & Brown analysis, 2020

Exhibit 8-6 presents the delay that can be attributed to the runway versus non-runway delays. Runway related delays include arrival air delays and departure queue delays. Non-runway delays include taxi and gate delays. Arrivals and departures both experience high amounts of delay largely due to the constraint of the runway system. Taxiway and ramp congestion as well as gate shortage generate additional delays. The average runway delay of 7.5 at the 2028 demand level and 9.4 minutes at the 2033 demand level exceeds the threshold for the acceptable level of runway delay (seven minutes).

Exhibit 8-6, No Action Runway vs Non-Runway Delay

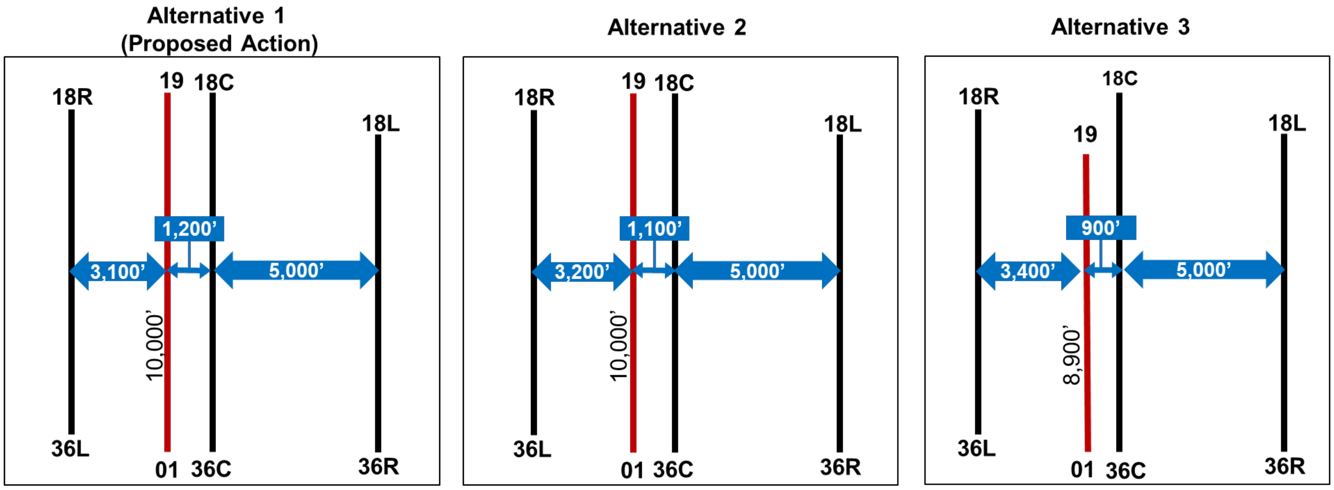


Source: Landrum & Brown analysis, 2020

9 Airfield Alternatives Operating Assumptions

Three alternatives were developed and evaluated to meet the purpose and need identified in the EA process. Alternative 1 assumes the construction of a new 10,000 feet runway (designated as Runway 01/19 for the purposes of the EA) that is located 1,200 feet to the west of existing Runway 18C/36C. Under current FAA regulations, this separation allows for simultaneous triple independent approaches in all weather conditions on Runways 18R/36L, 18C/36C, and 18L/36R. Alternative 2 is identical to Alternative 1, except the new runway is located 100 feet closer to Runway 18C/36C. This creates a 3,200 feet separation between Runways 18R/36L and 01/19. Alternative 2 was not simulated as results were assumed to be very similar to Alternative 1. Alternative 3 includes a new 8,900 feet runway located 900 feet west of Runway 18C/36C and 3,400 feet east of Runway 18R/36L. Based on newly updated FAA Order 7110.65, the 3,400 feet spacing between Runways 01/19 and 18R/36L allows for simultaneous triple independent approaches in all weather conditions on Runways 18R/36L, 01/19, and 18L/36R. **Exhibit 9-1** depicts the main differences between the alternatives.

Exhibit 9-1, Alternatives Overview



3,100' separation to 18R/36L
10,000' departure runway

3,200' separation to 18R/36L
10,000' departure runway

3,400' separation to 18R/36L
8,900' arrival runway

Source: Landrum & Brown, 2020

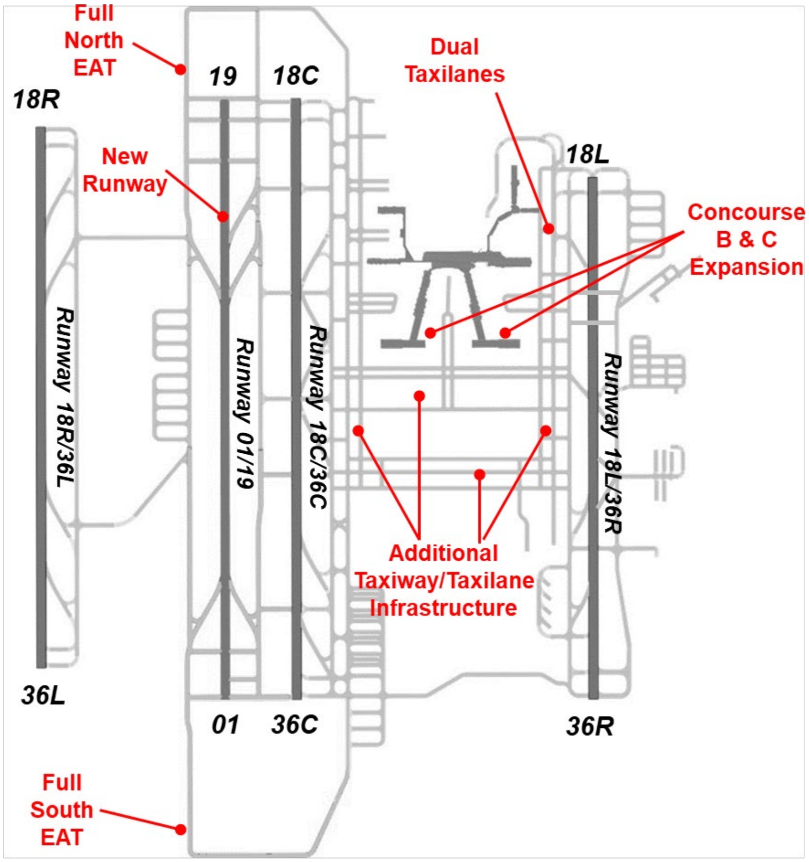
For purposes of the EA, each of the following modeling experiments were run for Alternatives 1 and 3:

- 2028 North Flow VMC
- 2028 North Flow IMC
- 2028 South Flow VMC
- 2028 South Flow IMC
- 2033 North Flow VMC
- 2033 North Flow IMC
- 2033 South Flow VMC
- 2033 South Flow IMC

9.1 Airfield and Aircraft Apron Layouts

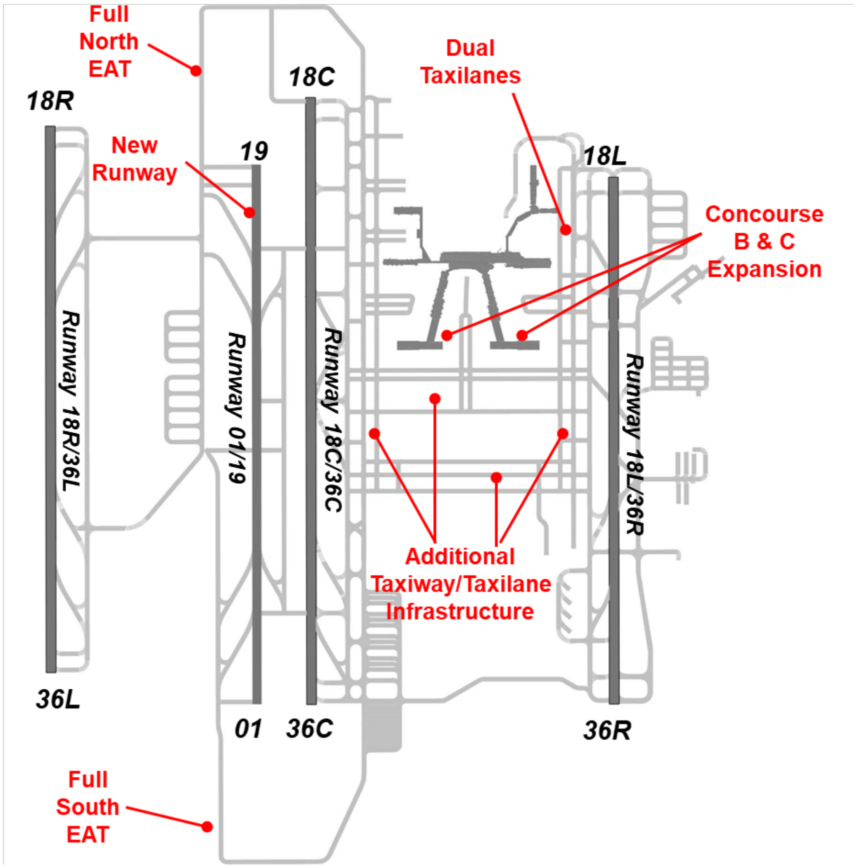
The alternatives' airfields and apron areas contain numerous improvements to support future demand levels. These include full North and South EATs, additional crossfield taxiways, extensions of Concourses B and C, and complete dual taxilanes around the terminals. This infrastructure, highlighted in **Exhibit 9-2** and **Exhibit 9-3** complements the new runway by allowing for efficient taxi flows between gates and runways and removing bottlenecks around the ramp area. Alternative 3 includes the same infrastructure improvements as Alternative 1 but has a shorter runway and does not have a full-length Taxiway V. The runway is shorter in Alternative 3 because it would be used primarily as an arrival runway so does not require the 10,000-foot length. Taxiway V cannot extend the full length of the runway due to the location of the Runway 18C/36C glideslopes.

Exhibit 9-2, Alternative 1 Airfield Layout



Source: CLT airport and Landrum & Brown, 2020

Exhibit 9-3, Alternative 3 Airfield Layout



Source: CLT airport and Landrum & Brown, 2020

Gating assignments assumptions, presented in **Table 9-1,** were updated to accommodate future demand. All OALs (except for Lufthansa) were assumed to operate out of the two new Concourse A piers, while the original Concourse A would exclusively serve American Mainline. Concourses B and C would continue to be used by American Mainline and accommodate some American Regional. Concourse D would remain as the international concourse, housing American and Lufthansa. Concourse E would also retain its current use serving American Regional.

Table 9-1, Alternatives Airline Gating Assignment Assumptions

Concourse	Airline Assignments	Number of Gates
A	American Mainline	9
A Phase I Pier	Other Airlines (OALs)	9
A Phase II Pier	Other Airlines (OALs)	10
B	American Mainline, American Regional	35
C	American Mainline, American Regional	32
D	American Mainline, Lufthansa	6
E	American Regional	37

Source: CLT Terminal Area Plan Forecasts, 2020; Landrum & Brown analysis, 2020

9.2 Runway Operating Configurations

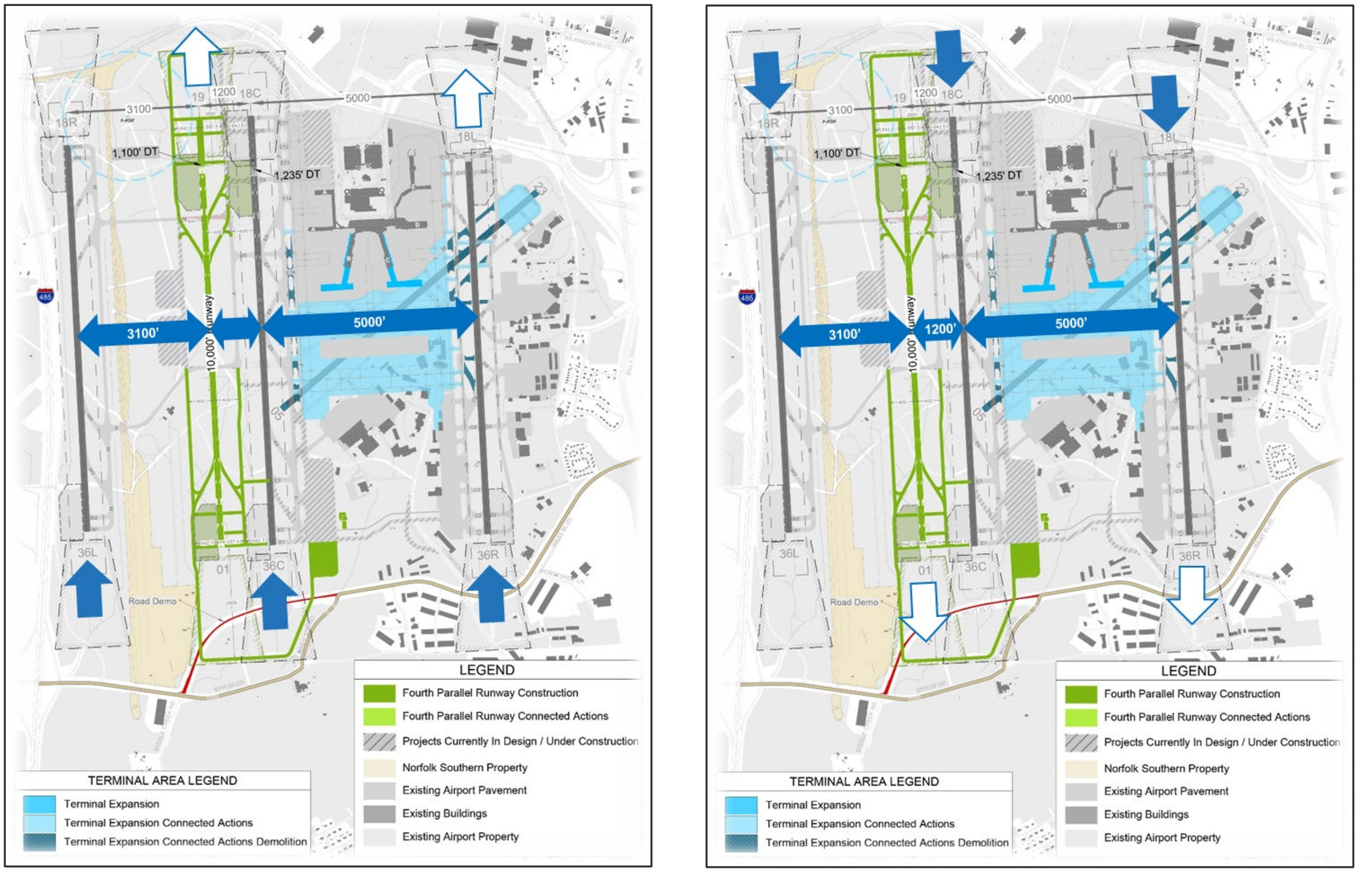
The addition of the fourth runway allows for greater flexibility in runway operating configurations. For the purposes of this study, one main set of runway configuration was assumed and simulated for each alternative. Other runway configurations and procedures can be developed based on the needs of future airport operations.

In Alternative 1, the new runway does not have sufficient spacing between it and either of its two adjacent runways to allow for triple simultaneous independent straight-in approaches, so it is intended to be used primarily by departures. Therefore, Runways 18R/36L, 18C/36C, and 18L/36R would be used for arrivals to provide simultaneous triple independent approaches capability. Runways 01/19 and 18L/36R would be used for departures. During off-peak periods when arrival demand is sparse, Runway 18C/36C could be used for departures.

In Alternative 3, the new runway has sufficient spacing between it and Runways 18R/36L and 18L/36R to allow for triple simultaneous independent straight-in approaches, so it intended to be used primarily by arrivals. Therefore, Runways 18R/36L, 01/19, and 18L/36R would be used for arrivals to provide simultaneous triple independent approaches capability. Runways 18C/36C and 18L/36R would be used for departures.

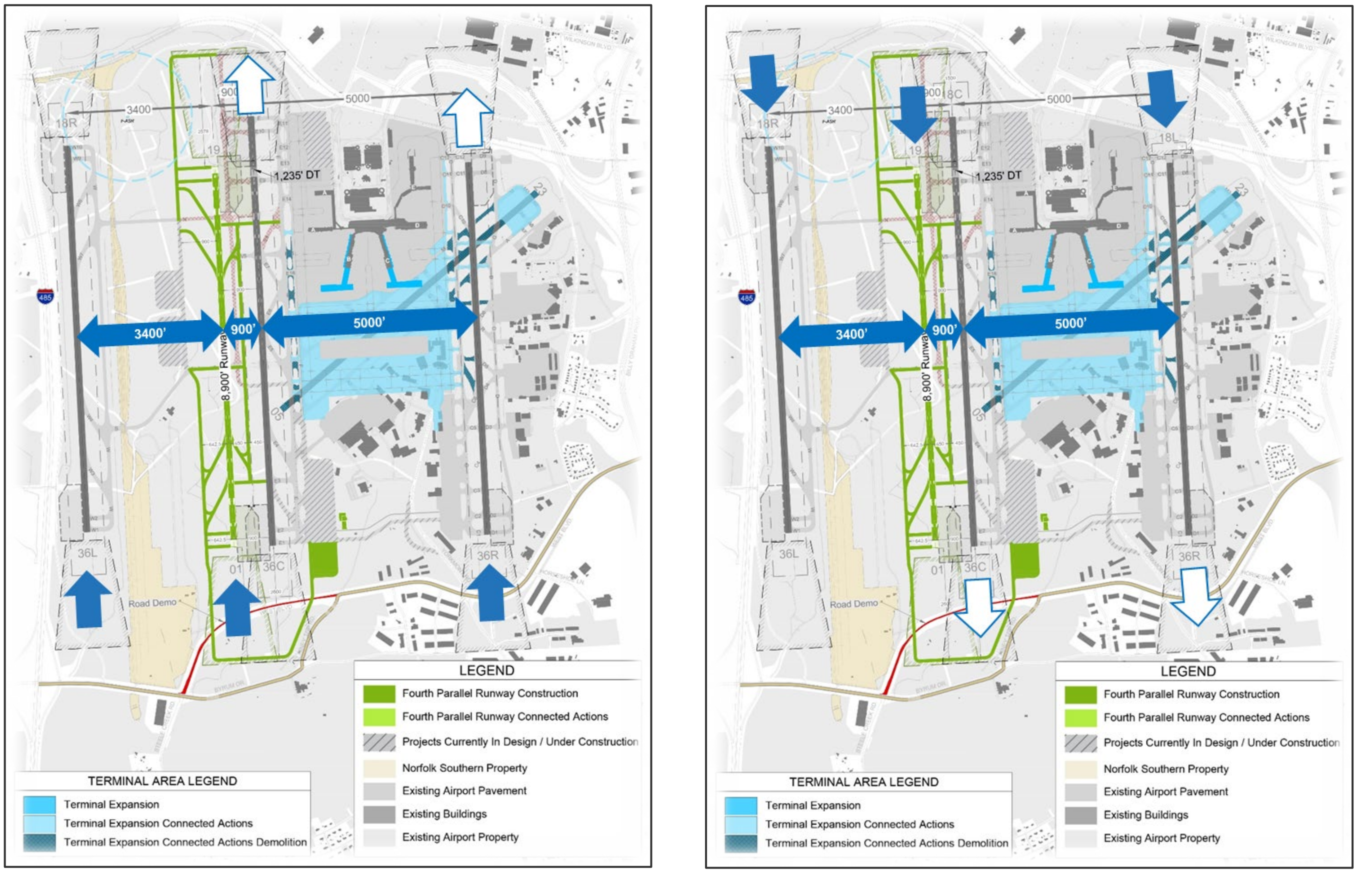
The runway usage for each Alternative is depicted on **Exhibit 9-4** and **Exhibit 9-5.**

Exhibit 9-4, Alternative 1 VMC/IMC Runway Configuration



Source: Landrum & Brown, 2020

Exhibit 9-5, Alternative 3 VMC/IMC Runway Configuration



North Flow

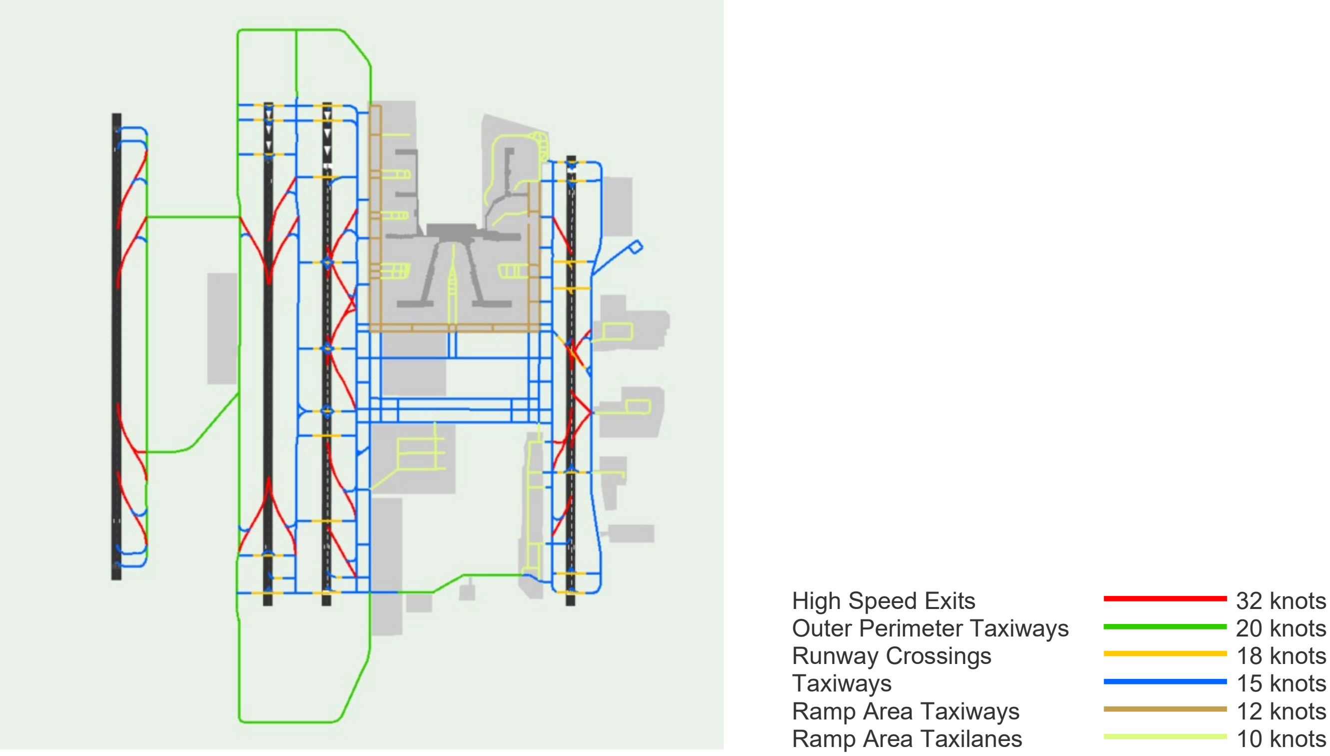
South Flow

Source: Landrum & Brown, 2020

9.3 Airfield Ground Speeds

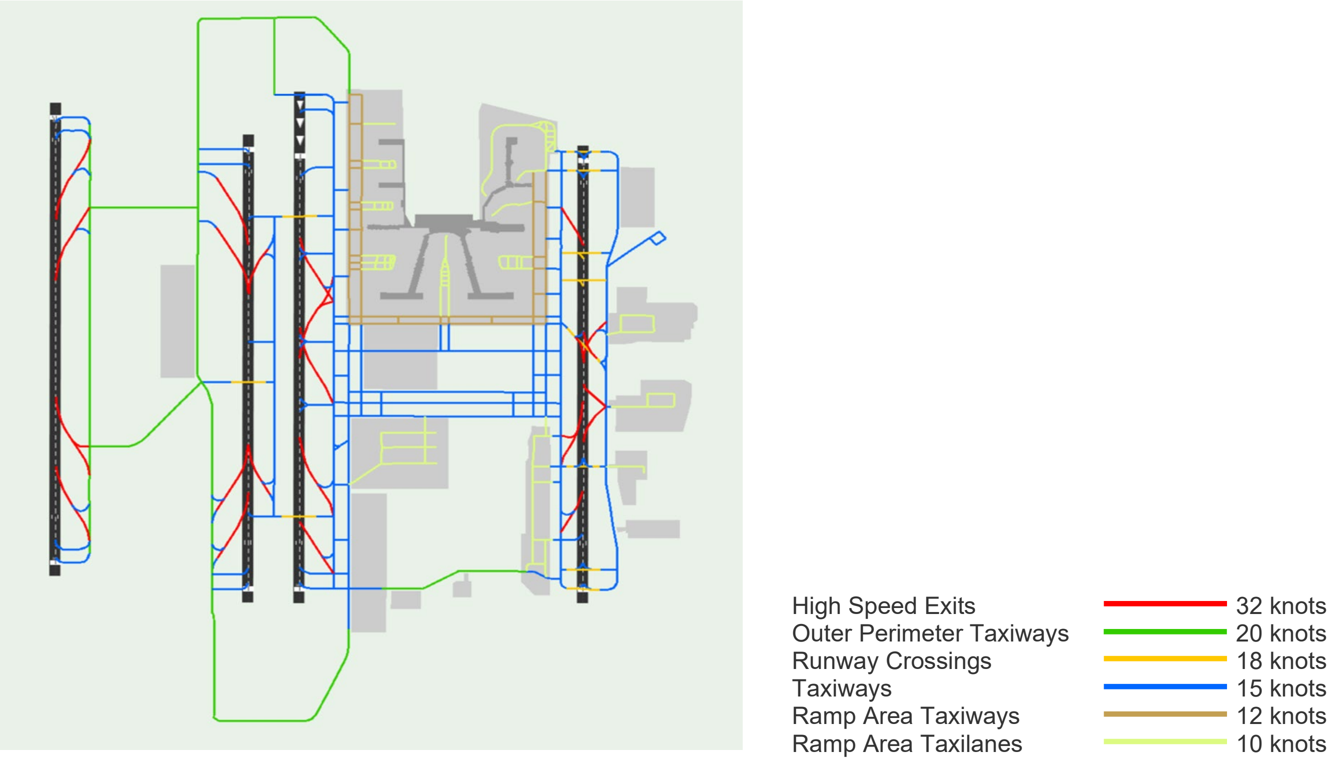
The overall ground speed assumptions are consistent with those in the No Action. New infrastructure, such as the full EATs, is subject to the speed limits listed on **Exhibit 9-6** and **Exhibit 9-7**.

Exhibit 9-6, Alternative 1 Airfield Ground Speed Assumptions



Source: ACEP, EIS, and Landrum & Brown analysis, 2020

Exhibit 9-7, Alternative 3 Airfield Ground Speed Assumptions

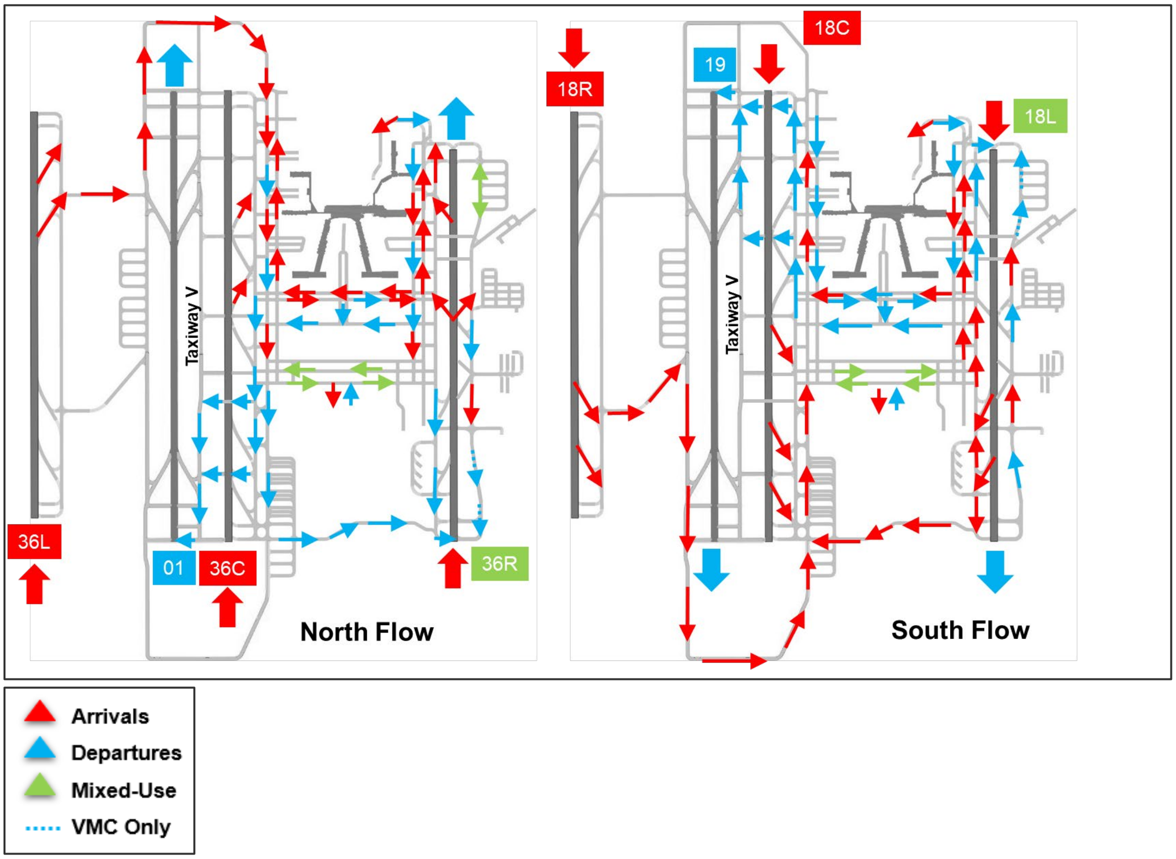


Source: ACEP, EIS, and Landrum & Brown analysis, 2020

9.4 Airfield Taxi Flows

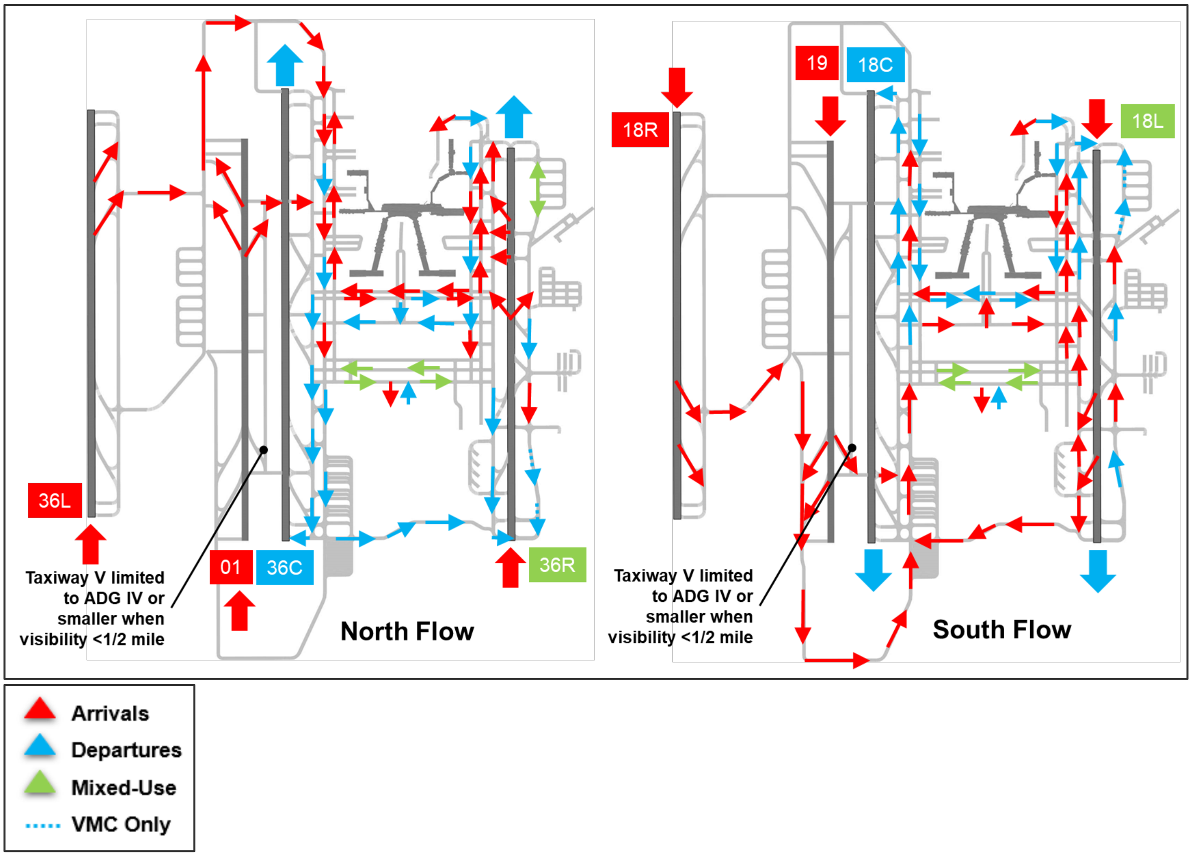
As depicted in **Exhibit 9-8** and **Exhibit 9-9,** both alternatives take advantage of the new crossfield taxiways to move traffic between the east and west sides of the airfield without interfering with ramp area movements. Traffic on the dual taxilanes abutting the ramp area would be unidirectional to avoid head-on conflicts. In Alternative 1, Runway 01/19 departures would cross Runway 18C/36C to access the departure queue on Taxiway V. Two locations are used in both flows to allow for two simultaneous crossings of Runway 18C/36C between each pair of arrivals. The locations were selected to avoid the high energy zone in the middle third of the runway and the glide slope critical areas. The departures would not use the EAT to reach Runway 01/19 to avoid taxiing under approaching aircraft, which is not allowed unrestricted. In Alternative 3, Runway 01/19 arrivals would exit east for a shorter taxi when there are no Runway 18C/36C departures. Otherwise, they exit west and taxi around one of the EATs to avoid interrupting the departure stream.

Exhibit 9-8, Alternative 1 Taxi Routes



Source: Landrum & Brown analysis and ATCT feedback, 2020

Exhibit 9-9, Alternative 3 Taxi Routes

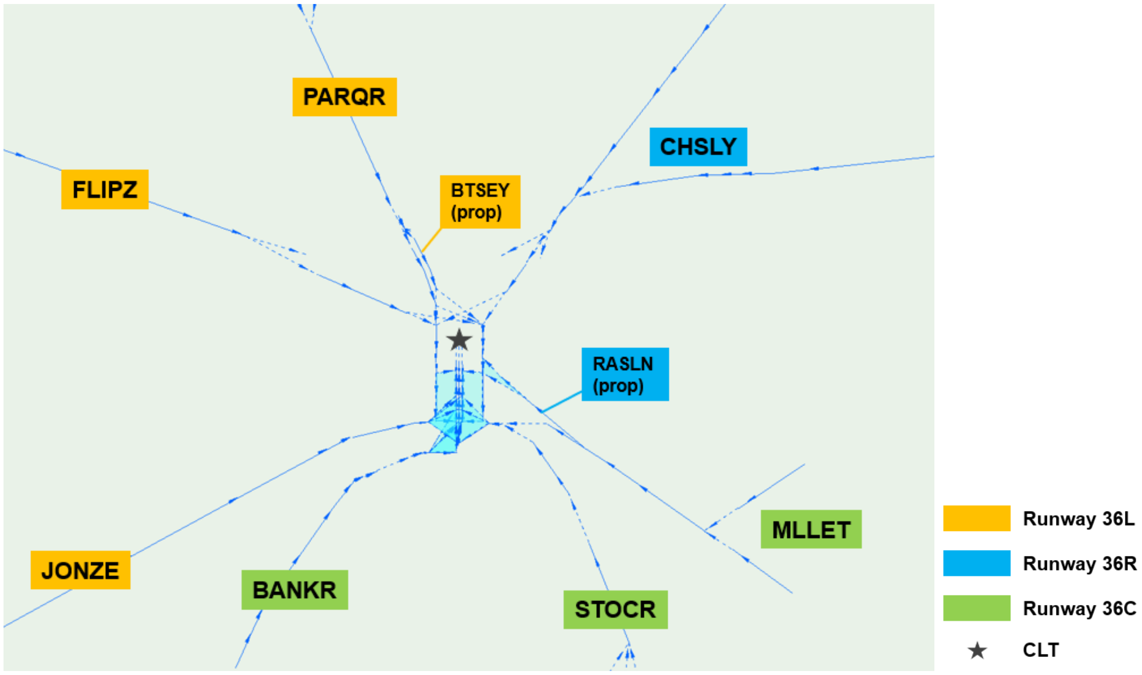


Source: Landrum & Brown analysis and ATCT feedback, 2020

9.5 Airspace Assumptions

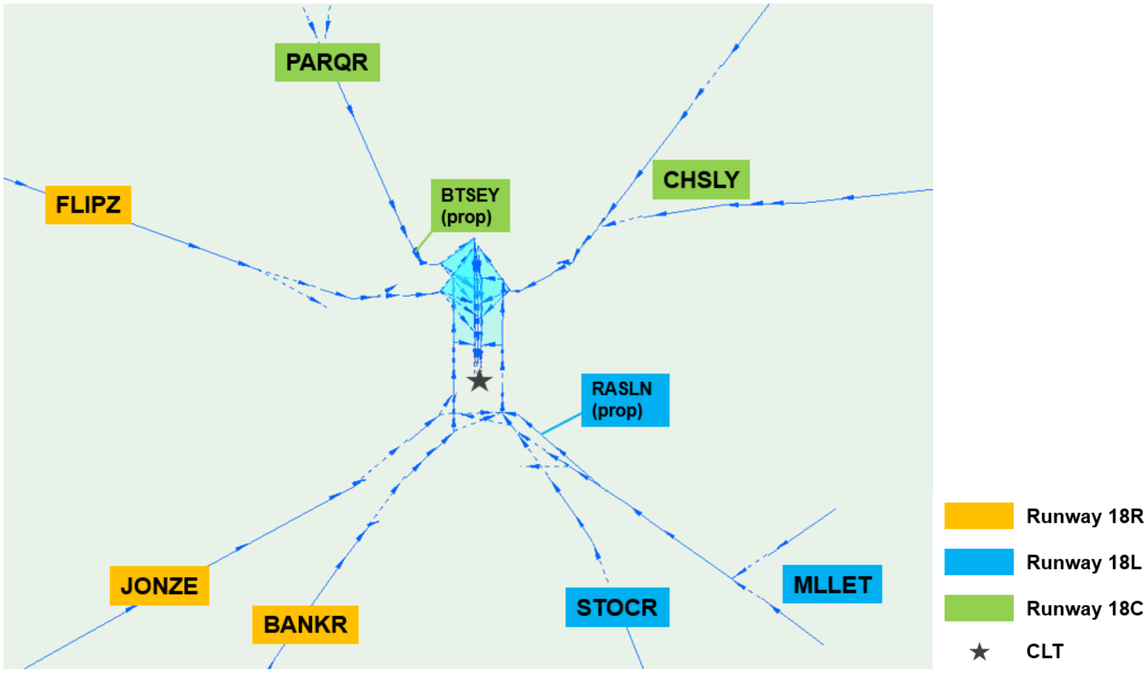
Exhibit 9-10 and **Exhibit 9-11** show the arrival fix assignments for each arrival runway. Arrival traffic can be swapped between runways to balance runway loads. Alternative 3 was assumed to have the same airspace assumptions, with Runway 18C/36C replaced by Runway 01/19.

Exhibit 9-10, Alternative 1 North Flow Arrival Route Structure



Note: Arrivals can be offloaded to other runways during busy periods
Source: FAA terminal procedures; Landrum & Brown analysis

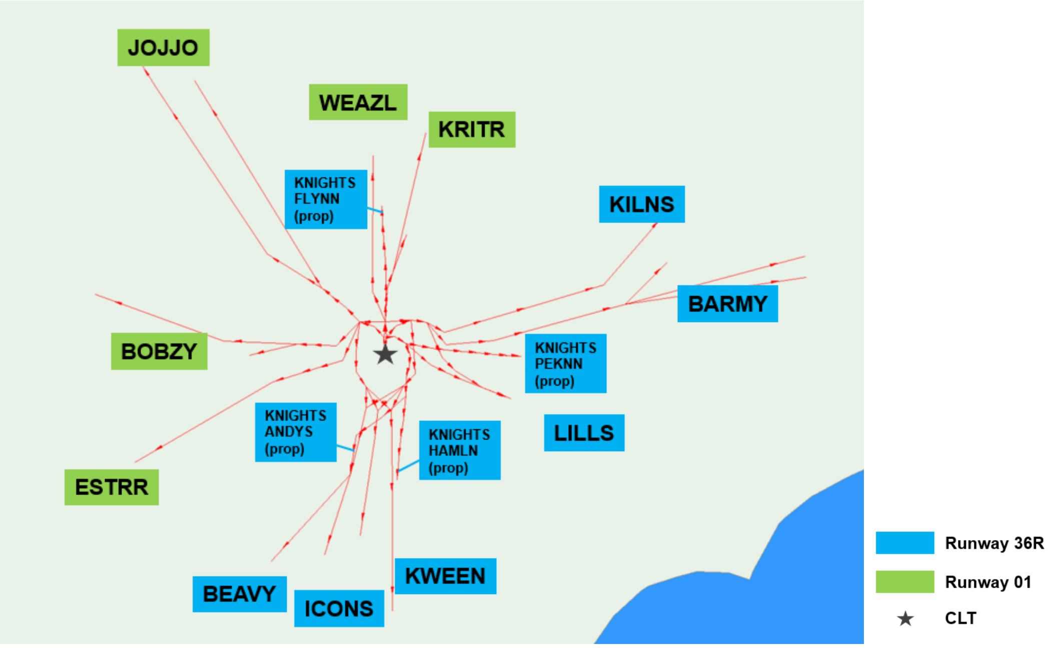
Exhibit 9-11, Alternative 1 South Flow Arrival Route Structure



Note: Arrivals can be offloaded to other runways during busy periods
Source: FAA terminal procedures; Landrum & Brown analysis

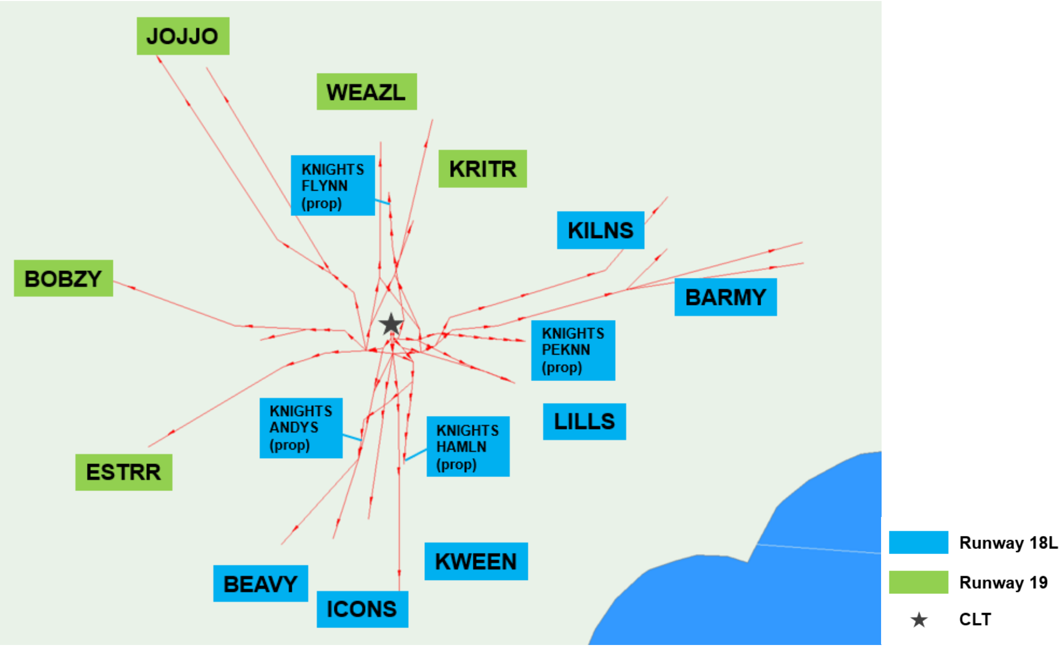
Exhibit 9-12 and **Exhibit 9-13** present the primary fix allocation for each departure runway. Departures to the north (JOJJO, WEAZL, KRITR) and south (BEAVY, ICONS, KWEEN) fixes can be switched between runways to balance the runway queues during departure pushes. Alternative 3 was assumed to have the same fix assignments, with Runway 01/19 replaced by Runway 18C/36C.

Exhibit 9-12, Alternative 1 North Flow Departure Route Structure



Note: Departures to north and south fixes can be swapped between runways to balance the airfield
Source: FAA terminal procedures; Landrum & Brown analysis, 2020

Exhibit 9-13, Alternative 1 South Flow Departure Route Structure



Note: Departures to north and south fixes can be swapped between runways to balance the airfield
Source: FAA terminal procedures; Landrum & Brown analysis, 2020

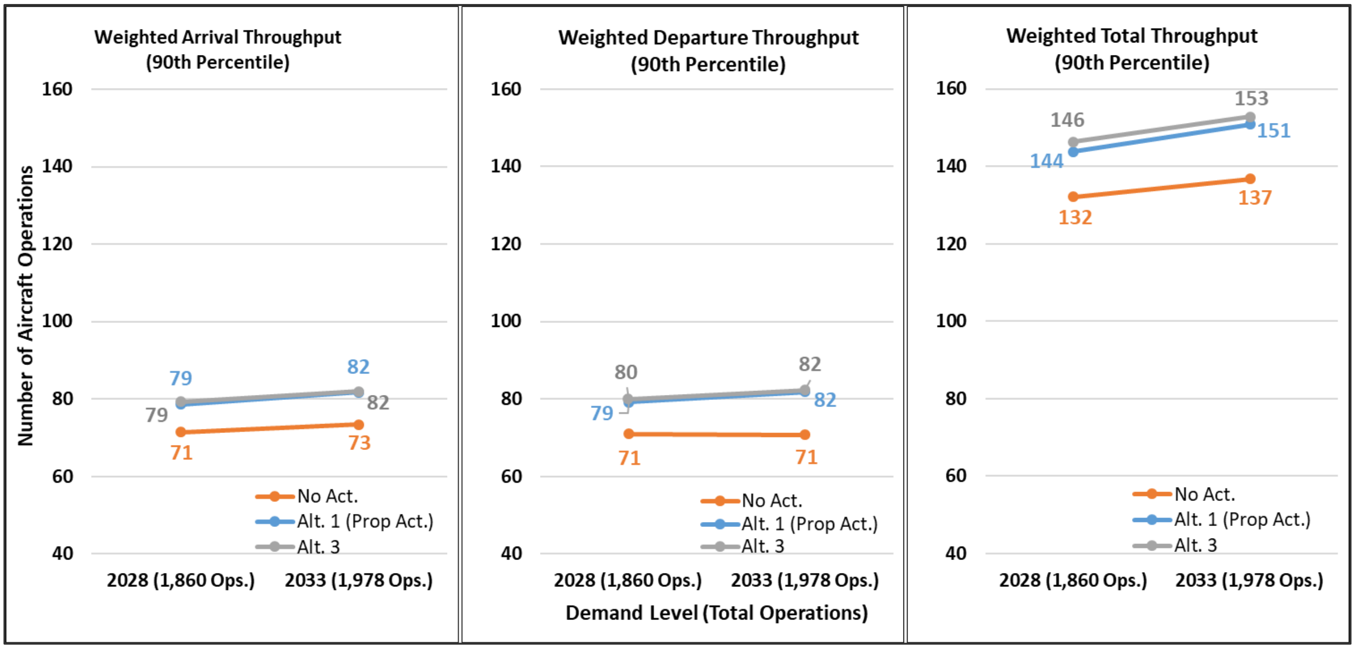
10 Airfield Alternatives Modeling Results

To provide a comparison against the No Action simulation results, the same metrics of throughput, taxi times, and delay were generated for the Alternative 1 and Alternative 3 simulation models. Alternative 2 was not modeled as it was expected to produce very similar results to Alternative 1. The same annualization percentages used to generate the No Action results were used for the alternatives.

10.1 Throughput Rates

The 90th percentile hourly throughput rates are displayed in **Exhibit 10-1**. The left chart presents the arrival rates, the middle chart the departure rates, and the right chart the overall airport rates. Each chart shows the No Action, Alternative 1, and Alternative 3 throughput rates for both the 2028 and 2033 demand levels. Alternatives 1 and 3 produce very similar throughputs and both outperform the No Action. This is the expected result as the alternatives add a runway and therefore allow the two center runways to operate as dedicated arrival/departure runways.

Exhibit 10-1, Throughput Rates from the No Action and Alternatives Simulations



Source: Landrum & Brown analysis, 2021

The 90th percentile throughput numbers presented do not necessarily represent total airport capacity because the modeled throughput rates are also a function of the flight schedule demand. While the additional runway and updated operating procedures allow for higher hourly rates, the schedule profile does not push the airport to capacity for extended periods at a time. Higher throughput may be achievable with a higher demand level or different demand profiles.

Table 10-1 and **Table 10-2** presents the 90th percentile hourly throughput by weather and flow configurations. The overall airport, arrival, and departure rates, and the throughput rates for the main operation on each runway is listed. Alternatives 1 and 3 produce similar throughputs on each runway. It is important to note that Runway 01/19 and 18C/36C swap arrival and departure operations between the alternatives. Alternative 1 Runway 18C/36C has slightly lower arrival throughput than Alternative 3 Runway 01/19 due to departures crossing Runway 18C/36C in Alternative 1.

Table 10-1, Alternative 1 Aircraft Throughput by Flow

90th Percentile Simulated Throughput	2028 Alternative 1				2033 Alternative 1			
	North VMC	North IMC	South VMC	South IMC	North VMC	North IMC	South VMC	South IMC
Airport	145	139	146	137	153	144	153	142
Arrival	79	78	79	76	83	79	82	77
Departure	81	74	80	74	84	75	83	76
18R/36L Arrival	36	33	37	35	38	34	39	35
01/19 Departure	41	37	40	36	42	38	42	38
18C/36C Arrival	31	31	31	28	33	32	33	29
18L/36R Departure	44	40	44	40	44	40	45	41

Source: Landrum & Brown analysis, 2021

Table 10-2, Alternative 3 Aircraft Throughput by Flow

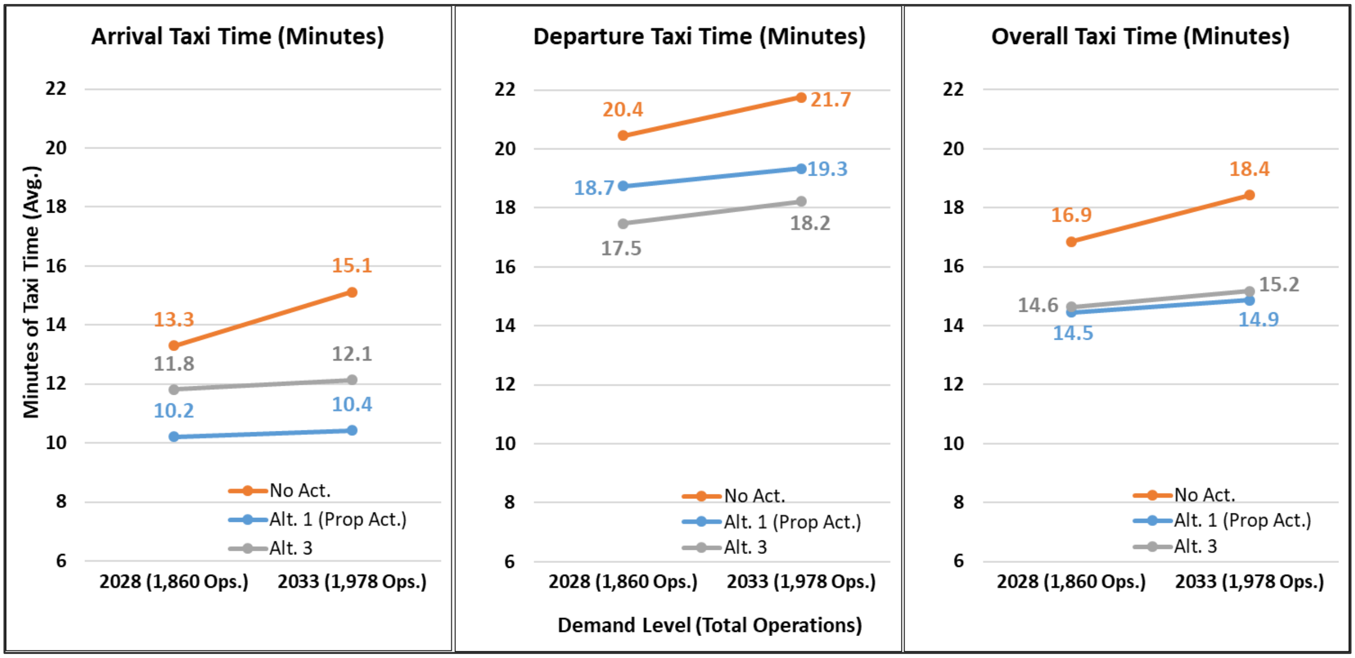
90th Percentile Simulated Throughput	2028 Alternative 3				2033 Alternative 3			
	North VMC	North IMC	South VMC	South IMC	North VMC	North IMC	South VMC	South IMC
Airport	149	140	147	138	156	144	154	143
Arrival	80	77	80	77	83	79	82	80
Departure	82	74	81	72	85	74	84	73
18R/36L Arrival	35	32	38	34	37	33	39	34
01/19 Arrival	35	30	32	30	37	31	34	31
18C/36C Departure	42	37	41	37	44	38	43	37
18L/36R Departure	44	39	44	38	45	39	45	39

Source: Landrum & Brown analysis, 2021

10.2 Aircraft Taxi Times and Delay

The average arrival, departure, and overall taxi times are presented in **Exhibit 10-2**. The No Action, Alternative 1, and Alternative 3 numbers are shown for the 2028 and 2033 demand levels. The taxi times capture delays experienced by aircraft during taxi, including time spent waiting at runway crossings and in the queue for takeoff. The alternatives have substantially lower taxi times than the No Action primarily due to the improved airfield geometry and the resulting reduced congestion around the ramp area. Alternative 1 has lower average arrival taxi times than Alternative 3 because arrivals land on Runway 18C/36C and have a short taxi in to the terminal area. Alternative 3 arrivals use the new runway and must taxi around the EAT. This is reversed for departure taxi times with Alternative 3 departures using Runway 18C/36C and Alternative 1 departures having to cross 18C/36C to depart on the new runway.

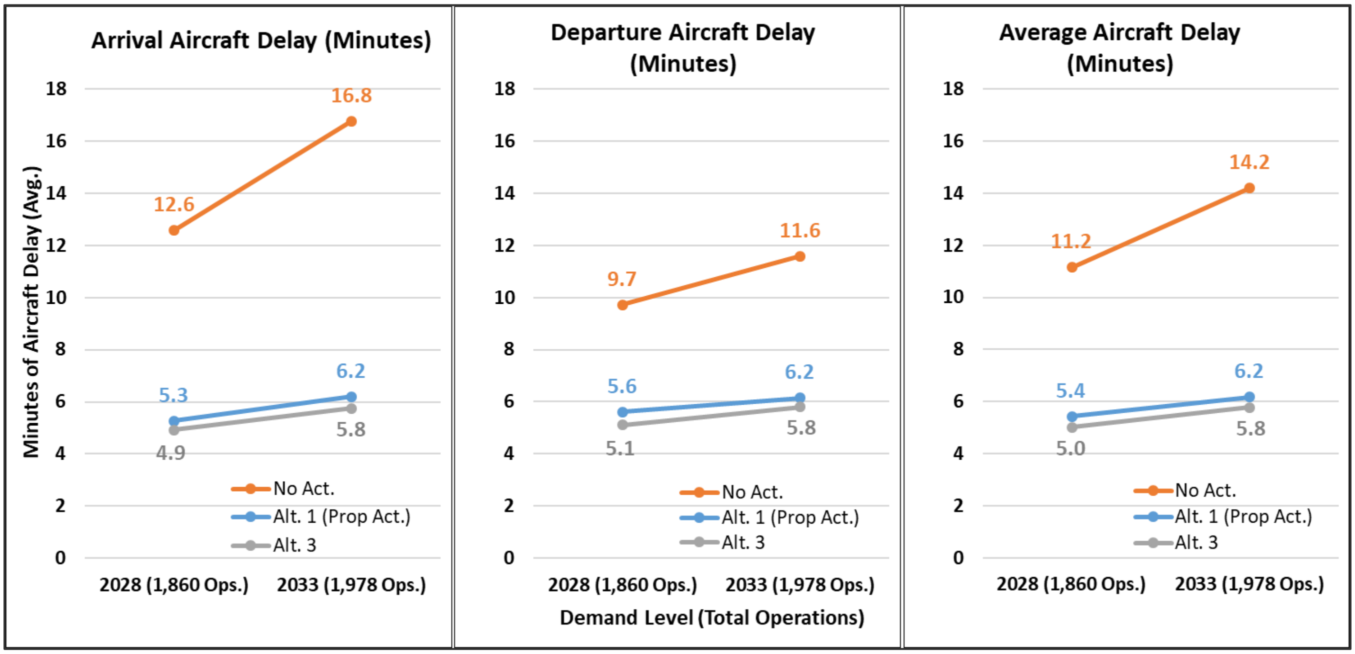
Exhibit 10-2, No Action and Alternatives Weighted Average Taxi Times



Source: Landrum & Brown analysis, 2021

The average arrival, departure, and overall aircraft delays are shown in **Exhibit 10-3**. Both arrival and departure delays are slightly higher in Alternative 1 than Alternative 3 due to Runway 01/19 departures needing to cross Runway 18C/36C to reach the departure queue on Taxiway V. The departures experience delay at the runway crossing, and arrivals experience air delay due to increased arrival separations on Runway 18C/36C.

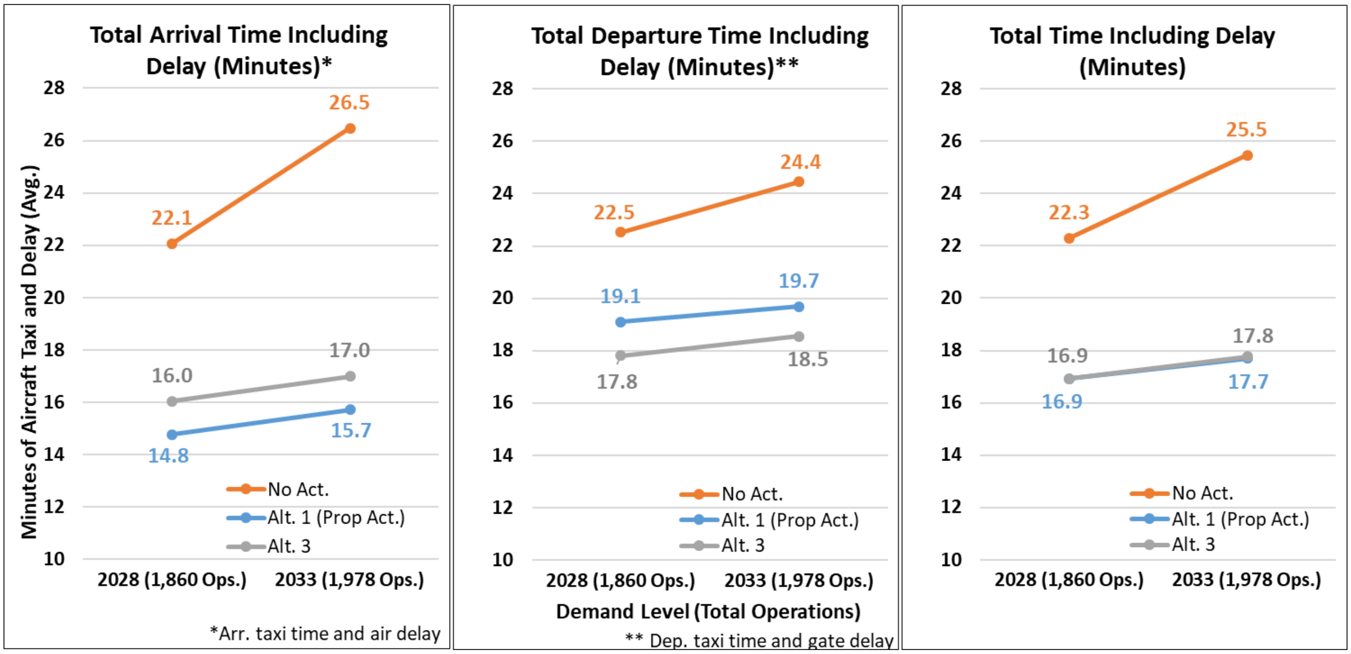
Exhibit 10-3, No Action and Alternatives Weighted Average Delay



Source: Landrum & Brown analysis, 2021

To provide a holistic measure of the alternatives, both taxi time and delay must be considered. **Exhibit 10-4** captures the total delay that aircraft experience by adding arrival air delay and departure gate holding delay to arrival and departure taxi times respectively. Both alternatives benefit from the additional runway, improved taxiway and ramp layout, and concourse extensions. These improvements result in lower air and ground delays than the No Action experiment. This difference is especially noticeable at the 2033 demand level, with the alternatives able to handle the increased traffic demand much more effectively than the No Action (note the steeper slope of the No Action lines compared to the alternatives lines). The overall airport performance for Alternatives 1 and 3 is very similar. The difference in arrivals and departures between Alternative 1 and Alternative 3 is due to the usage of Runway 18C/36C and 01/19. In Alternative 1, arrivals benefit from a short taxi in from Runway 18C/36C and departures must cross Runway 18C/36C to reach the new runway. In Alternative 3, departures use Runway 18C/36C, while arrivals use the new runway and must taxi around one of the EATs to reach the ramp area in periods of high demand.

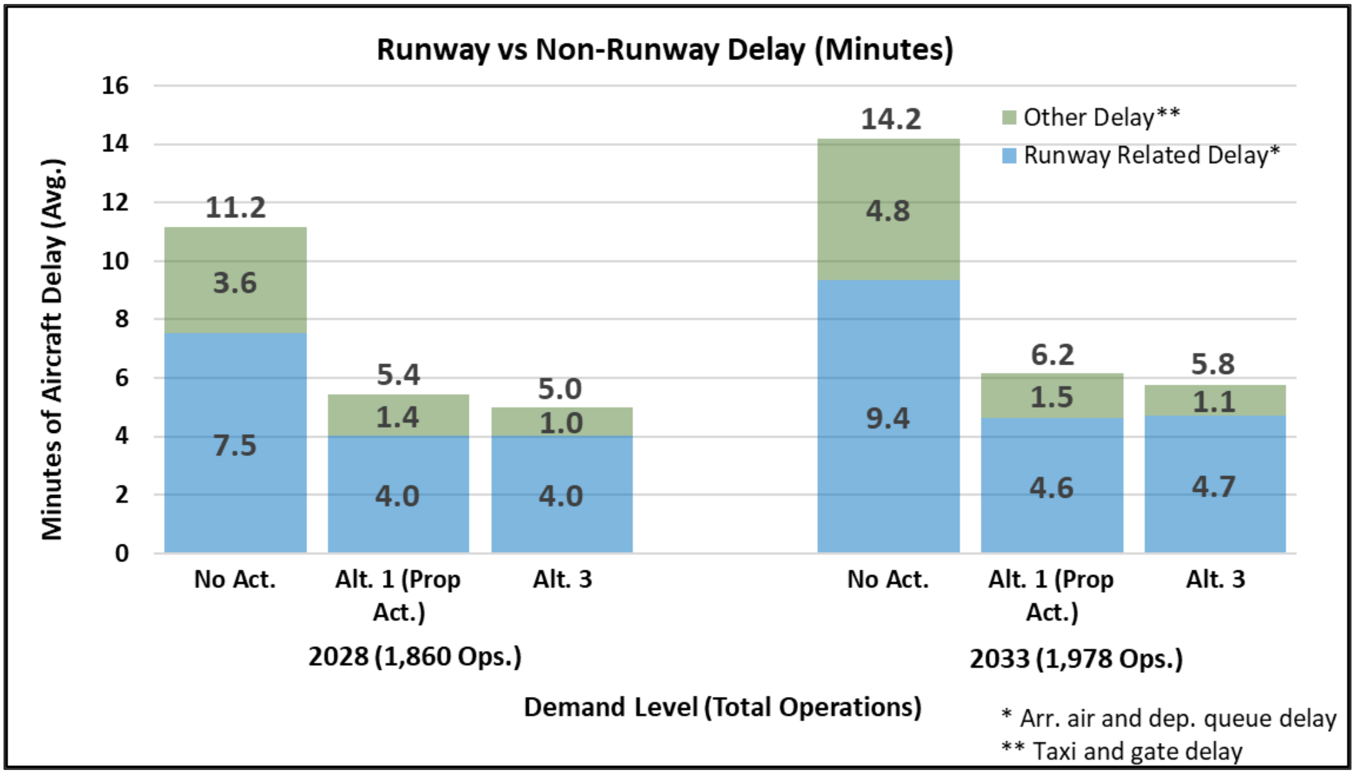
Exhibit 10-4, No Action and Alternatives Total Time Including Delay



Source: Landrum & Brown analysis, 2021

Exhibit 10-5 presents the delay associated with the runway compared to non-runway delay. Runway-related delays include arrival air delays and departure queue delays. Other delays include taxi and gate delays. Alternatives 1 and 3 achieve lower delay in both categories compared to No Action, while performing very similarly to each other. The alternatives runway delays remain below the seven-minute threshold for acceptable delays.

Exhibit 10-5, No Action and Alternatives Runway vs Non-Runway Delay



Source: Landrum & Brown analysis, 2021

11 Conclusions

The EA simulation modeling analysis simulated two proposed airfield alternatives which provide the additional runway, taxiway, ramp and gate infrastructure necessary to accommodate the forecasted increase in aviation traffic at reasonable delay levels. The simulation modeling analysis was vetted through the official FAA DORA process which includes participation from FAA Office of Airports, Air Traffic Control staff from the Tower, TRACON and Traffic Management Units. In addition, representatives from American Airlines and other airlines, City of Charlotte Aviation Department, and Landrum & Brown participated in four working group meetings to discuss the simulation analysis methodology, approach, results and refinements. Based on the simulation modeling analysis conducted by L&B, all three alternatives would provide the required capacity and infrastructure to be able to accommodate the 2033 demand level of 1,978 daily operations while maintaining average runway delays of less than seven minutes per aircraft operation.

DORA (Direction, Oversight, Review & Agree) Coordination

Meeting #1 Materials
Meeting #2 Materials
Meeting #3 Materials
Meeting #4 Materials

CLT DORA (Direction, Oversight, Review & Agree) Meeting #1

March 25, 2020

Agenda

- Introductions
- Meeting Objectives
- DORA Process
- EA Process Overview
- Review of Calibration
- 2019 Baseline & Future No Action Airfield Modeling Assumptions
- Next Steps

Meeting Objectives

Meeting Objectives

- To present an overview of the DORA process
- To present an overview of the Environmental Assessment (EA) process
- To present the 2019 Baseline and Future No Action modeling assumptions
- To present the next steps in the overall project

DORA Process

Charlotte Douglas International Airport EA

DORA Process Overview

Prepared for: CLT EA DORA Meeting #1

By: Kent Duffy

Date: March 2020

Federal Aviation
Administration

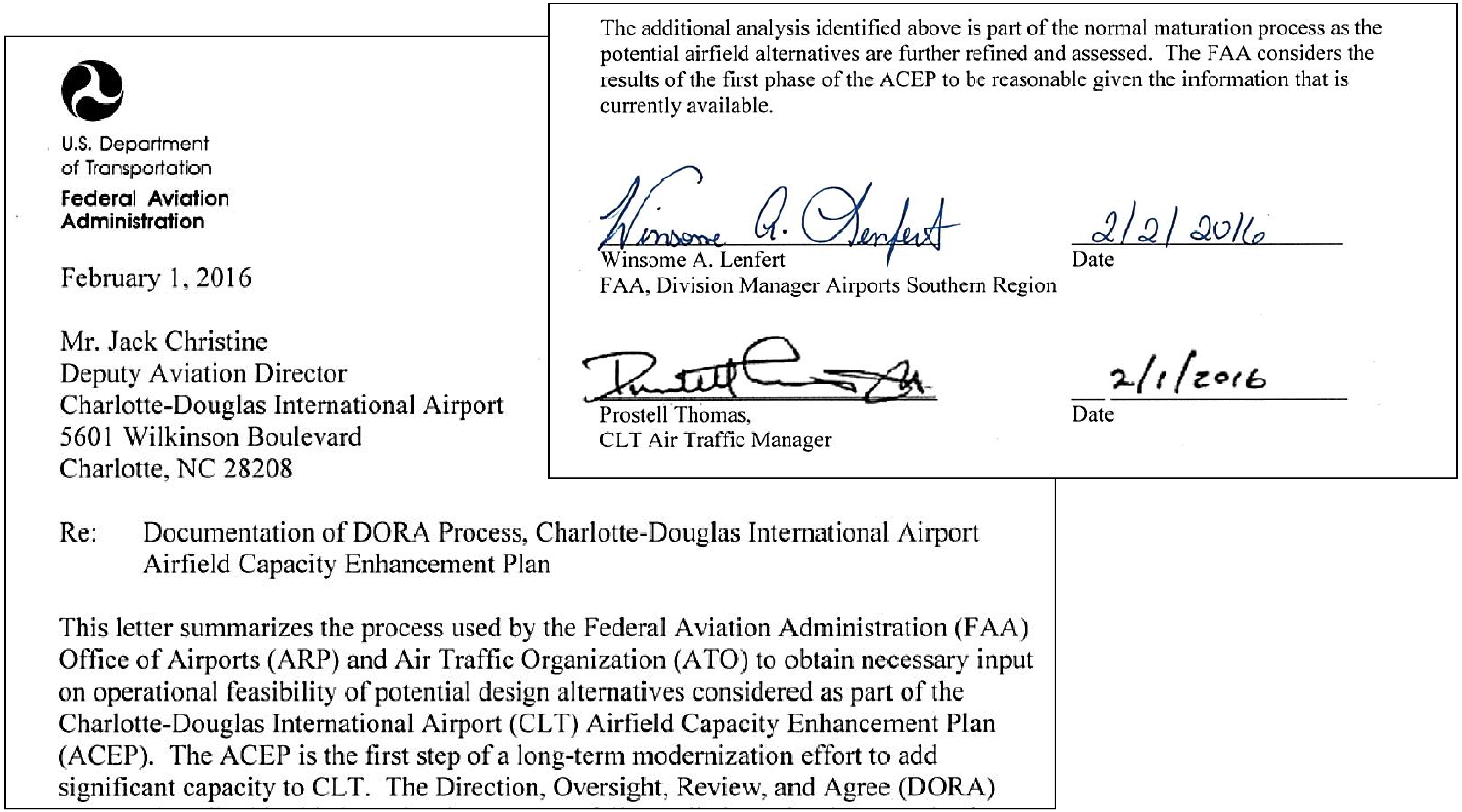
What is DORA?

- **DORA** =
  Direction, **O**versight, **R**eview and **A**gree
- Obtaining and understanding controller input on operational issues and viability of proposed alternatives is a key to airport capacity development
- DORA has been applied successfully to other large-scale airport and airspace modernization efforts (e.g., O’Hare Modernization Program)

Objectives: Why are we here?

- **Ensure collaboration w/ATO on simulation activities as needed to complete EA**
  - Obtain input development of the simulation model
  - Revise and refine simulation model, rather than develop new alternatives
- **Build from successful process used during planning phase**
  - Update with recent changes: forecast trends, CRO, metroplex, heading usage, Atlantic coast routes, etc.
  - Validate operating assumptions used in the simulation model
    - Airspace flows and procedures, Runway usage and balancing, Aircraft separation and buffers, Taxi-flows and ground movement, etc.
  - Review and validate airspace's ability to accommodate new runway throughput
- **Collaboration ensures the simulation results can be used in the EA analyses with confidence**

Planning Phase DORA Letter



U.S. Department
of Transportation
**Federal Aviation
Administration**

February 1, 2016

Mr. Jack Christine
Deputy Aviation Director
Charlotte-Douglas International Airport
5601 Wilkinson Boulevard
Charlotte, NC 28208

Re: Documentation of DORA Process, Charlotte-Douglas International Airport Airfield Capacity Enhancement Plan

This letter summarizes the process used by the Federal Aviation Administration (FAA) Office of Airports (ARP) and Air Traffic Organization (ATO) to obtain necessary input on operational feasibility of potential design alternatives considered as part of the Charlotte-Douglas International Airport (CLT) Airfield Capacity Enhancement Plan (ACEP). The ACEP is the first step of a long-term modernization effort to add significant capacity to CLT. The Direction, Oversight, Review, and Agree (DORA)

The additional analysis identified above is part of the normal maturation process as the potential airfield alternatives are further refined and assessed. The FAA considers the results of the first phase of the ACEP to be reasonable given the information that is currently available.

Winsome A. Lenfert 2/2/2016
Winsome A. Lenfert Date
FAA, Division Manager Airports Southern Region

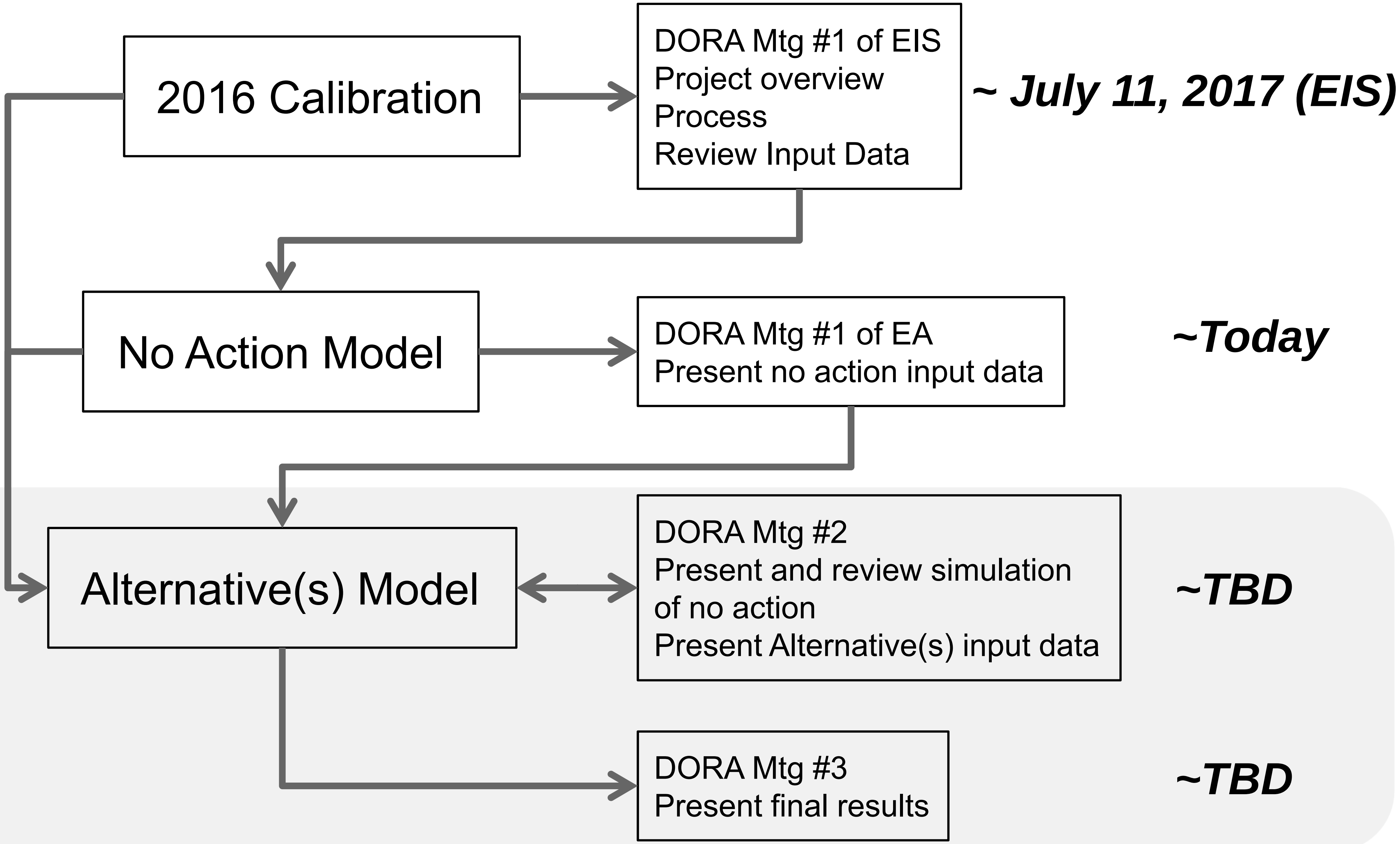
2/1/2016
Prostell Thomas, Date
CLT Air Traffic Manager

Desired Result: 2nd DORA Letter

Active ATC participation

- **FAA Letter signed by ATO and ARP**
- **Explains process and summarizes meetings**
- **Identifies further analyses required in subsequent phases (e.g., design/ implementation), as needed**
- **Desired findings:**
  - Modeling approach is reasonable
  - Modeling assumptions accurately reflects operational perspectives
  - Subsequent capacity, throughput and delay results are reasonable representations of the proposed airfield and airspace designs

DORA Process Relationship to Modeling



2016 Calibration

DORA Mtg #1 of EIS
Project overview
Process
Review Input Data

~ July 11, 2017 (EIS)

No Action Model

DORA Mtg #1 of EA
Present no action input data

~Today

Alternative(s) Model

DORA Mtg #2
Present and review simulation of no action
Present Alternative(s) input data

~TBD

DORA Mtg #3
Present final results

~TBD

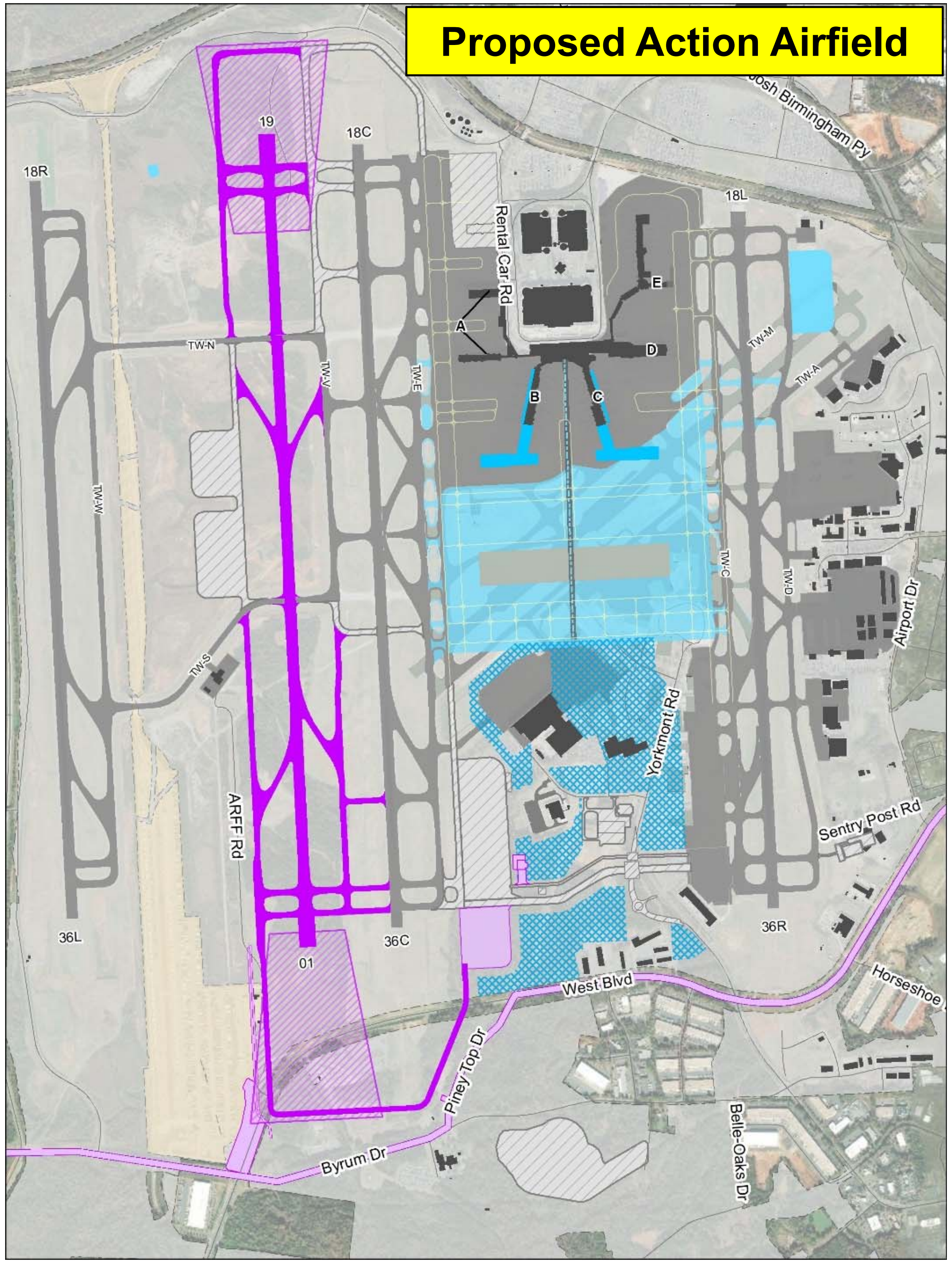
EA Process Overview

EA Process Overview - Background

- The CLT Environmental Impact Statement (EIS) that the Federal Aviation Administration (FAA) began was cancelled on February 27, 2019.
- The FAA cancelled the EIS because a runway length analysis determined only a 10,000 foot runway is required to meet the purpose and need.
- The FAA determined that this was a sufficient change to warrant cancellation of the EIS and conversion to an Environmental Assessment (EA).
- The City of Charlotte (Airport Sponsor) is responsible for preparing the EA.
- FAA is still the lead agency.
- Similar to the EIS, the EA will evaluate the potential direct, indirect, and cumulative environmental impacts that may result from the Proposed Action.

EA Process Overview – Proposed Action

- 4th Parallel Runway (10,000 feet long)
  - North and South End Around Taxiways
- Extensions of Concourse B and C
  - Decommissioning Runway 5/23
  - Crossfield Corridor
  - Dual Taxilanes Around Ramp
    - Requires the removal of gates off the end of Concourse D and E



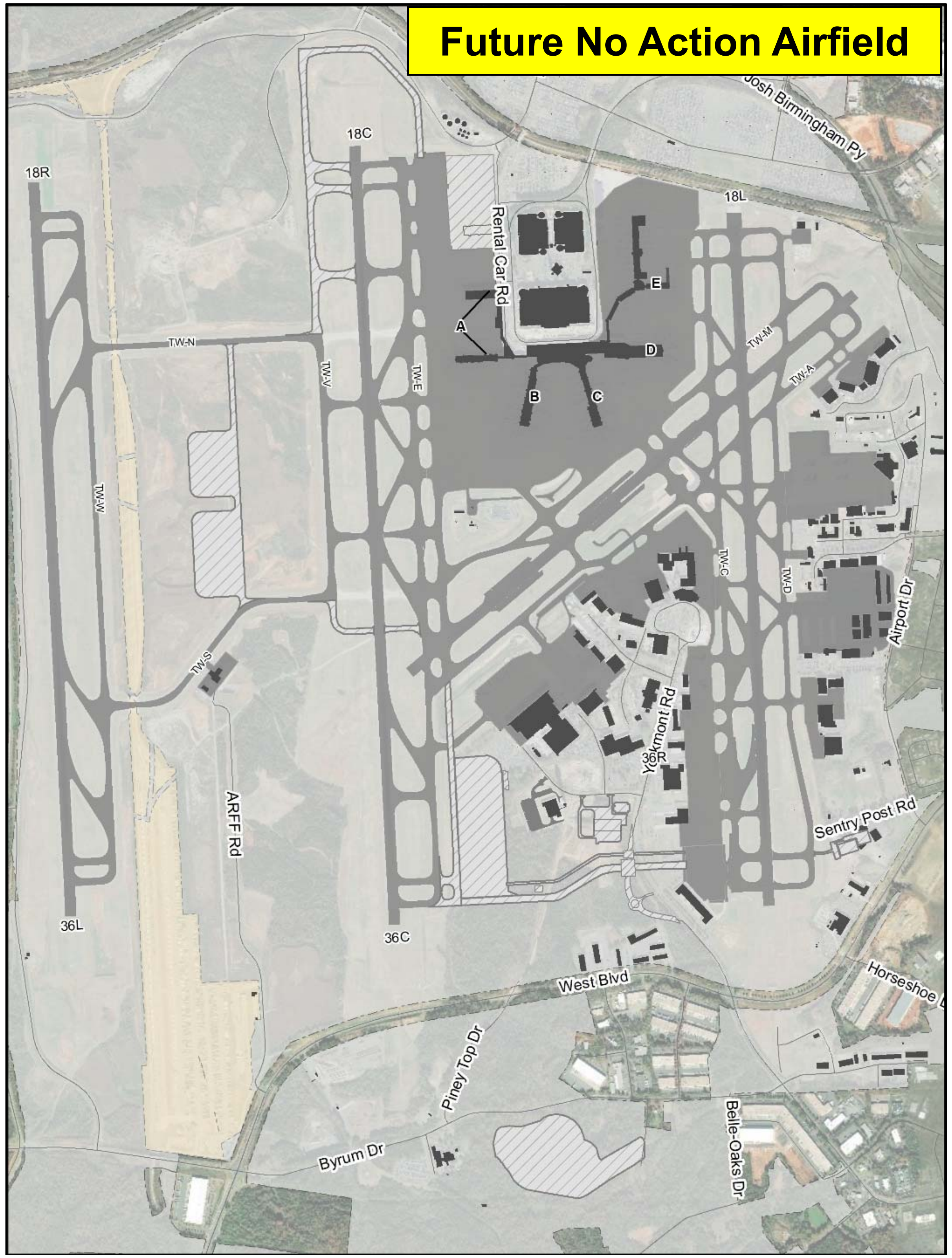
Proposed Action Airfield

EA Process Overview

1. Conversion of EIS to EA
2. Confirm Purpose and Need
3. Develop Alternatives
4. Study Affected Environment
5. Analyze Environmental Impact
6. Identify Mitigation
7. Publish Draft EA
8. Public Review Period
9. Hold Public Hearings
10. Publish Final EA
11. FAA Issues the Federal Decision

EA Process Overview - Simulations

- Simulations will:
  - Be used in developing the Purpose and Need, noise modeling, and air quality modeling.
  - conducted for the following scenarios:
    - 2016 Calibration
    - 2019 Baseline
    - 2028 Future No Action
    - 2033 Future No Action
    - 2028 Alternative(s)
    - 2033 Alternative(s)
  - use forecast of operations approved by the FAA.
  - include 3 independent projects as part of the Future No Action.
    - Deice Pad and crossfield taxiway
    - North End Around Taxiway around Runway 18C/36C and hold pads
    - Concourse A Phase II


Future No Action Airfield

Review of Calibration

Review of Calibration Findings

- As part of the EIS, the SIMMOD simulation model was calibrated for the 2016 existing conditions
- The calibrated model was approved by the FAA and shared in the EIS DORA meetings
- For purposes of the EA, the simulation model has been changed to the AirTOp simulation model and the previously approved 2016 calibration has been validated with AirTOp
- The AirTOp models produces results which are consistent with the previous calibration assessment
- The following slides summarize the results of the AirTOp calibration

Rolling Hour Operation Throughput

- Throughput rates are calibrated to 2016-2017 FAA ASPM or Aerobahn data and compared to the previous EIS calibration effort
- While the maximum throughput is achievable under certain circumstances, it is not a good indication of capacity. Therefore, the 90th percentile hourly rates is used as a measure of capacity per previous DORA stakeholder group recommendations

Total Operations Throughput

- Simulated hourly throughput are within 10 percent of ASPM and EIS simulation effort

Airport Throughput			
	ASPM – 90th*	**EIS – 90th***	**AirTOp – 90th**
North VMC	121	118	117
North IMC	114	116	114
South VMC	121	121	117
South IMC	112	116	115

* Source: Capacity/Delay Analysis and Airfield Modeling Technical Memorandum, CLT EIS
ASPM data, 2016-2017

Arrival and Departure Throughput

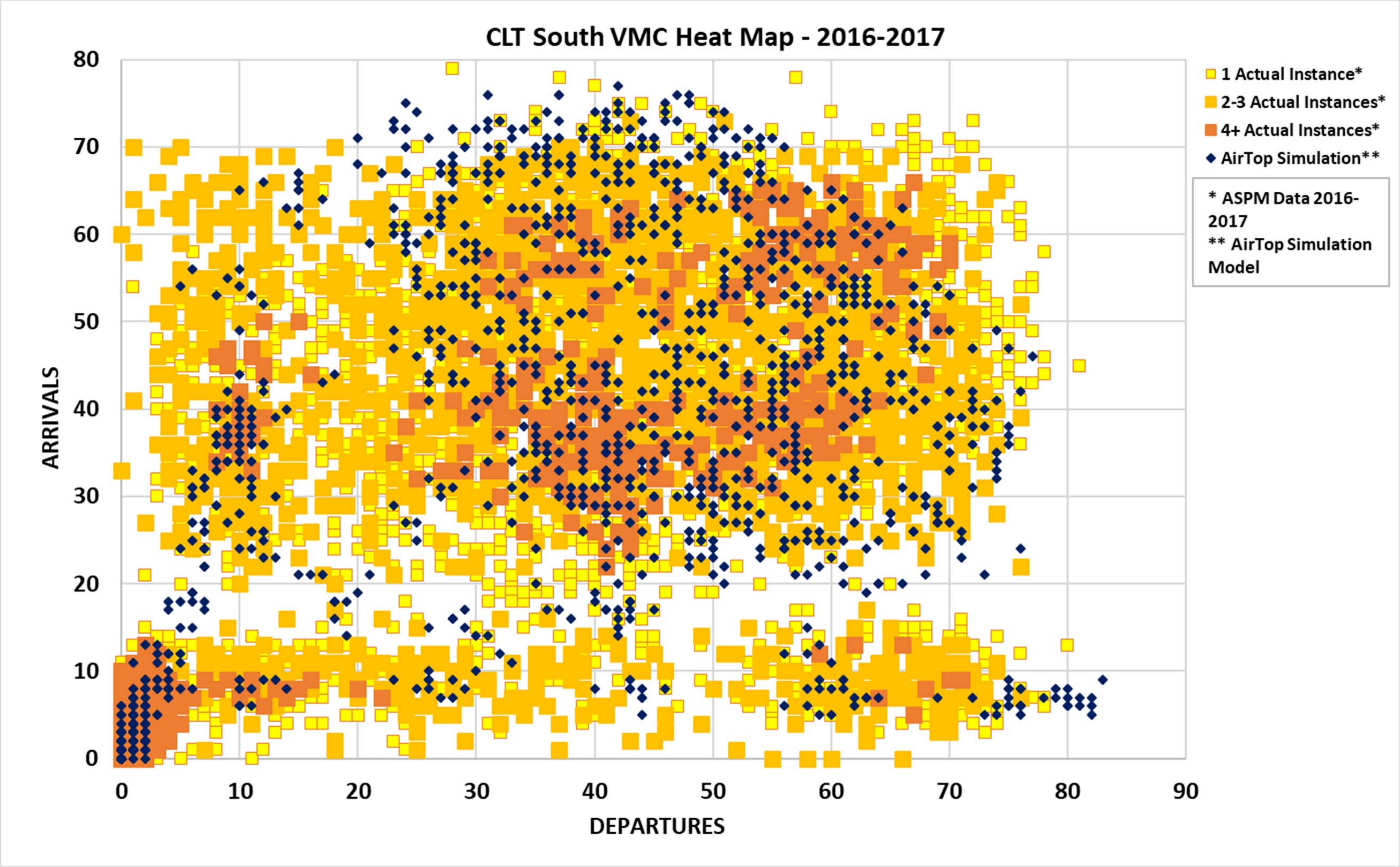
- Simulated hourly arrival and departure throughput match closely with ASPM and results of EIS simulation effort
- The FAA's Capacity Airport Arrival Rates or called arrival rates in VMC are much higher than actual hourly counts

Arrival and Departure Throughput

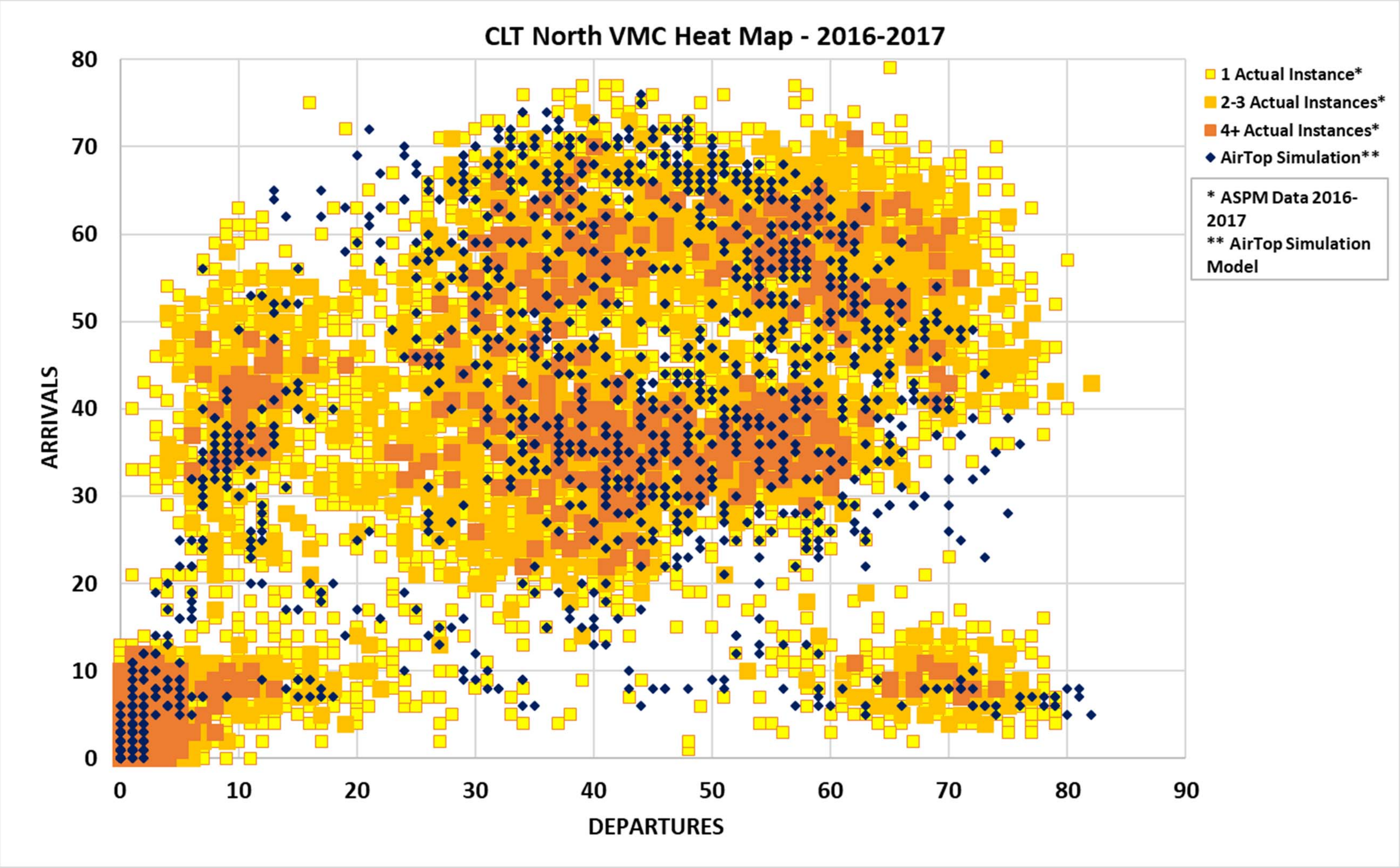
	Operation	ASPM - Called Rate*	ASPM - Max*	ASPM - 90th	EIS - Max*	AirTOp - Max	AirTOp - 90th
North VMC	Arr	92	79	63	73	76	67
	Dep	69	82	67	78	82	63
North IMC	Arr	75	76	64	73	72	64
	Dep	65	79	62	68	78	59
South VMC	Arr	92	78	63	77	77	68
	Dep	82	81	66	78	83	64
South IMC	Arr	75	77	64	74	77	66
	Dep	65	74	58	68	79	61

* Source: Capacity/Delay Analysis and Airfield Modeling Technical Memorandum, CLT EIS
ASPM data, 2016-2017
A variety of called rates were found in ASPM for a particular runway configuration, the most frequent called rate for each configuration is included in the table
90th percentile data was not provided in the EIS calibration report

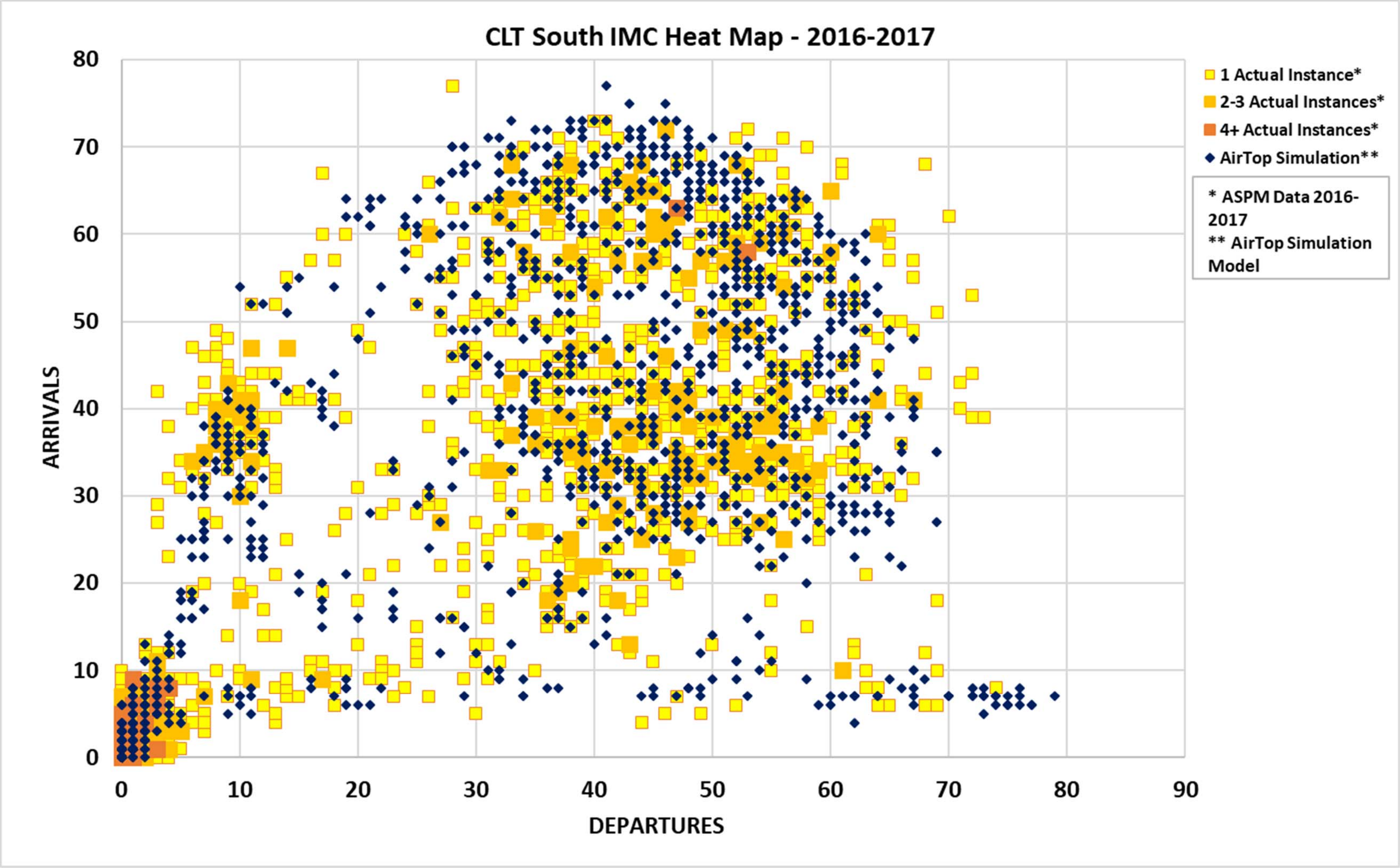
South VMC Heat Map



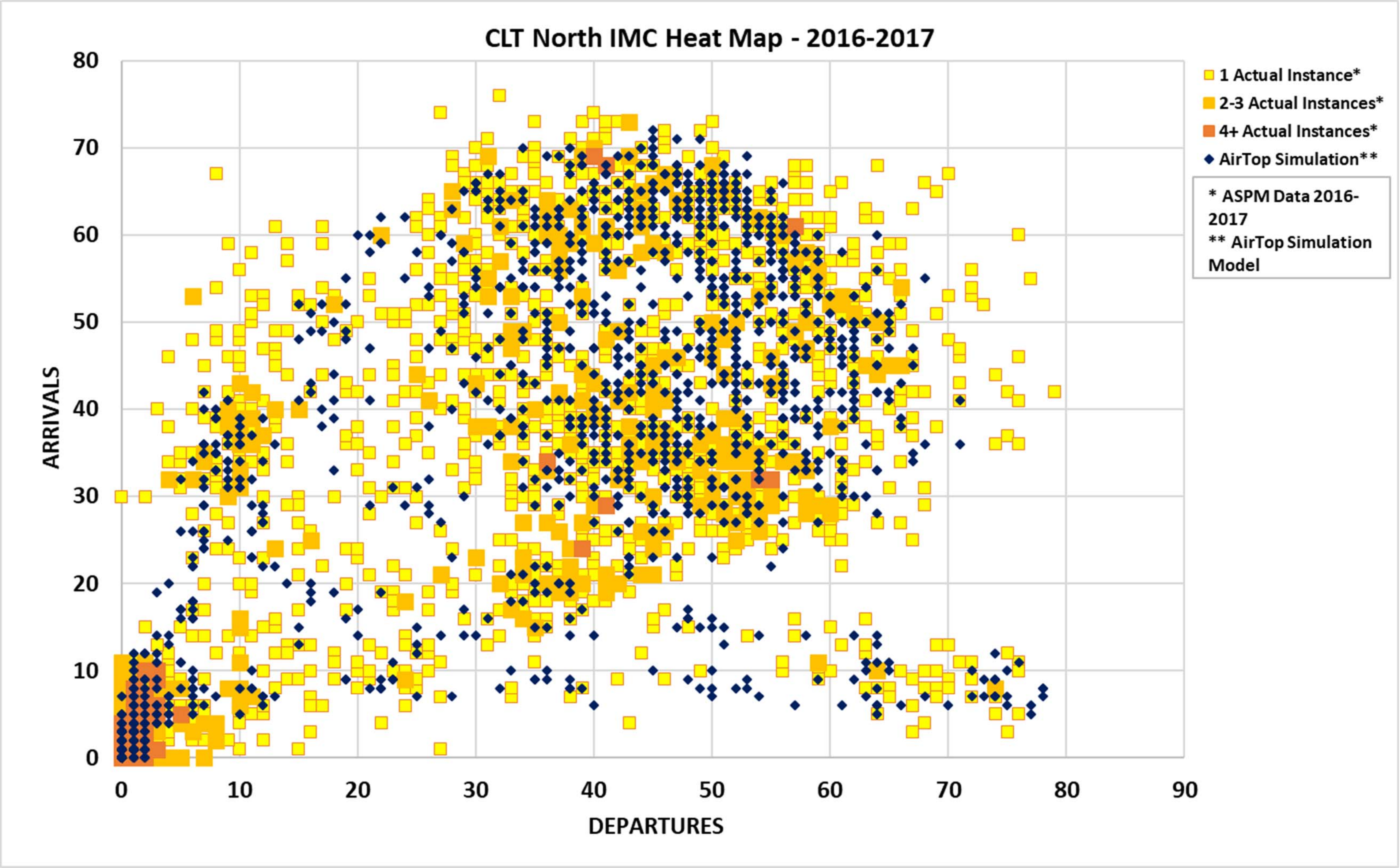
North VMC Heat Map



South IMC Heat Map



North IMC Heat Map



Aircraft Taxi Time Analysis

- A key metric in the calibration analysis are aircraft ground taxi times
- The FAA ASPM database was queried for data from 2016 regarding total taxi in (arrivals) and taxi out (departures) times
- AirTOp ground speeds are adjusted to ensure that the model produces taxi times which are within an acceptable range of actual data

2016 Average Total Taxi Times from FAA ASPM Database (minute)		
	Arrival Taxi In Time	Departure Taxi Out Time
North Flow ASPM	11.0	20.3
North VMC Simulation	11.9	20.2
South Flow ASPM	12.4	19.5
South VMC Simulation	11.6	17.6

Calibration Simulation Modeling Results

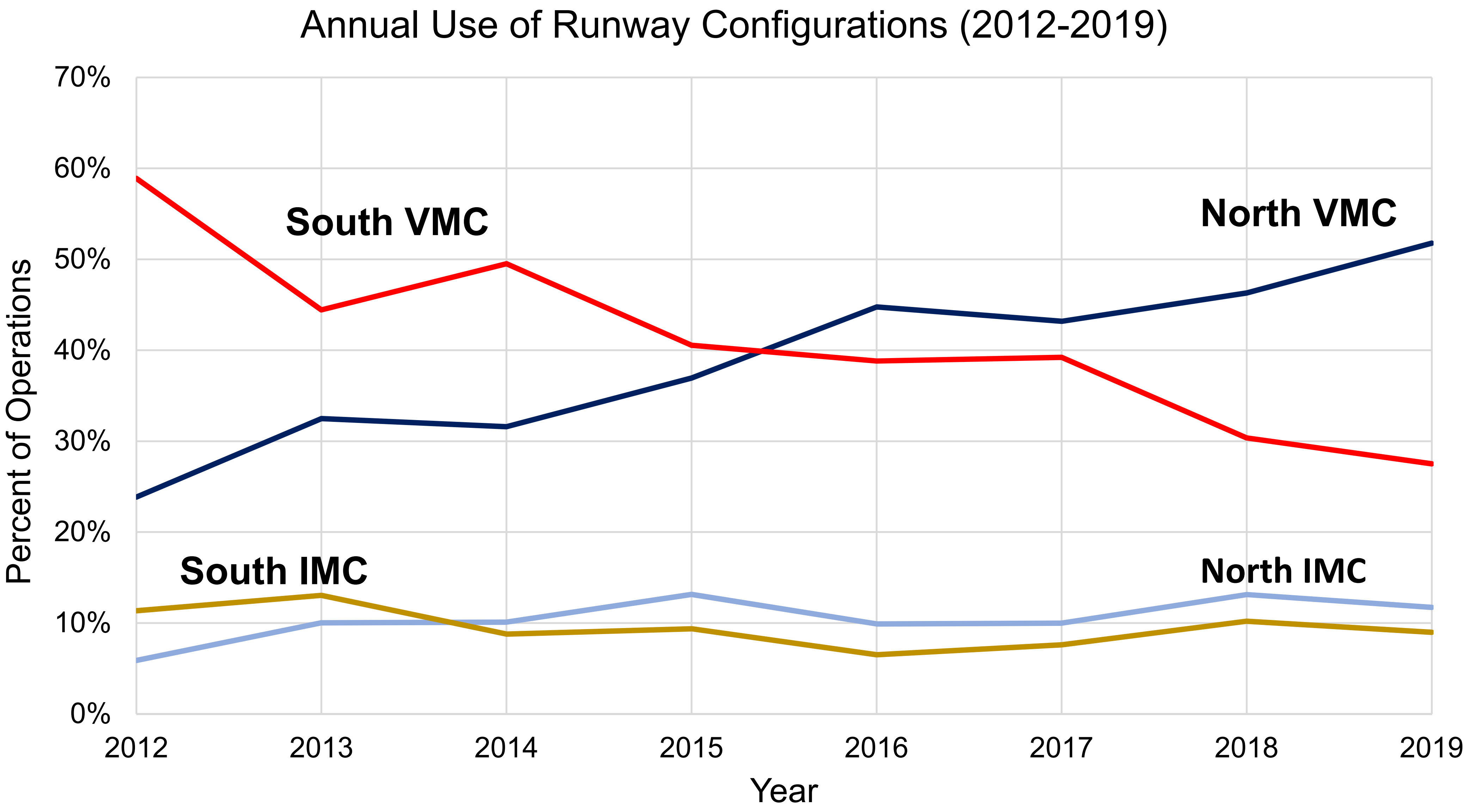
- Taxi time and delay metrics are presented for each runway configuration
- Annualization is calculated by averaging the metrics using the runway configuration use percentage

Baseline Simulation Model Results Summary (minute)					
	North VMC	**North IMC**	**South VMC**	**South IMC**	***Annualization***
Avg arrival taxi time	11.9	13.1	11.6	12.2	***11.9***
Avg departure taxi time	20.2	22.3	17.6	20.6	***19.4***
Avg arrival air delay	6.1	7.5	5.1	5.6	***5.8***
Avg arrival delay	11.3	13.8	9.6	10.8	***10.9***
Avg departure taxi delay	7.0	9.1	6.8	9.5	***7.3***
Avg departure delay	8.8	11.3	8.9	11.5	***9.2***
Avg delay	10.1	12.5	9.2	11.2	***10.1***
*Use of Runway Configurations in 2016**	*44.8%*	*9.9%*	*38.8%*	*6.5%*	

* Based on ASPM configurations and called rates

Runway Configuration Changes

- Significant increase in percent of north flow operations and decrease in south flow operations over the past few years



Based on ASPM configurations and called rates

2019 Baseline and Future No Action Airfield Modeling Assumptions

2019 Baseline and Future No Action Modeling Scenarios

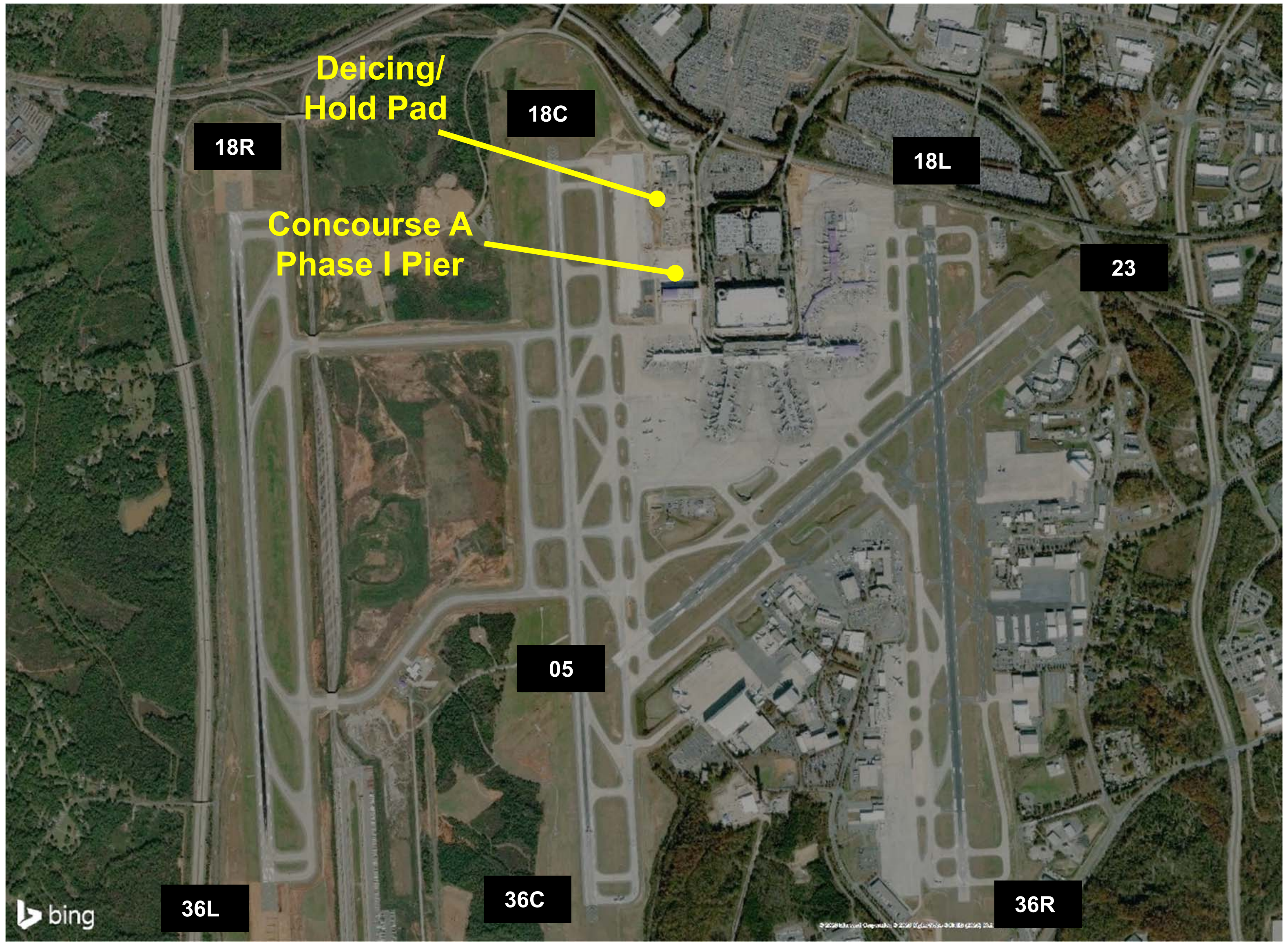
- The use of Runway 5/23 has changed since the 2016 calibration
- In this section of the presentation, we review the assumptions of how the airfield is operating today
- These assumptions will be applied to the following simulation scenarios:
  - 2019 Baseline
  - 2028 Future No Action
  - 2033 Future No Action

2019 Baseline and Future No Action Summary of Experiments

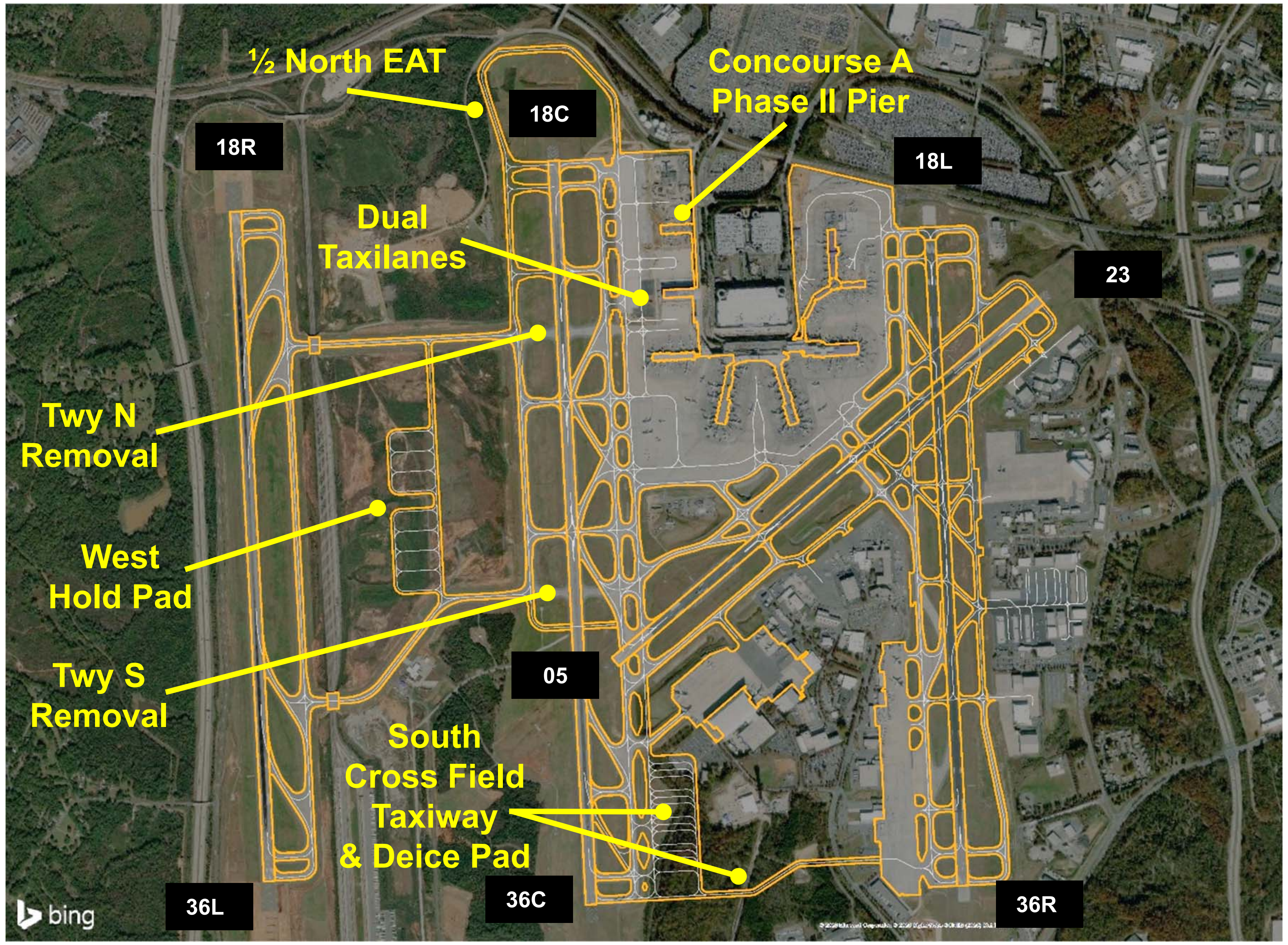
- Baseline Modeling Experiments
  - 2019 South VMC
  - 2019 South IMC
- Future No Action Modeling Experiments
  - 2028 South VMC
  - 2028 South IMC
  - 2028 North VMC
  - 2028 North IMC
  - 2033 South VMC
  - 2033 South IMC
  - 2033 North VMC
  - 2033 North IMC

Airfield Layouts for Simulation

2019 Baseline Airfield Layout



2028/2033 Future No Action Airfield Layout

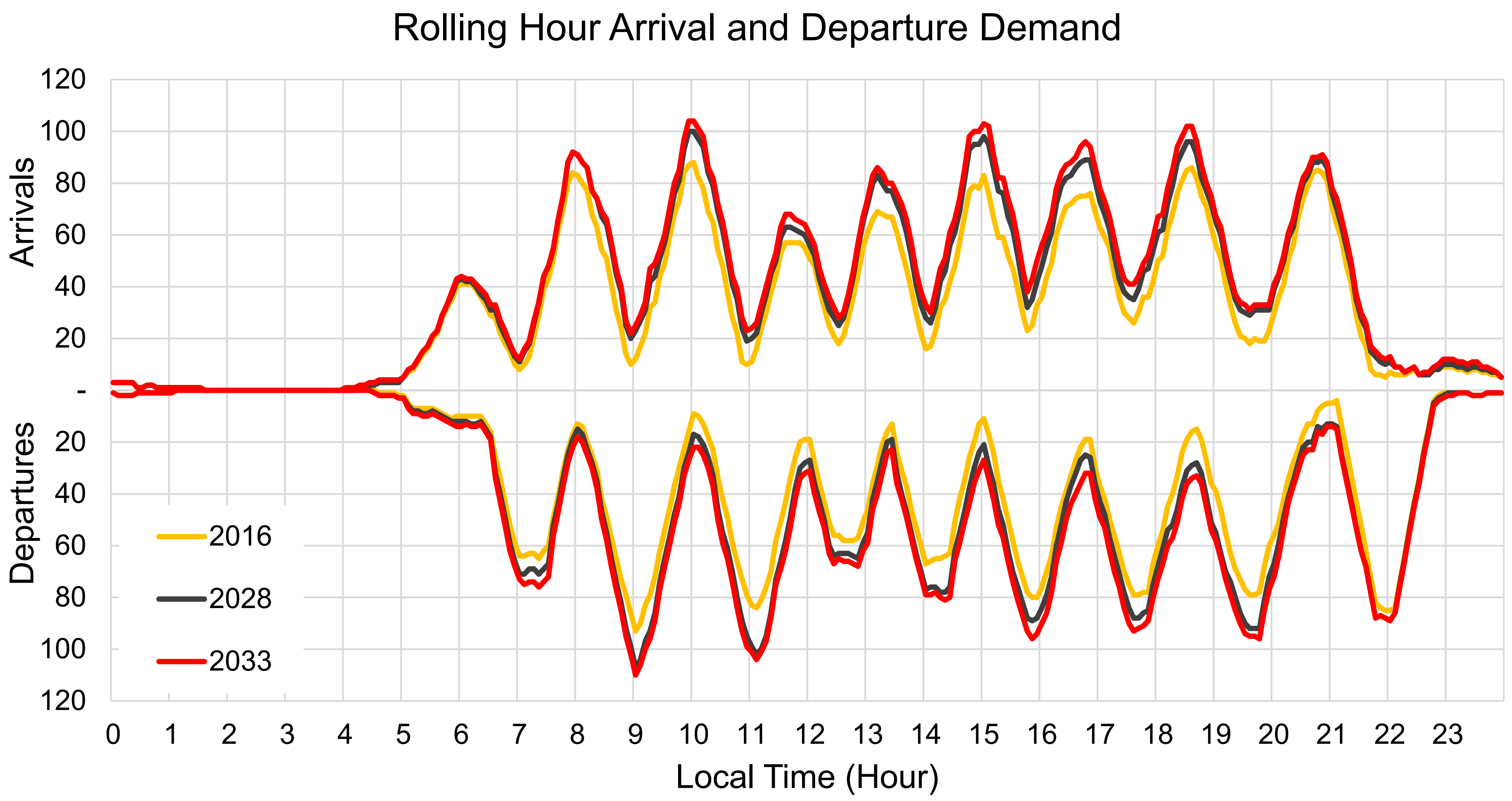


Notes: The 2019 baseline airfield layout will include the new aircraft holdpad/deicing pad located north of the new Concourse A Phase 1 expansion

Simulation Flight Schedules

- Total Daily Operations
  - 2016: 1,563
  - 2019: 1,626*
  - 2028: 1,860
  - 2033: 1,978

*2019 schedule currently in development



Review of 2019 Baseline and Future No Action Modeling Assumptions

- Airfield Operating Assumptions
  - Terminal/Concourse Layouts
  - Airfield Deicing/Hold Pad Usage
  - Runway Operating Configurations
  - Aircraft Taxi Flows
  - Aircraft Ground Speeds
- Airspace Operating Assumptions
  - Airspace Route Structure
  - Intrail Separations (Wake RECAT)
  - Airspace Route Structure

Terminal/Concourse Layout Assumptions

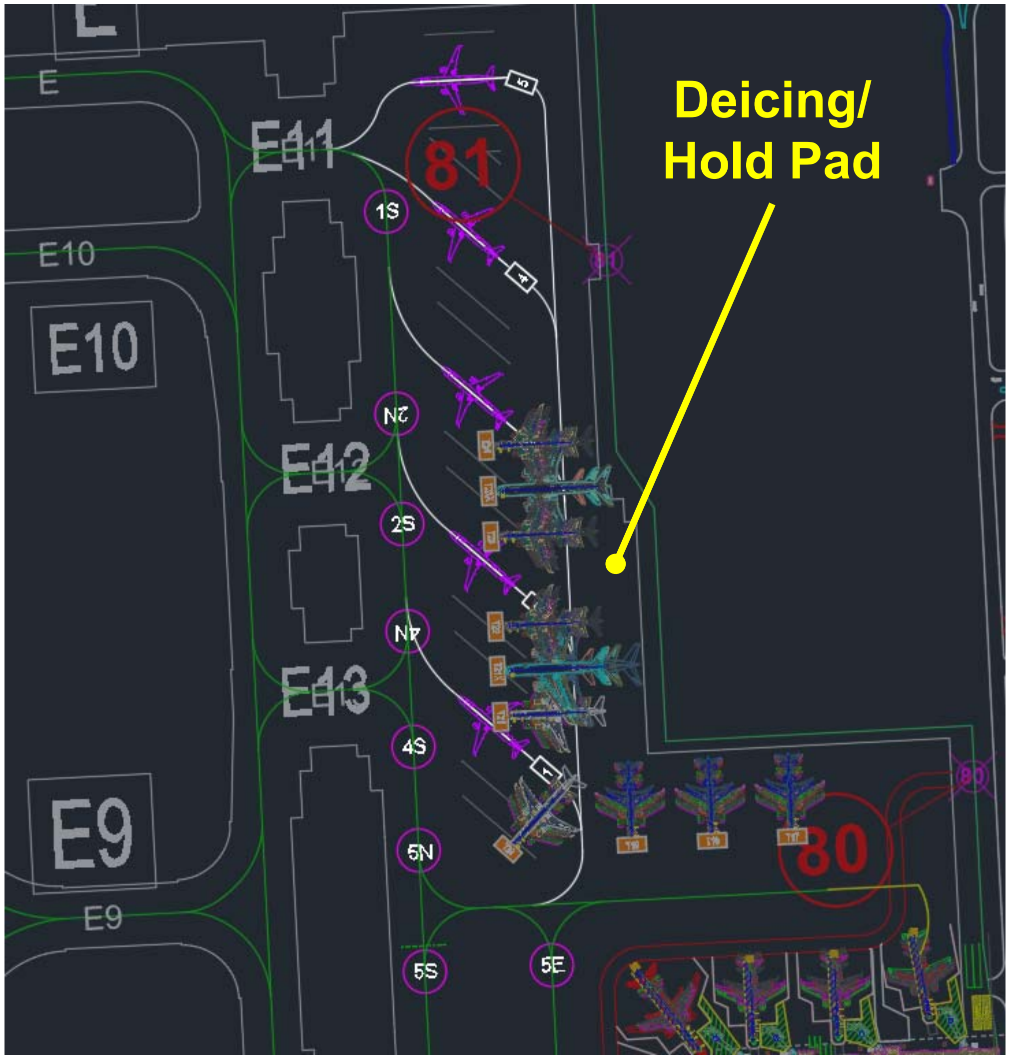
- Aircraft gate layouts will be input into AirTOp and will include airline assignment and aircraft size restrictions to simulate actual gate usage
- General Aviation and Cargo (FDX/UPS) operations were simulated and parked at their primary facility located on the existing airfield
- Aircraft holdpad and towing areas simulated
- Modeling of future gate capacity

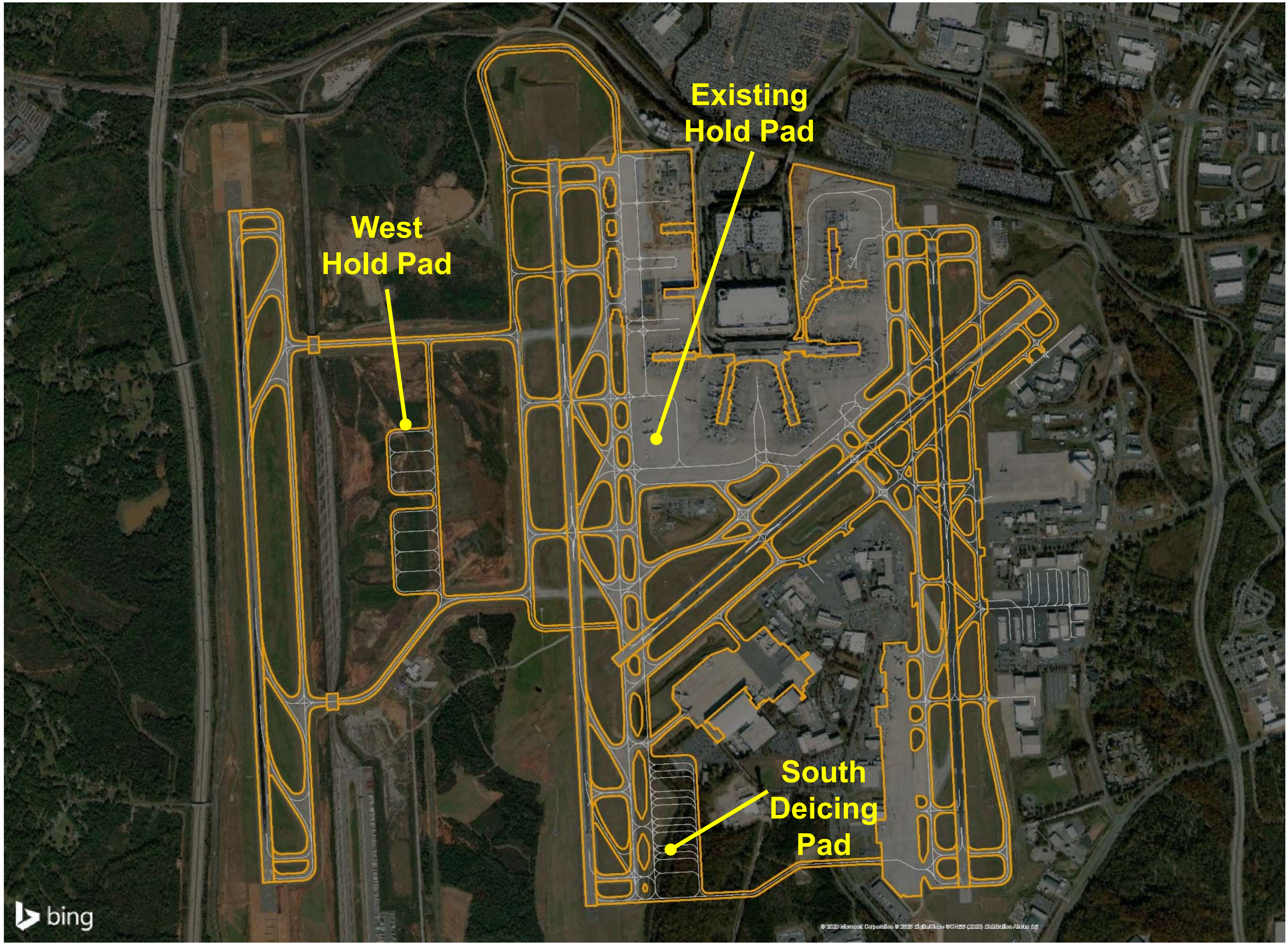
Airline Gating Assignment Assumptions (2019 Baseline)	
Concourse A	AA, DL
Concourse A (Phase 1 Expansion)	OALs
Concourse B & C	AA Mainline
Concourse D	AA Mainline, LH
Concourse E	AA Regional

Airline Gating Assignment Assumptions (2028/2033 Future No Action)	
Concourse A	AA
Concourse A (Phase 1 Expansion)	OALs
Concourse A (Phase 2 Expansion)	OALs
Concourse B & C	AA Mainline
Concourse D	AA Mainline, LH
Concourse E	AA Regional

Airfield Deicing/Hold Pad Usage

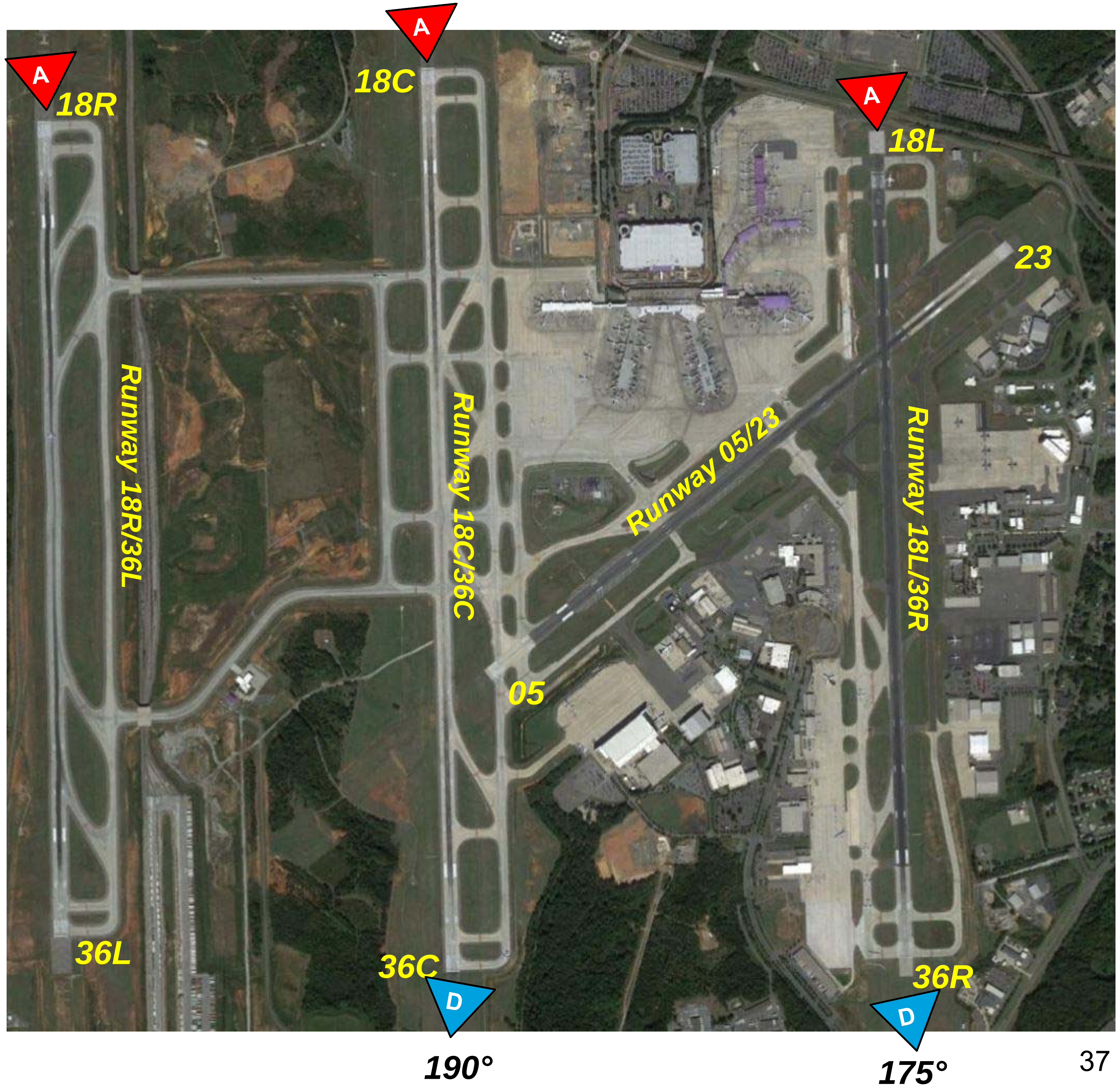
- Airfield deicing/hold pads will be simulated to accommodate arrivals waiting for gates, RON operations and aircraft towing operations





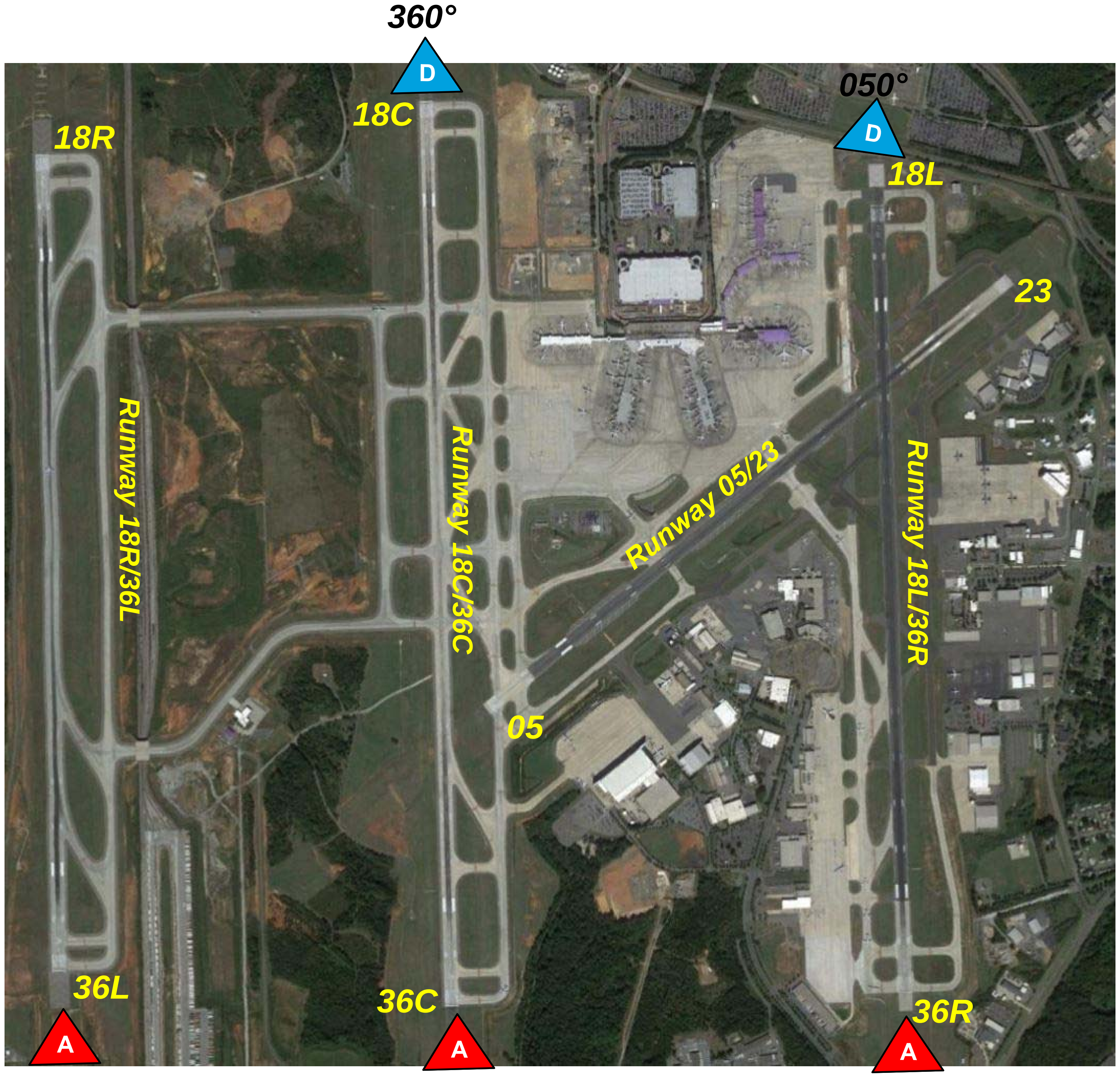
South VMC/IMC Runway Configuration

- 2019 Baseline and Future No Action runway use will be identical
- Primary Arrival Runways:
  - VMC: 18L & 18R
  - IMC: 18L & 18R
  - 18C (Trips)/Offload
- Primary Departure Runways:
  - 18C – North & West
  - 18C – International Heavy Eastbound
  - 18L – East & South
- Runway 05/23 is used as a taxiway



North VMC/IMC Runway Configuration

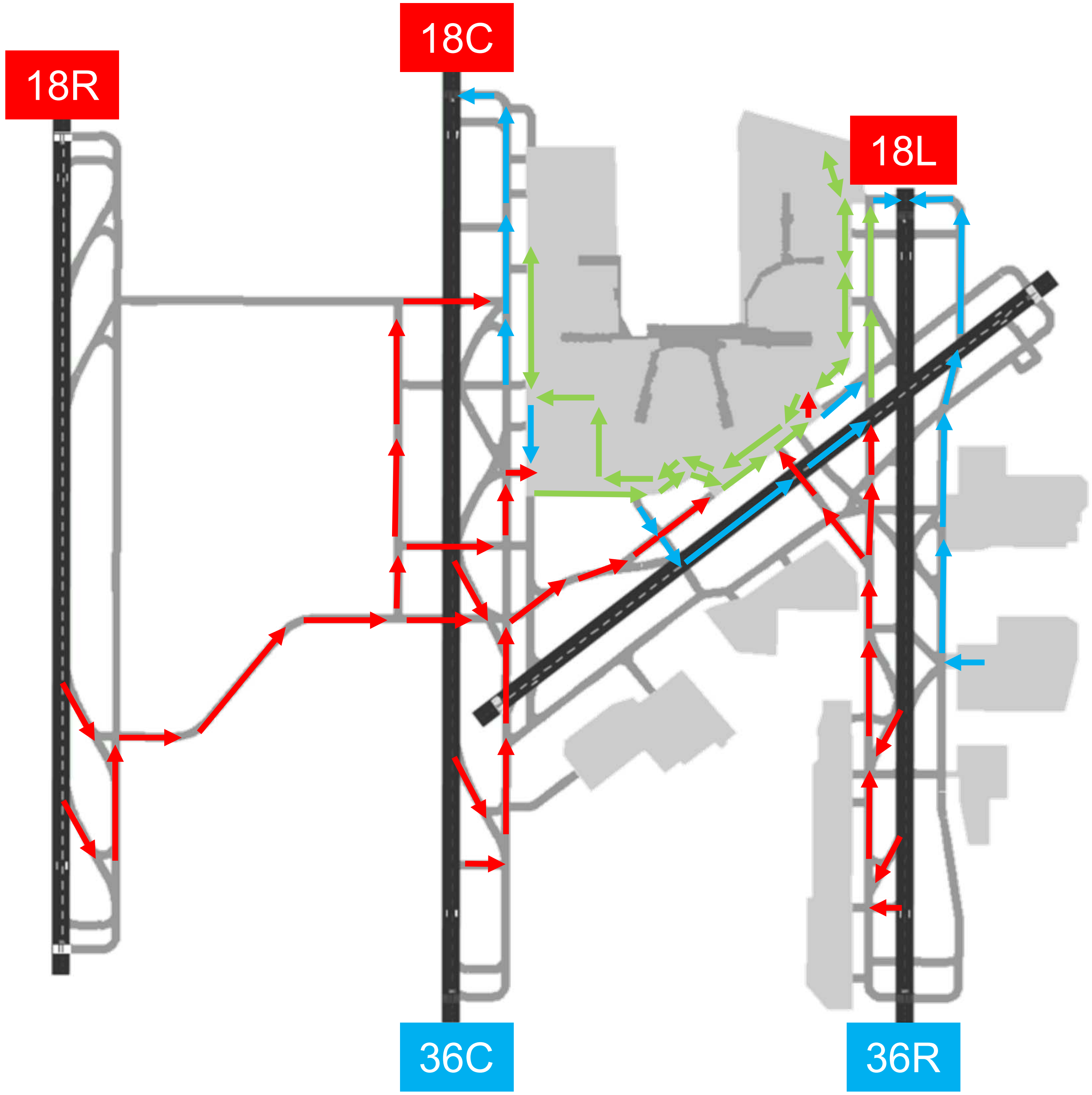
- 2019 Baseline and Future No Action runway use will be identical
- Primary Arrival Runways:
  - 36L & 36R
  - 36C (Trips)/Offload
- Primary Departure Runways:
  - 36C – North & West
  - 36C – International Heavy Eastbound
  - 36R – East & South
  - Single jet departure heading, no fanning
  - Prop aircraft make turn immediately after becoming airborne
- Runway 05/23 is used as a taxiway



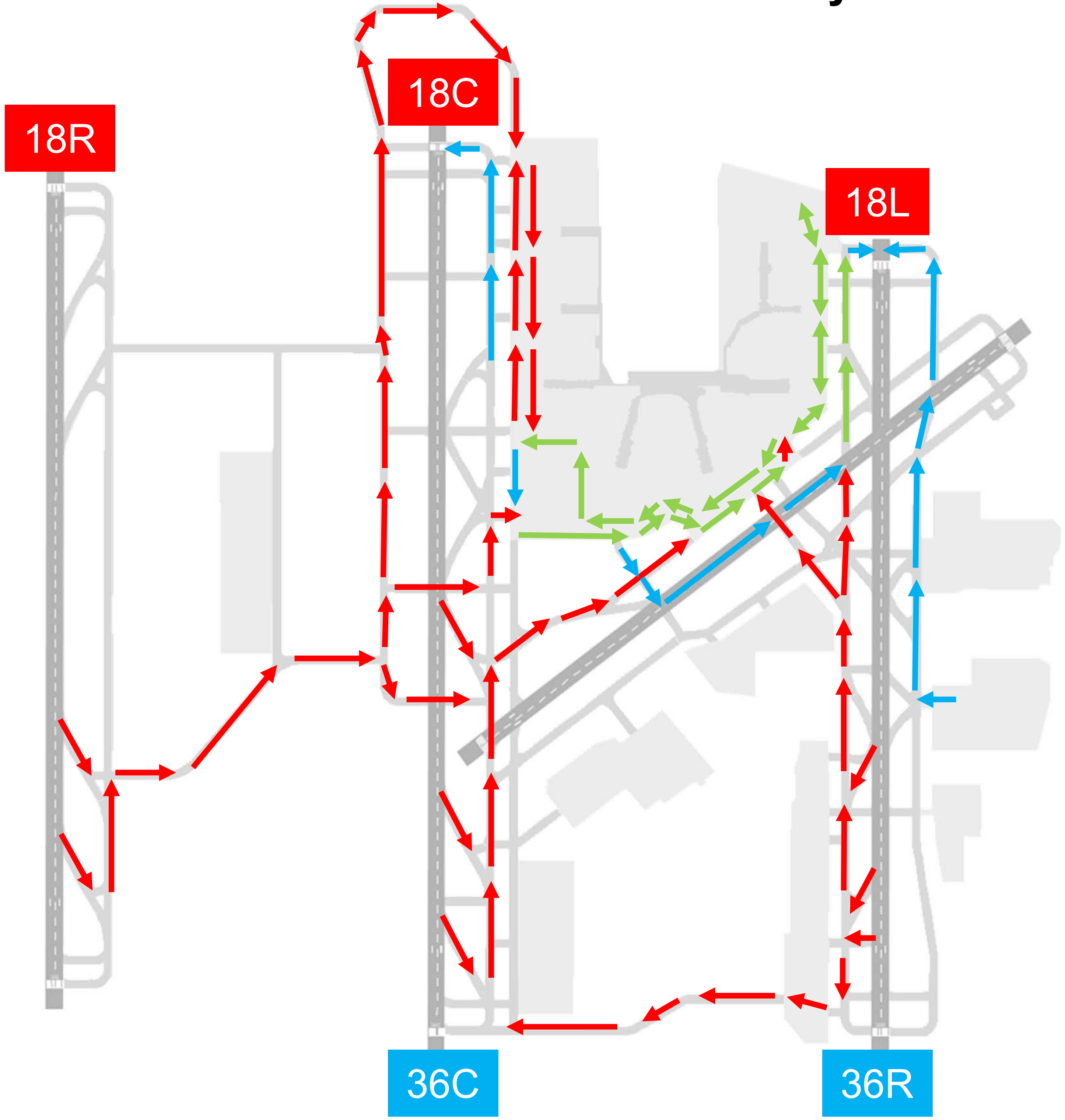
South Flow Aircraft Taxi Flows

🔺 Arrivals
🔺 Departures
🔺 Mixed

2019 Baseline Airfield Layout

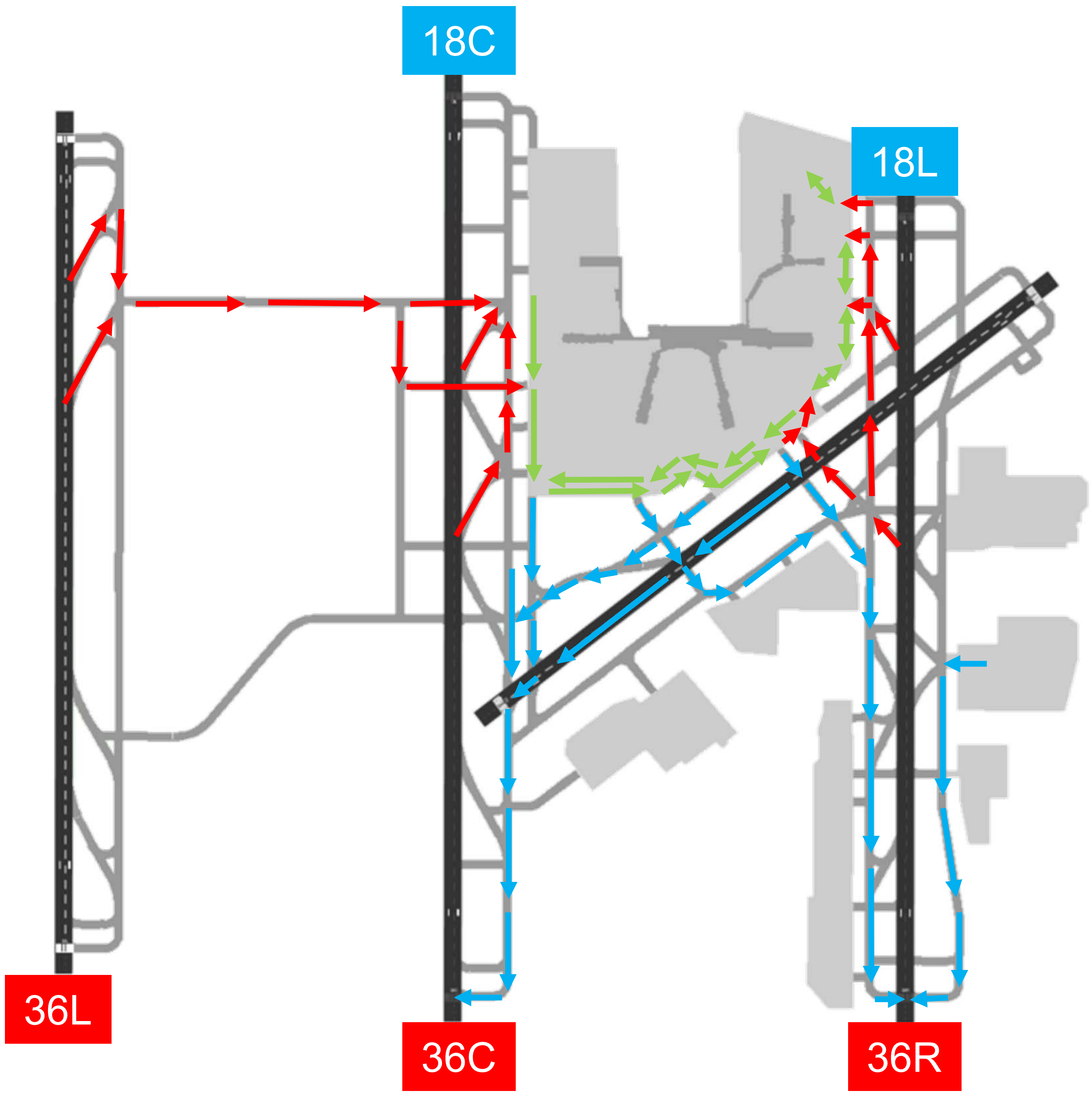


2028/2033 Future No Action Airfield Layout

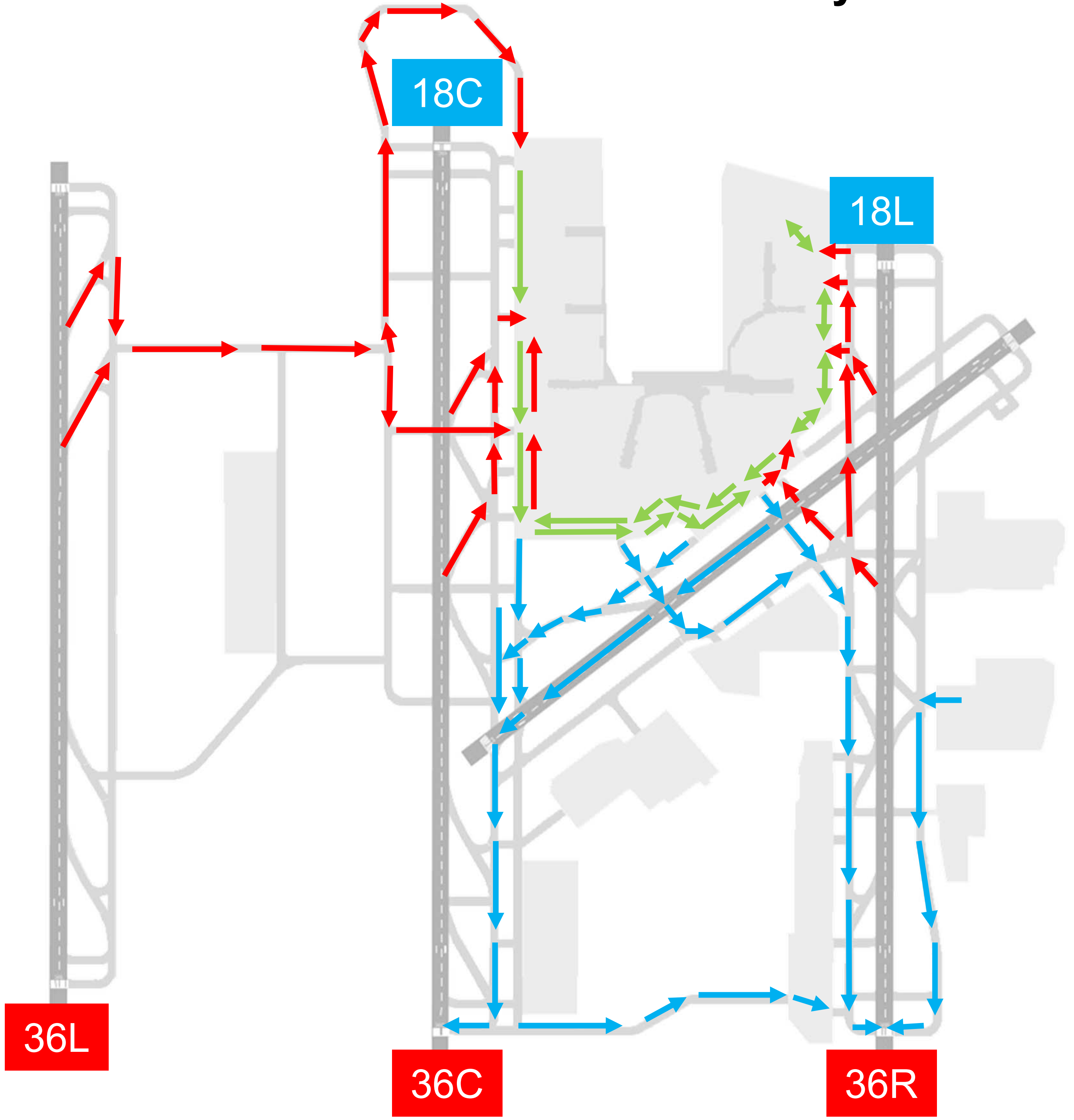


North Flow Aircraft Taxi Flows

▲ Arrivals
▲ Departures
▲ Mixed

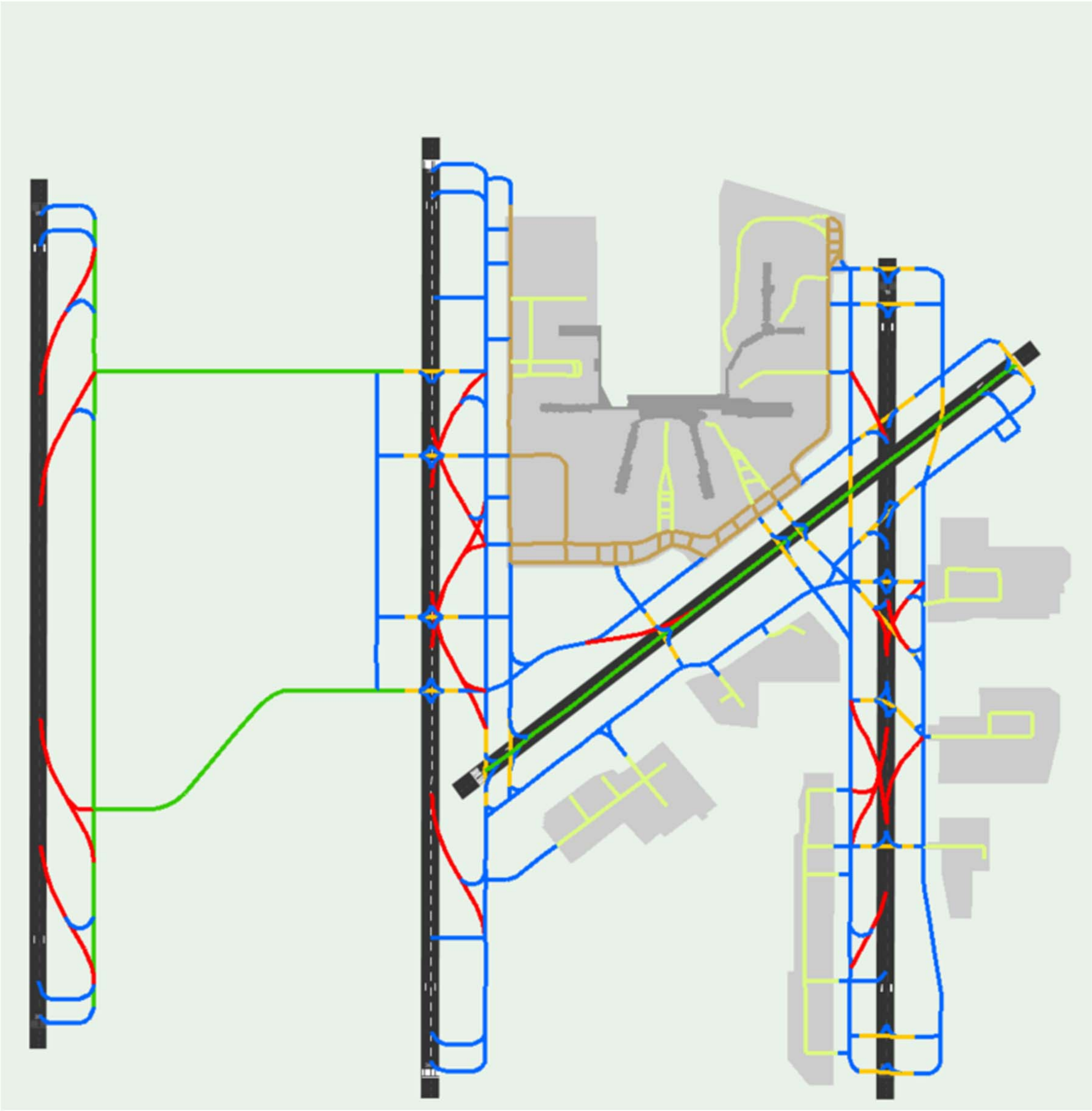


2019 Baseline Airfield Layout



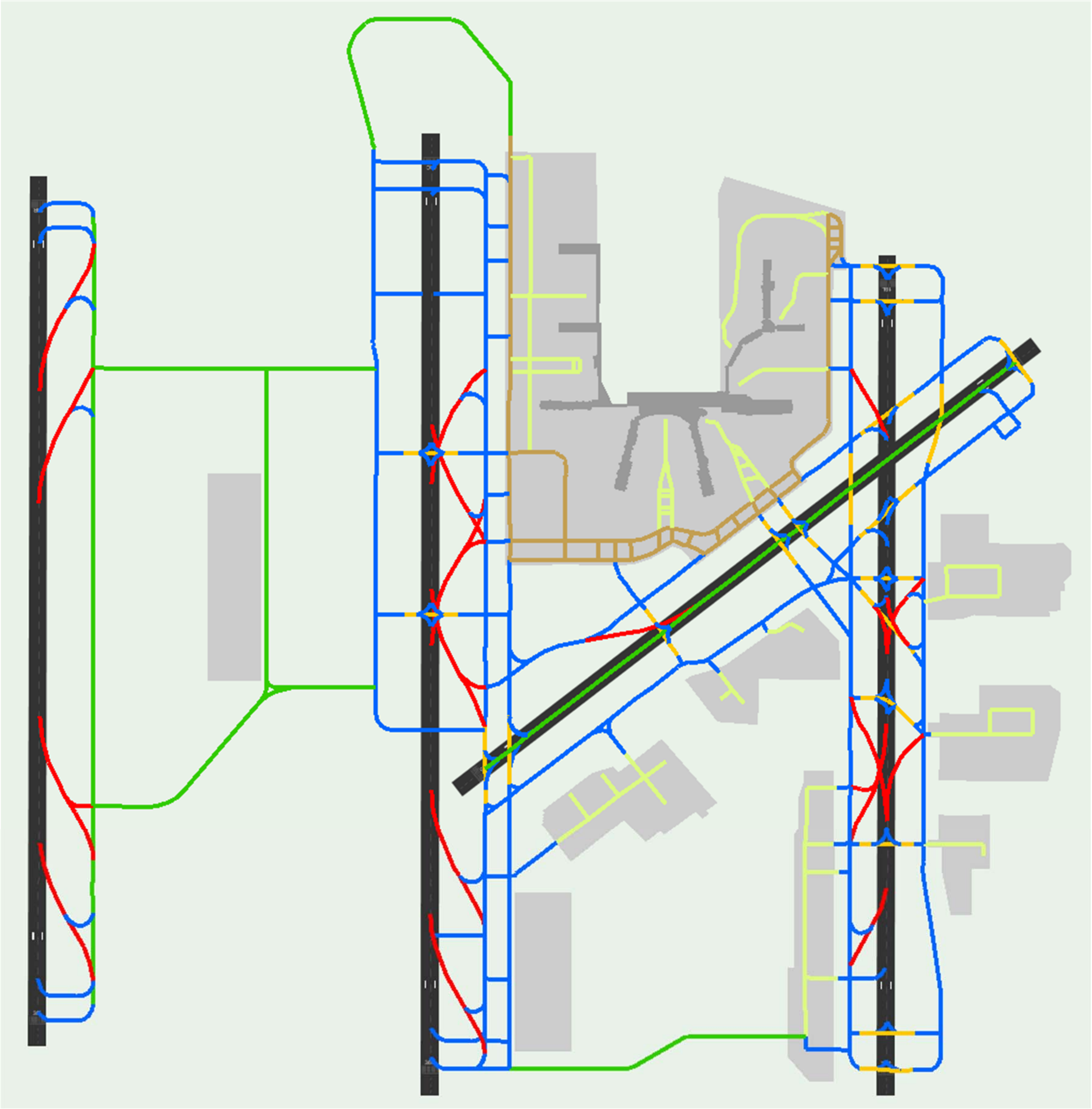
2028/2033 Future No Action Airfield Layout

Airfield Ground Speed Assumptions – Baseline



High Speed Exits	🟥	32 knots
Outer Perimeter Taxiways	🟩	20 knots
Runway Crossings	🟨	18 knots
Taxiways	🟦	15 knots
Ramp Area Taxilanes	🟫	12 knots
Ramp Area Taxilanes	⬜	10 knots

Airfield Ground Speed Assumptions – Future No Action



High Speed Exits	🟥	32 knots
Outer Perimeter Taxiways*	🟩	20 knots
Runway Crossings	🟨	18 knots
Taxiways	🟦	15 knots
Ramp Area Taxilanes	🟫	12 knots
Ramp Area Taxilanes	🟩	10 knots

*North EAT and south cross field taxiway are also assumed to have 20 knot speed limits

Airspace Operating Assumptions

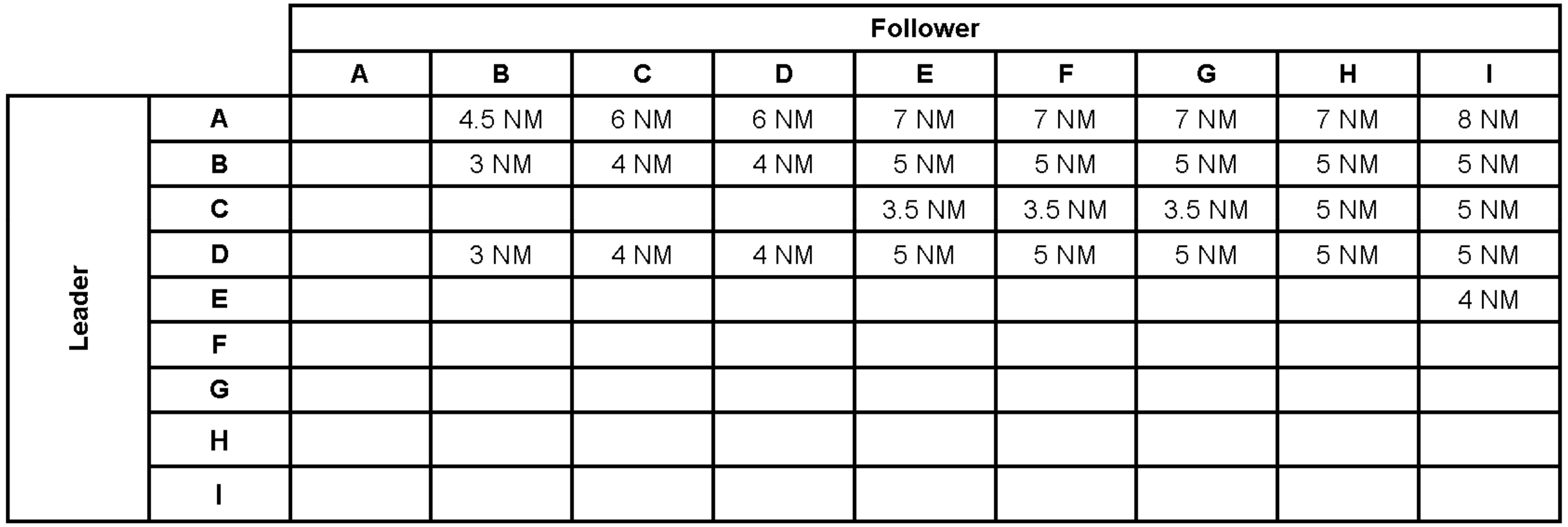
Airspace Operating Assumptions/Overview

- The simulated airspace encompasses the CLT Metroplex terminal airspace which is an approximate 40nm radius around the Airport
- Currently published RNAV arrival and departure procedures were analyzed and used as the basis for constructing the simulation airspace
- Existing radar data was analyzed and used to determine origin/destination city pair airspace fix assignments for input into the simulation flight schedule
- 6 nm intrail separations were applied at arrival corner post fixes for transition from the center airspace to the terminal environment
- When operating a mixed used runway operation, arrivals block departures 2.3 nm from the runway threshold
- During mixed arrival/departure operation, minimum of 4.5 nm arrival intrail separation is kept to ensure one departure between every arrival

Intrail Separation Minimums – Wake RECAT

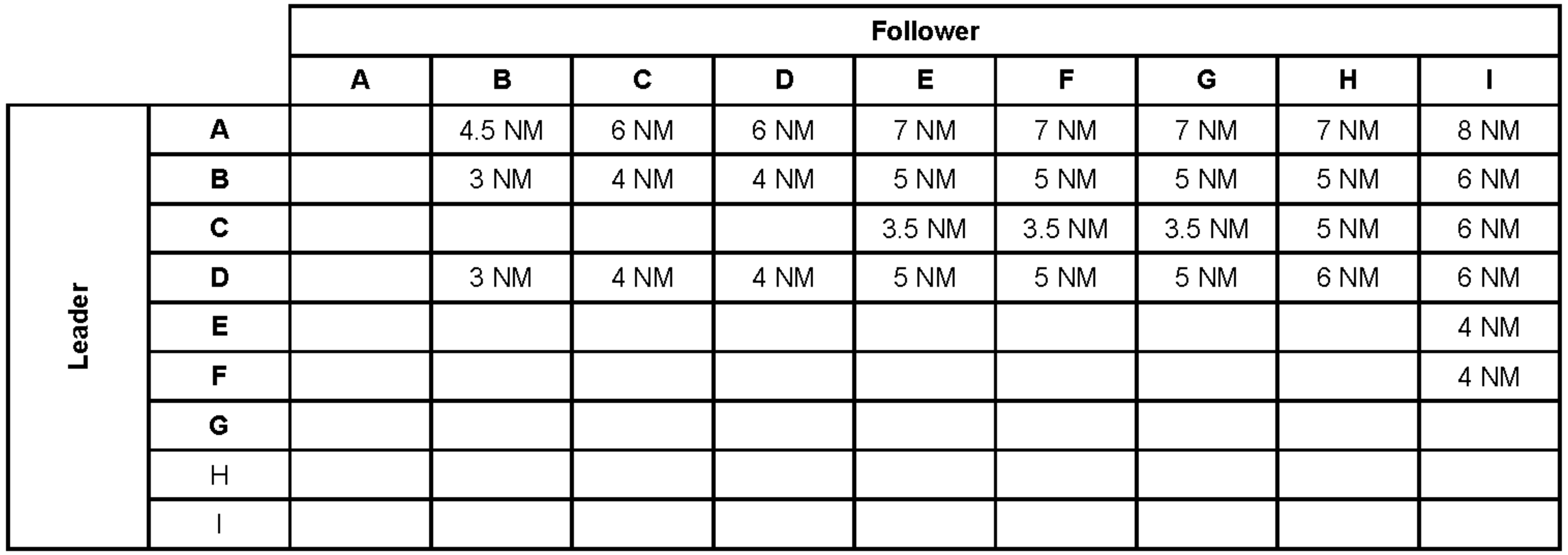
- Simulation of FAA Wake RECAT separation criteria will be applied to the Baseline and Future No Action scenarios
- Previous simulation modeling and intrail separation analyses indicate minimum arrival separations on final approach range between 3.3nm (VMC) and 3.8nm (IMC)

TBL 5–5–1
Wake Turbulence Separation for Directly Behind



		Follower								
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Leader	**A**		4.5 NM	6 NM	6 NM	7 NM	7 NM	7 NM	7 NM	8 NM
	B		3 NM	4 NM	4 NM	5 NM	5 NM	5 NM	5 NM	5 NM
	C					3.5 NM	3.5 NM	3.5 NM	5 NM	5 NM
	D		3 NM	4 NM	4 NM	5 NM	5 NM	5 NM	5 NM	5 NM
	E									4 NM
	F									
	G									
	H									
	I									

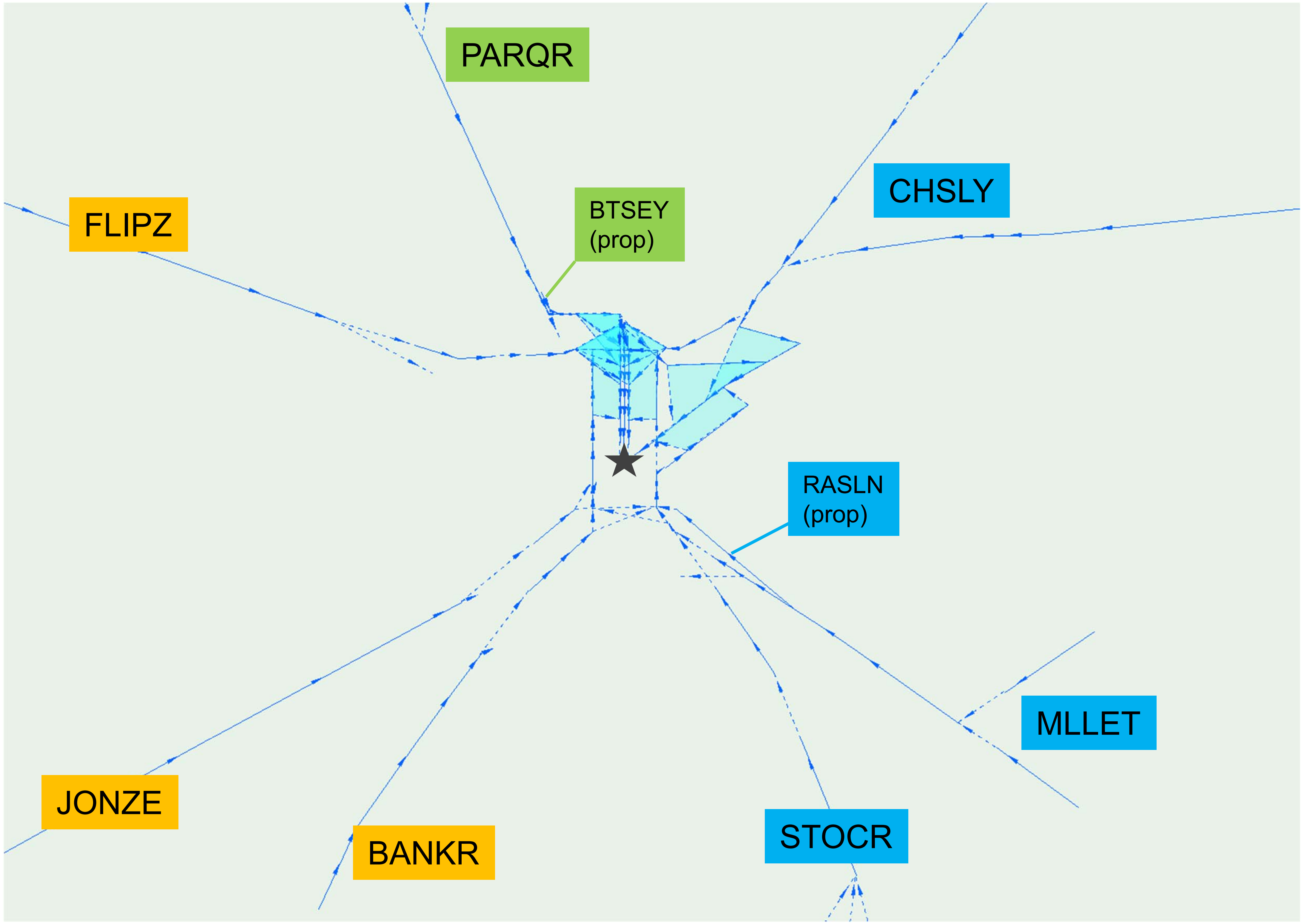
TBL 5–5–2
Wake Turbulence Separation for On Approach



		Follower								
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Leader	**A**		4.5 NM	6 NM	6 NM	7 NM	7 NM	7 NM	7 NM	8 NM
	B		3 NM	4 NM	4 NM	5 NM	5 NM	5 NM	5 NM	6 NM
	C					3.5 NM	3.5 NM	3.5 NM	5 NM	6 NM
	D		3 NM	4 NM	4 NM	5 NM	5 NM	5 NM	6 NM	6 NM
	E									4 NM
	F									4 NM
	G									
	H									
	I									

Source: JO 7110.126A - Consolidated Wake Turbulence (CWT) Separation Standards
Effective Date: September 28, 2019

South Flow Arrival Airspace



🟨 18R

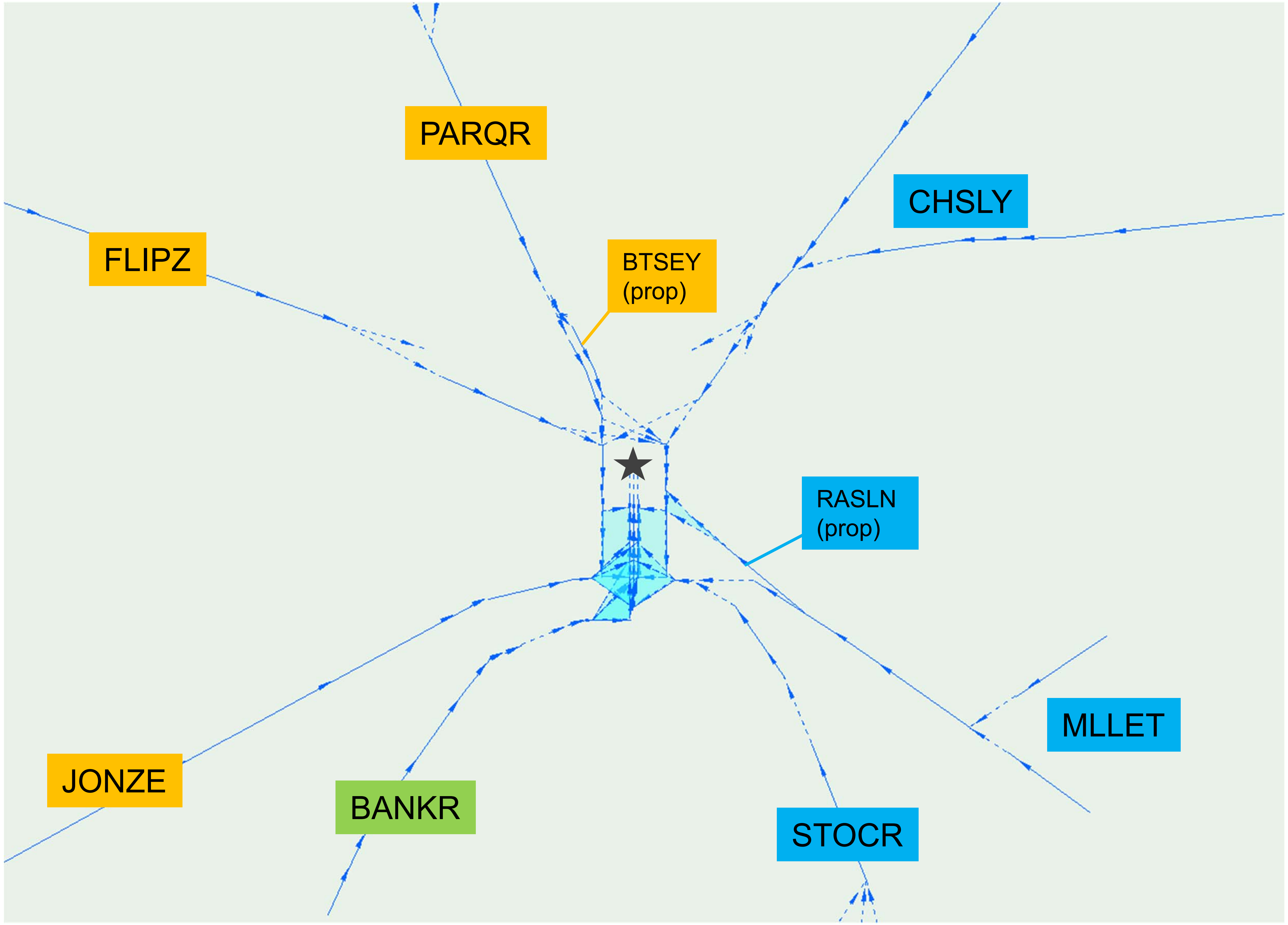
🟦 18L or 23

🟩 18C

★ CLT

Note: Arrivals can be offloaded to other runways during busy periods

North Flow Arrival Airspace



🟨 36L

🟦 36R

🟩 36C

★ CLT

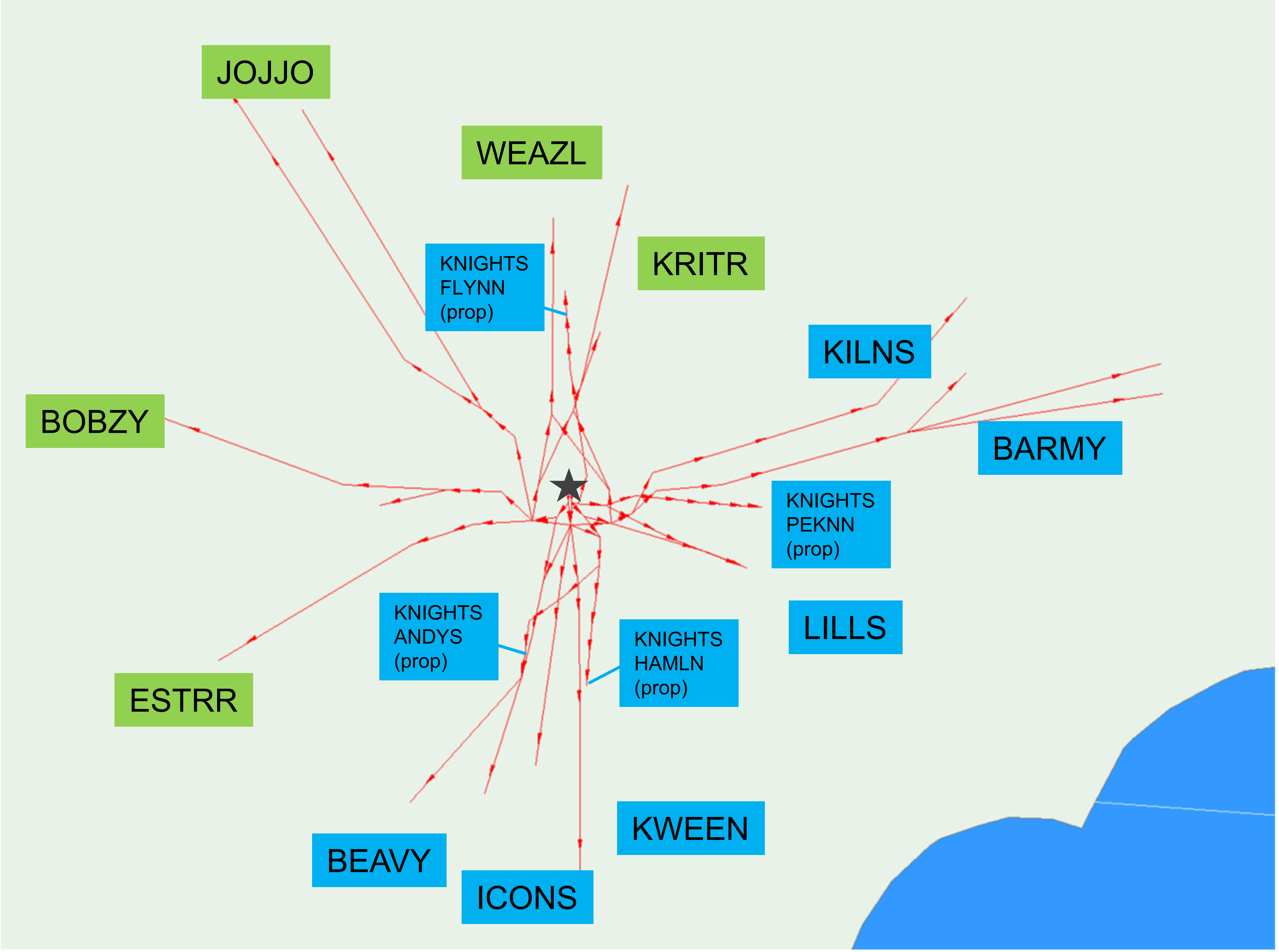
Note: Arrivals can be offloaded to other runways during busy periods

Sample Origins by Arrival Routing

Arrival Route	Origin Examples*
North	
PARQR TAFTT	MDW, CLE, MSP, ORD, SEA
East	
CHSLY LYH	BOS, EWR, FRA, JFK, LHR
South	
BANKR	JAX, MIA
West	
JONZE BESTT	ATL, IAH, MEX
FLIPZ COMDY	DEN, DFW, LAX, PDX, SFO

*Note that these lists are not all-inclusive. They merely contain examples of some of the major airports that use each route.

South Flow Departure Airspace



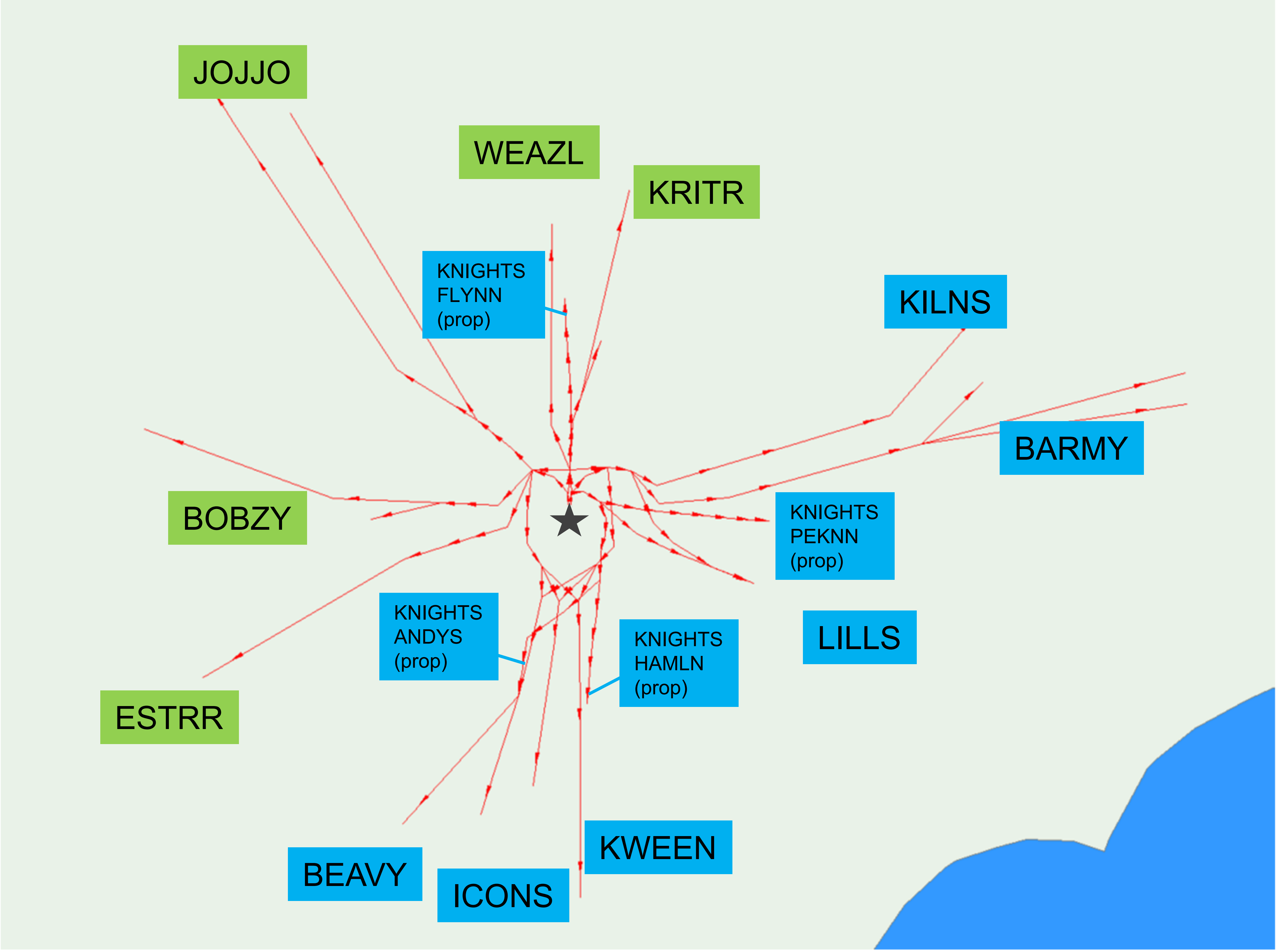
🟦 18L

🟩 18C

★ CLT

Note: KRITR departures can be offloaded to 18L during busy periods

North Flow Departure Airspace



🟦 36R

🟩 36C

★ CLT

Note: BEAVY, ICONS, and KWEEN departures can be offloaded to 36C during busy periods

Sample Destinations by Departure Routing

Departure Route	**Destination Examples***
	North
JOJJO DODGE	MDW, ORD, PDX, SEA
KRITR FILDS	BUF, PIT, YYZ
	East
KILNS	BWI, IAD, EWR, PHL
BARMY RDU	BOS, FRA, LGA
	South
ICONS	JAX, MIA
	West
ESTRR	AUS, DAL, IAH, MEX
BOBZY BNA	DEN, DFW, LAX, PHX, SFO

*Note that these lists are not all-inclusive. They merely contain examples of some of the major airports that use each route.

Next Steps

- Provide comments to EA Team by March 31, 2020
  - Send comments to spotter@landrum-brown.com
- Incorporate comments from DORA Team
- Conduct 2019 Baseline & 2028 & 2033 Future No Action simulations
- Conduct alternatives evaluation
- DORA Meeting #2 – present results of the 2019 Baseline & Future No Action simulations
  - Tentative 3rd week of April (week of the 20th)
- Continue preparation of the Draft EA

CLT DORA (Direction, Oversight, Review & Agree) Meeting #2

June 11, 2020

Agenda

- Introductions
- Meeting Objectives
- DORA Process
- EA Process Overview
- No Action Modeling Simulation Overview
  - Airfield Operating Assumptions
  - Airspace Operating Assumptions
- Proposed Action Modeling Assumptions
  - Airfield Operating Assumptions
  - Airspace Operating Assumptions
- Next Steps

Meeting Objectives

Meeting Objectives

- – To present and review Future No Action modeling assumptions and simulation modeling results
- – To present the Proposed Action airfield modeling assumptions
- – To present the next steps in the overall project

DORA Process

Charlotte Douglas International Airport EA

DORA Process Overview


Federal Aviation Administration

Prepared for:	**CLT EA DORA Meeting #2**
By:	**Kent Duffy**
Date:	**June 2020**

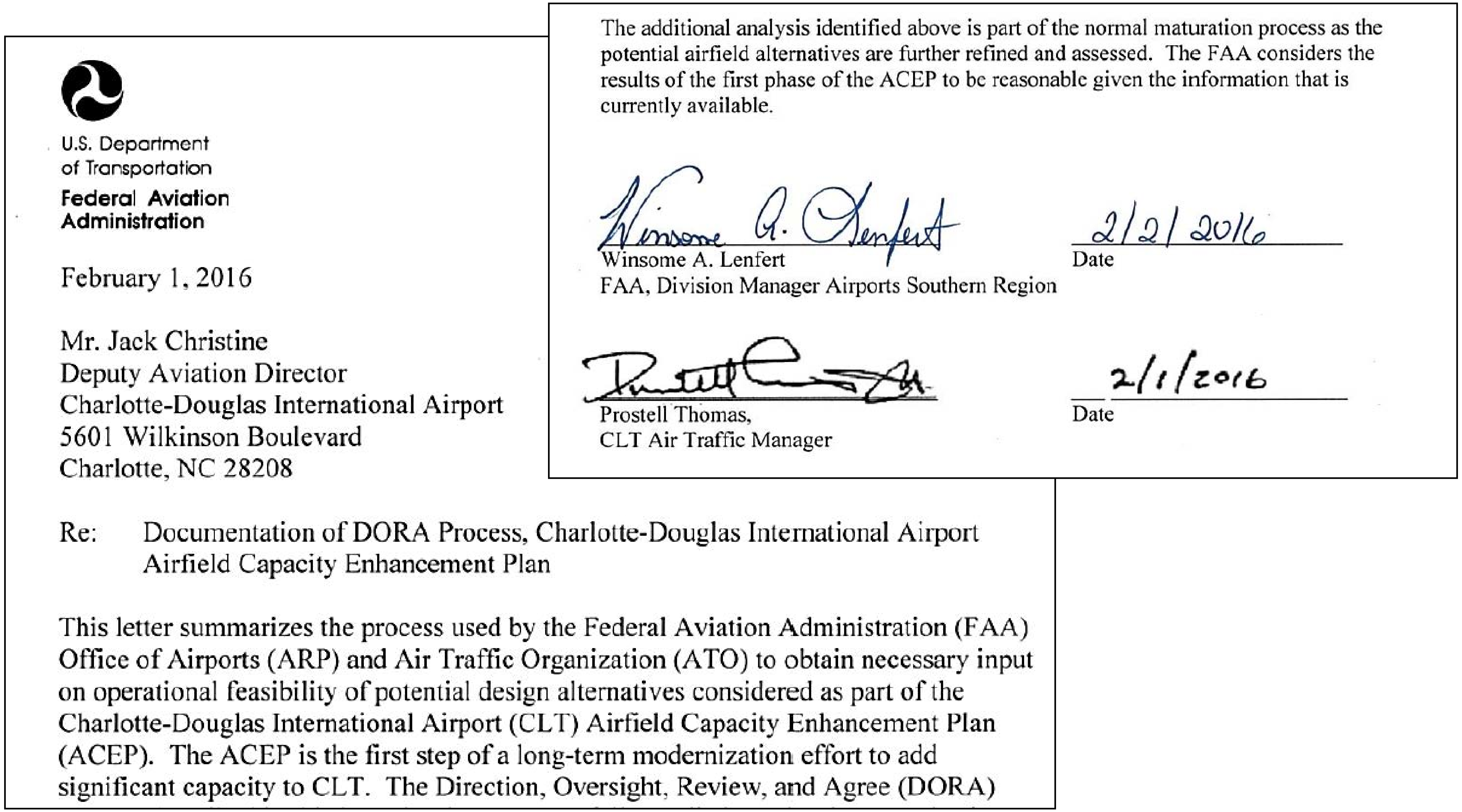
What is DORA?

- **DORA** = **D**irection, **O**versight, **R**eview and **A**gree
- Obtaining and understanding controller input on operational issues and viability of proposed alternatives is a key to airport capacity development
- DORA has been applied successfully to other large-scale airport and airspace modernization efforts (e.g., O'Hare Modernization Program)

Objectives: Why are we here?

- **Ensure collaboration w/ATO on simulation activities as needed to complete EA**
  - Obtain input development of the simulation model
  - Revise and refine simulation model, rather than develop new alternatives
- **Build from successful process used during planning phase**
  - Update with recent changes: forecast trends, CRO, metroplex, heading usage, Atlantic coast routes, etc.
  - Validate operating assumptions used in the simulation model
    - Airspace flows and procedures, Runway usage and balancing, Aircraft separation and buffers, Taxi-flows and ground movement, etc.
  - Review and validate airspace's ability to accommodate new runway throughput
- **Collaboration ensures the simulation results can be used in the EA analyses with confidence**

Planning Phase DORA Letter



U.S. Department
of Transportation
**Federal Aviation
Administration**

February 1, 2016

Mr. Jack Christine
Deputy Aviation Director
Charlotte-Douglas International Airport
5601 Wilkinson Boulevard
Charlotte, NC 28208

Re: Documentation of DORA Process, Charlotte-Douglas International Airport Airfield Capacity Enhancement Plan

This letter summarizes the process used by the Federal Aviation Administration (FAA) Office of Airports (ARP) and Air Traffic Organization (ATO) to obtain necessary input on operational feasibility of potential design alternatives considered as part of the Charlotte-Douglas International Airport (CLT) Airfield Capacity Enhancement Plan (ACEP). The ACEP is the first step of a long-term modernization effort to add significant capacity to CLT. The Direction, Oversight, Review, and Agree (DORA)

The additional analysis identified above is part of the normal maturation process as the potential airfield alternatives are further refined and assessed. The FAA considers the results of the first phase of the ACEP to be reasonable given the information that is currently available.

Winsome A. Lenfert 2/2/2016
Winsome A. Lenfert Date
FAA, Division Manager Airports Southern Region

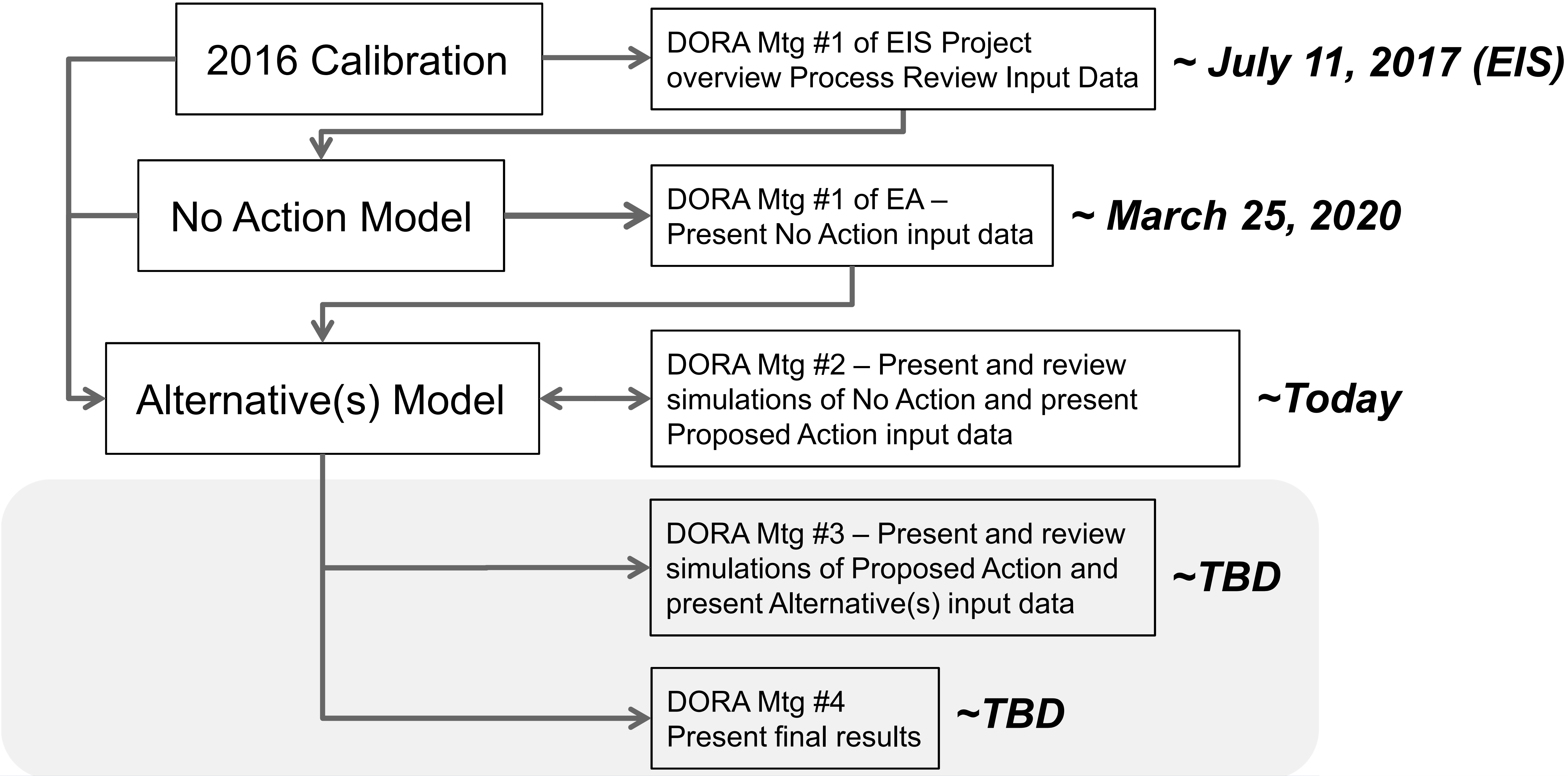
2/1/2016
Prostell Thomas, Date
CLT Air Traffic Manager

Desired Result: 2^{nd} DORA Letter

Active ATC participation

- **FAA Letter signed by ATO and ARP**
- **Explains process and summarizes meetings**
- **Identifies further analyses required in subsequent phases (e.g., design/ implementation), as needed**
- **Desired findings:**
  - Modeling approach is reasonable
  - Modeling assumptions accurately reflects operational perspectives
  - Subsequent capacity, throughput and delay results are reasonable representations of the proposed airfield and airspace designs

DORA Process Relationship to Modeling



2016 Calibration

DORA Mtg #1 of EIS Project overview Process Review Input Data

~ July 11, 2017 (EIS)

No Action Model

DORA Mtg #1 of EA – Present No Action input data

~ March 25, 2020

Alternative(s) Model

DORA Mtg #2 – Present and review simulations of No Action and present Proposed Action input data

~Today

DORA Mtg #3 – Present and review simulations of Proposed Action and present Alternative(s) input data

~TBD

DORA Mtg #4 Present final results

~TBD

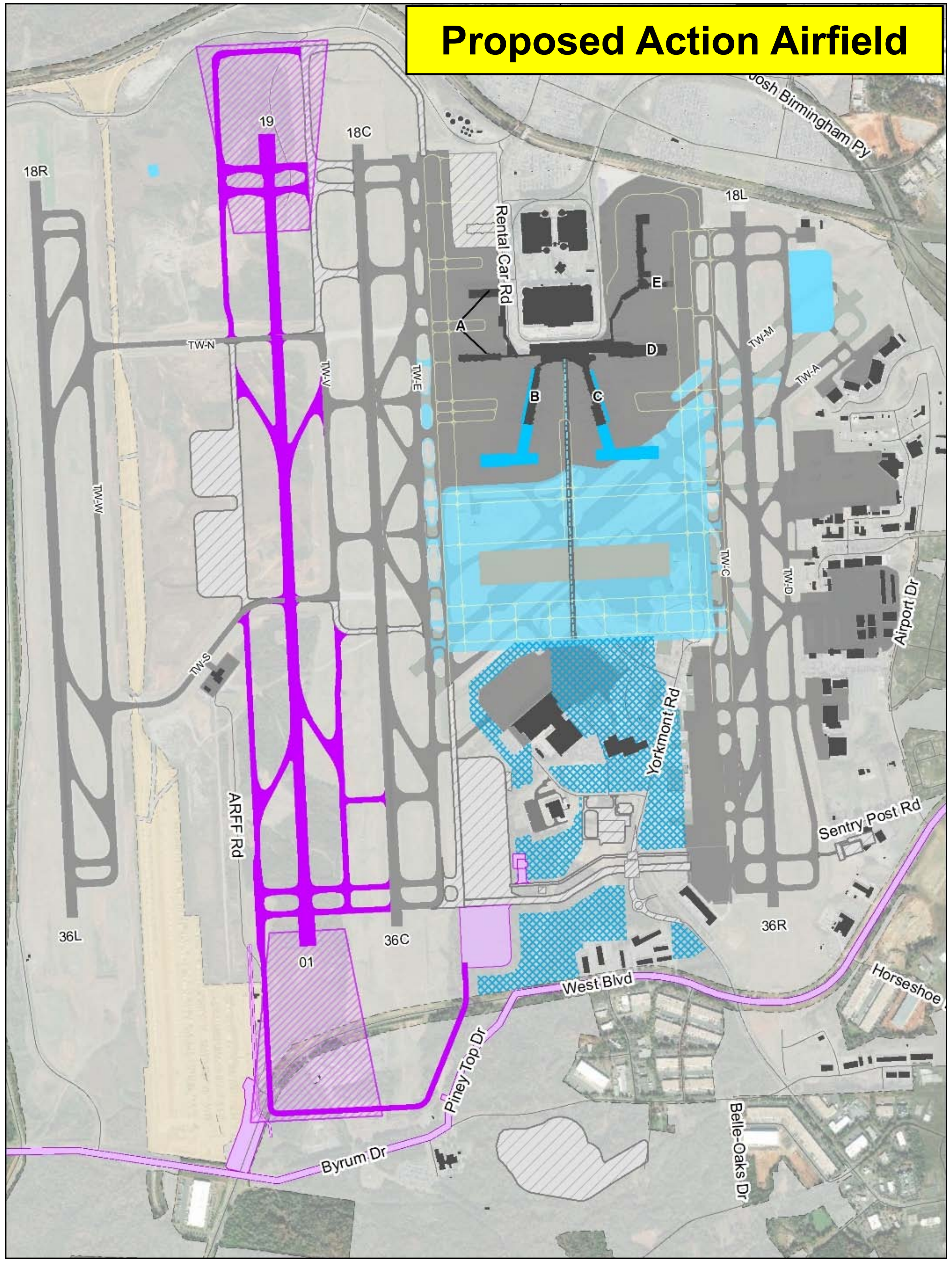
EA Process Overview

EA Process Overview - Background

- The CLT Environmental Impact Statement (EIS) that the Federal Aviation Administration (FAA) began was cancelled on February 27, 2019.
- The FAA cancelled the EIS because a runway length analysis determined only a 10,000 foot runway is required to meet the purpose and need.
- The FAA determined that this was a sufficient change to warrant cancellation of the EIS and conversion to an Environmental Assessment (EA).
- The City of Charlotte (Airport Sponsor) is responsible for preparing the EA.
- FAA is still the lead agency.
- Similar to the EIS, the EA will evaluate the potential direct, indirect, and cumulative environmental impacts that may result from the Proposed Action.

EA Process Overview – Proposed Action

- 4th Parallel Runway (10,000 feet long)
  - North and South End Around Taxiways
- Extensions of Concourse B and C
  - Decommissioning Runway 5/23
  - Crossfield Corridor
  - Dual Taxilanes Around Ramp
    - Requires the removal of gates off the end of Concourse D and E

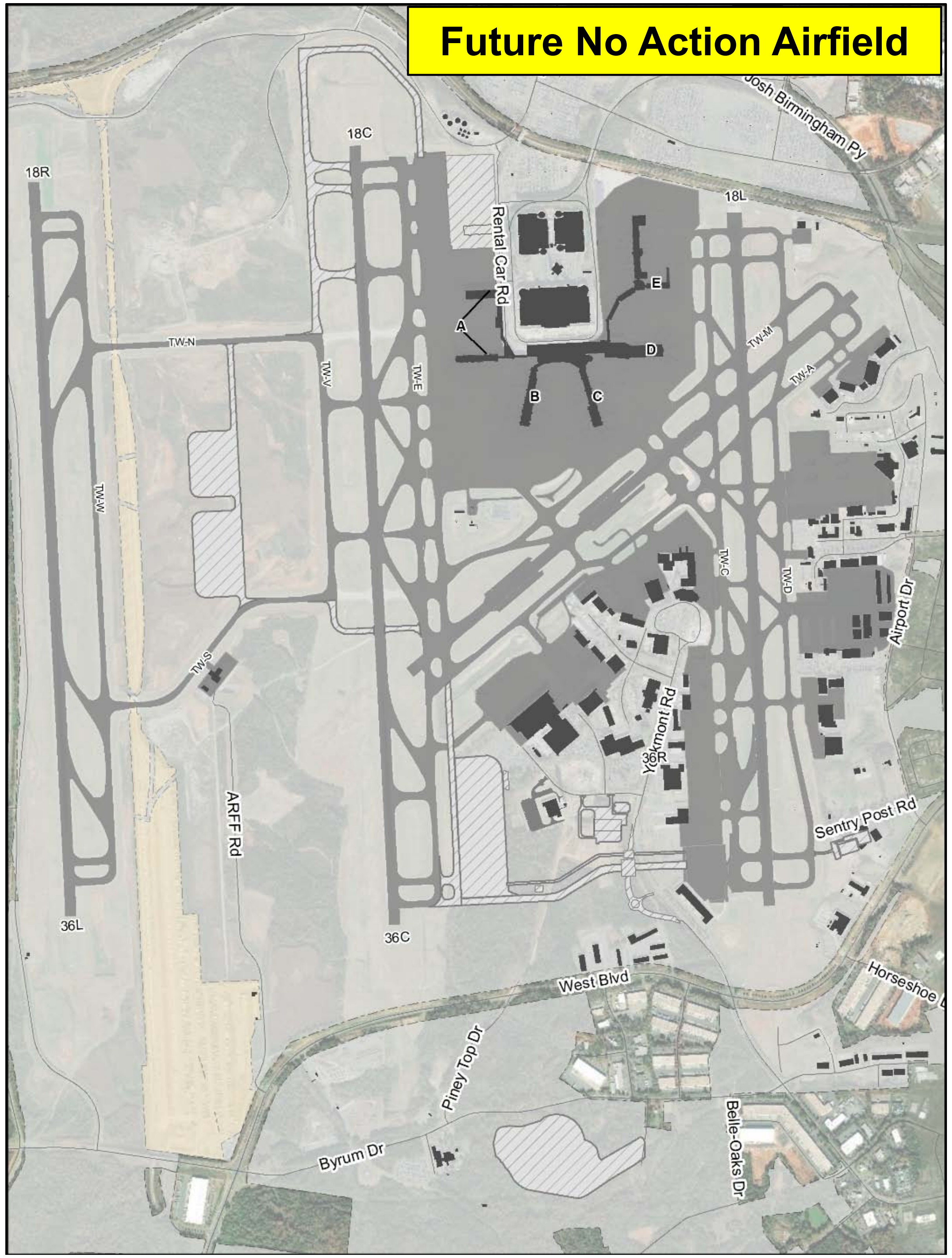


EA Process Overview

1. Conversion of EIS to EA
2. Confirm Purpose and Need
3. Develop Alternatives
4. Study Affected Environment
5. Analyze Environmental Impact
6. Identify Mitigation
7. Publish Draft EA
8. Public Review Period
9. Hold Public Hearings
10. Publish Final EA
11. FAA Issues the Federal Decision

EA Process Overview - Simulations

- Simulations will:
  - Be used in developing the Purpose and Need, noise modeling, and air quality modeling.
  - Conducted for the following scenarios:
    - 2016 Calibration
    - 2019 Baseline
    - 2028 Future No Action
    - 2033 Future No Action
    - 2028 Alternative(s)
    - 2033 Alternative(s)
  - Use forecast of operations approved by the FAA.
  - Include 3 independent projects as part of the Future No Action.
    - Deice Pad and crossfield taxiway
    - North End Around Taxiway around Runway 18C/36C, hold pads and threshold displacement (1,235 feet)
    - Concourse A Phase II



Future No Action Airfield

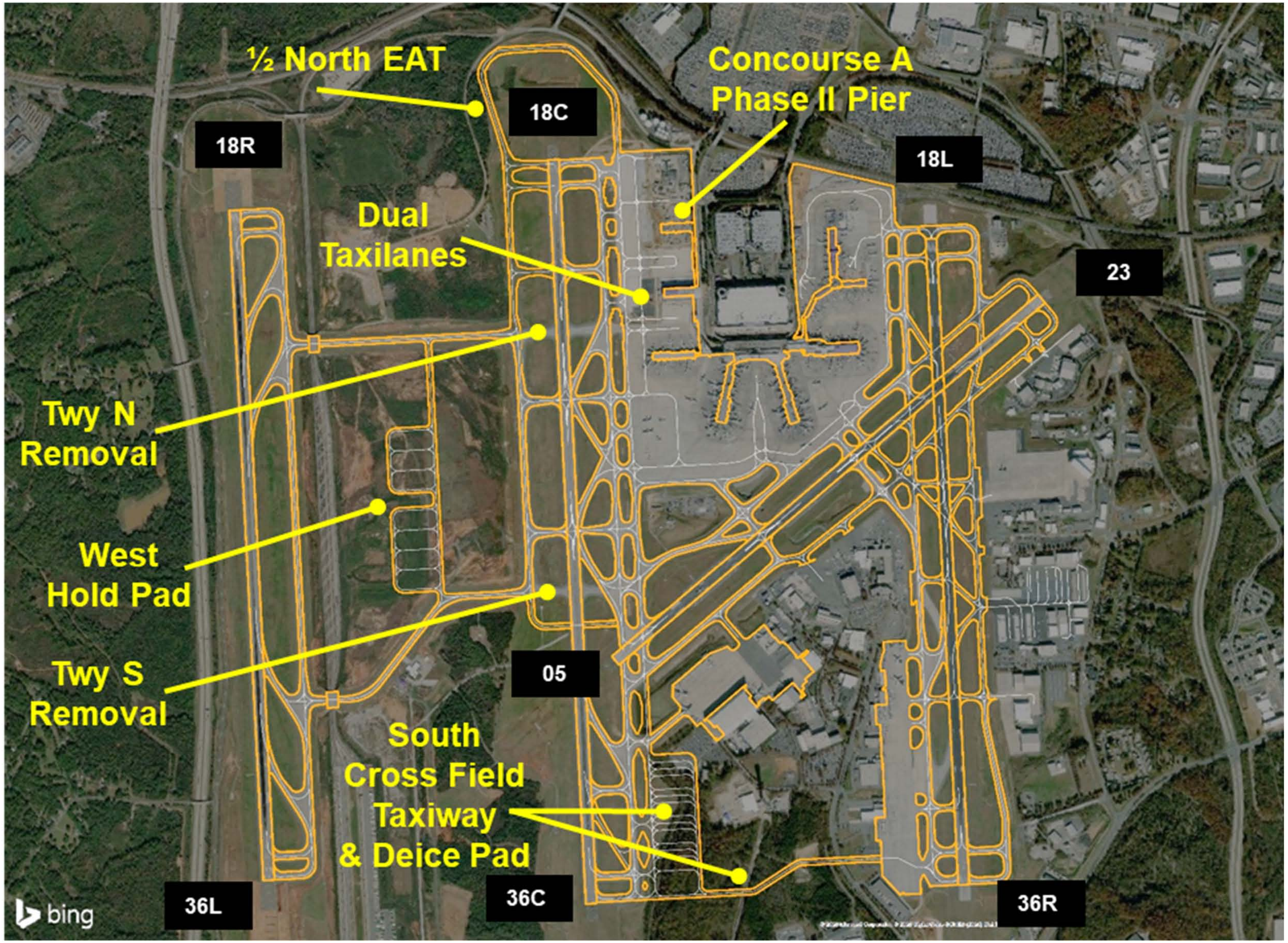
No Action Modeling Simulation Overview

Follow Up Comments Addressed From DORA #1

- The following items were identified for further discussion by Scott O’Halloran with FAA Local Air Traffic and have been addressed:
    - The use of the new west hold pads may be limited as most aircraft without a gate would have taxied past those positions by the time they are notified they need to hold.
    - The use of Taxiway B and west on Runway 05/23 was identified as a route that doesn’t happen or is not common within the existing airfield.
    - Safety issues regarding the Future No Action taxi flows in South Flow (i.e. the use of Taxiway B and Runway 05/23, the amount of flow on the ramp, and one-way flow on Taxiway E).

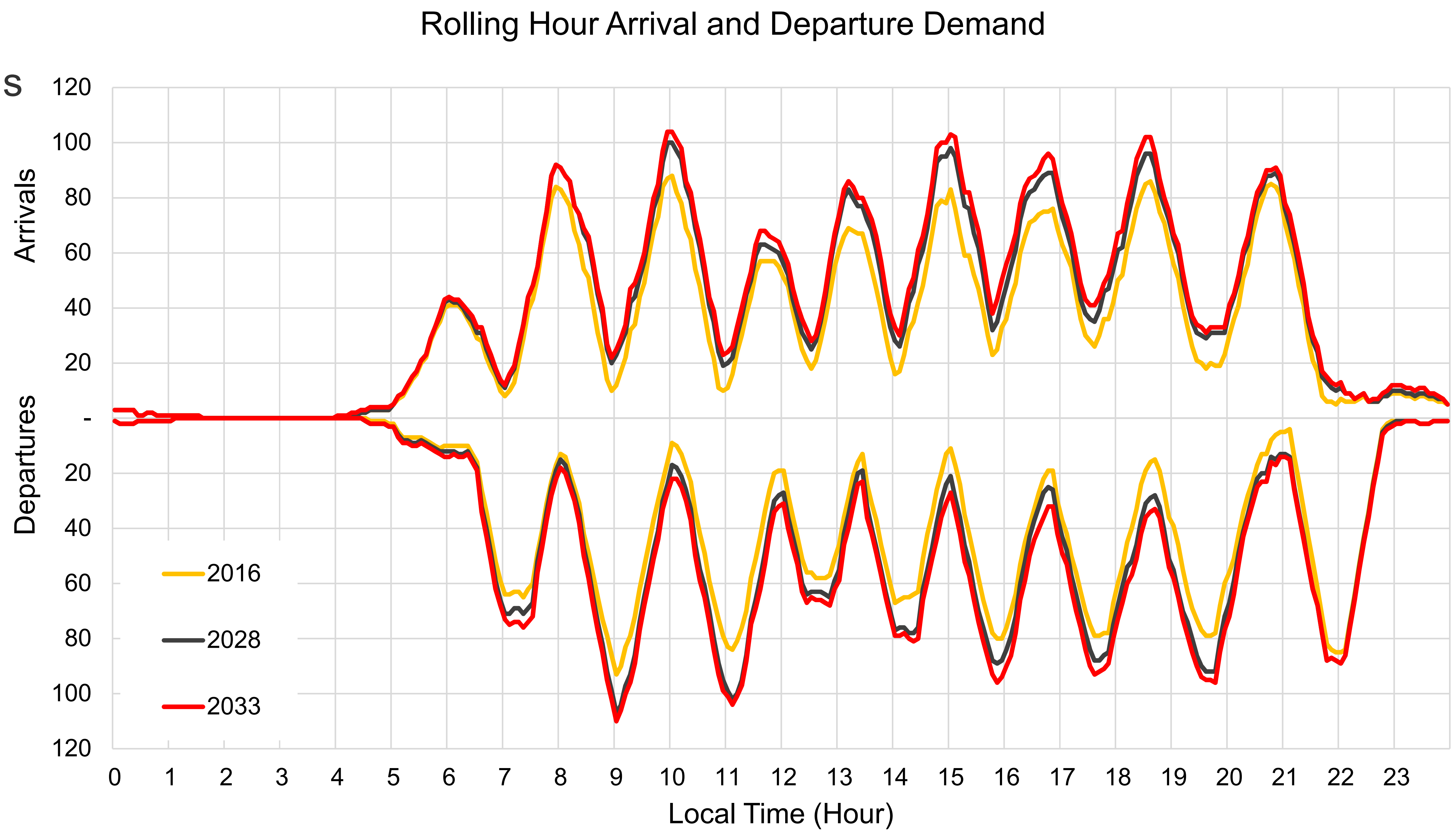
No Action Airfield Layout for Simulation

- **South Flow Experiments**
  - 2028 South VMC
  - 2028 South IMC
  - 2033 South VMC
  - 2033 South IMC
- **North Flow Experiments**
  - 2028 North VMC
  - 2028 North IMC
  - 2033 North VMC
  - 2033 North IMC



Simulation Flight Schedules

- Total Daily Operations
  - 2016: 1,563
  - 2028: 1,860
  - 2033: 1,978



Terminal/Concourse Layout Assumptions

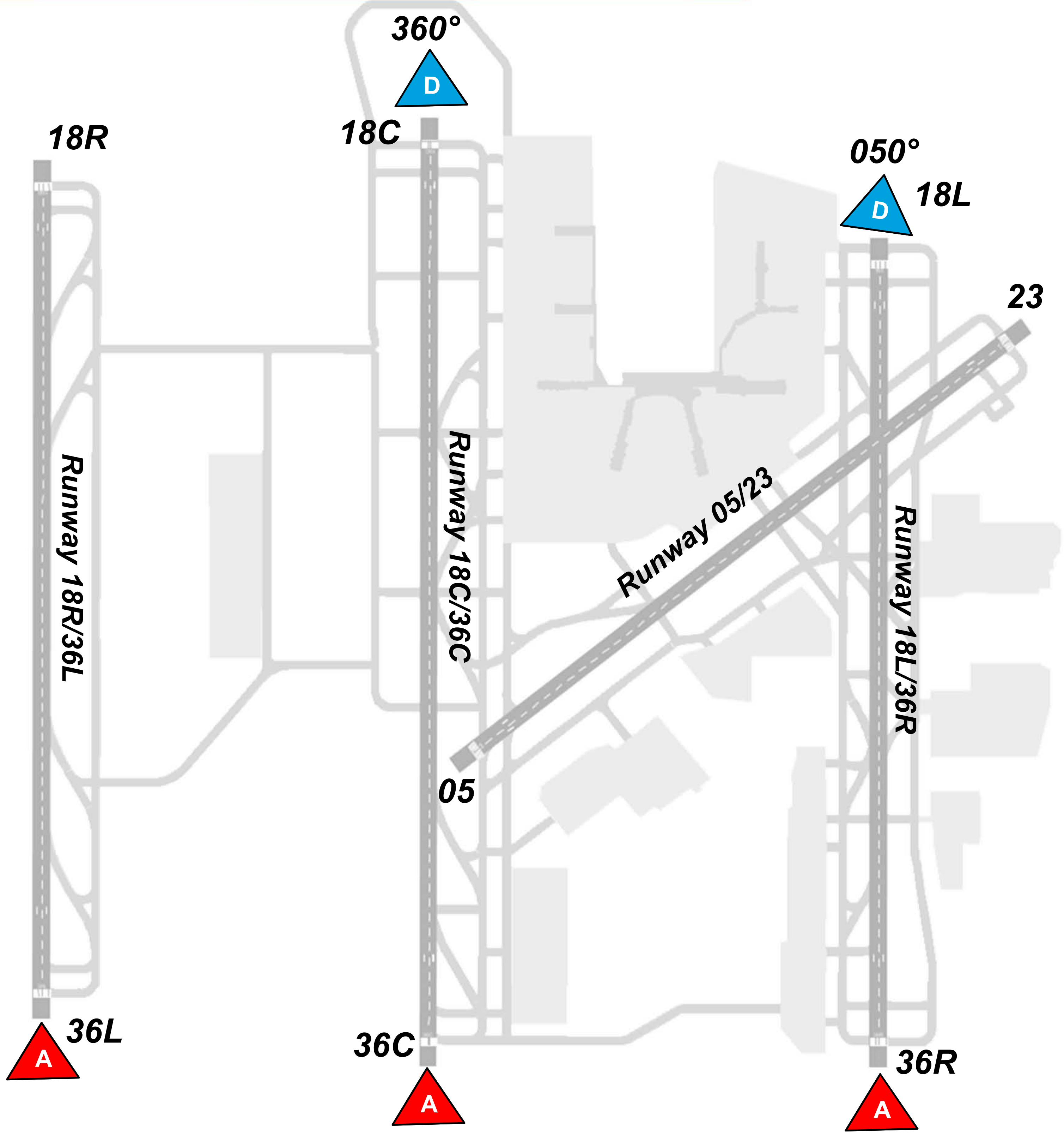
- Aircraft gate layouts will be input into AirTOp and will include airline assignment and aircraft size restrictions to simulate actual gate usage
- General Aviation and Cargo (FDX/UPS) operations were simulated and parked at their primary facility located on the existing airfield
- Aircraft holdpad and towing areas simulated
- Modeling of future gate capacity

Airline Gating Assignment Assumptions (2028/2033 Future No Action)	
Concourse A	AA
Concourse A (Phase 1 Expansion)	OALs
Concourse A (Phase 2 Expansion)	OALs
Concourse B & C	AA Mainline
Concourse D	AA Mainline, LH
Concourse E	AA Regional

North VMC/IMC Runway Configuration

- Primary Arrival Runways:
  - Runways 36L & 36R
  - Runway 36C (Trips)/Offload
- Primary Departure Runways:
  - Runway 36C – North & West
  - Runway 36C – International Heavy Eastbound
  - Runway 36R – East & South
  - Single jet departure heading, no fanning
  - Prop aircraft make turn immediately after becoming airborne
- Runway 05/23 is used as a taxiway

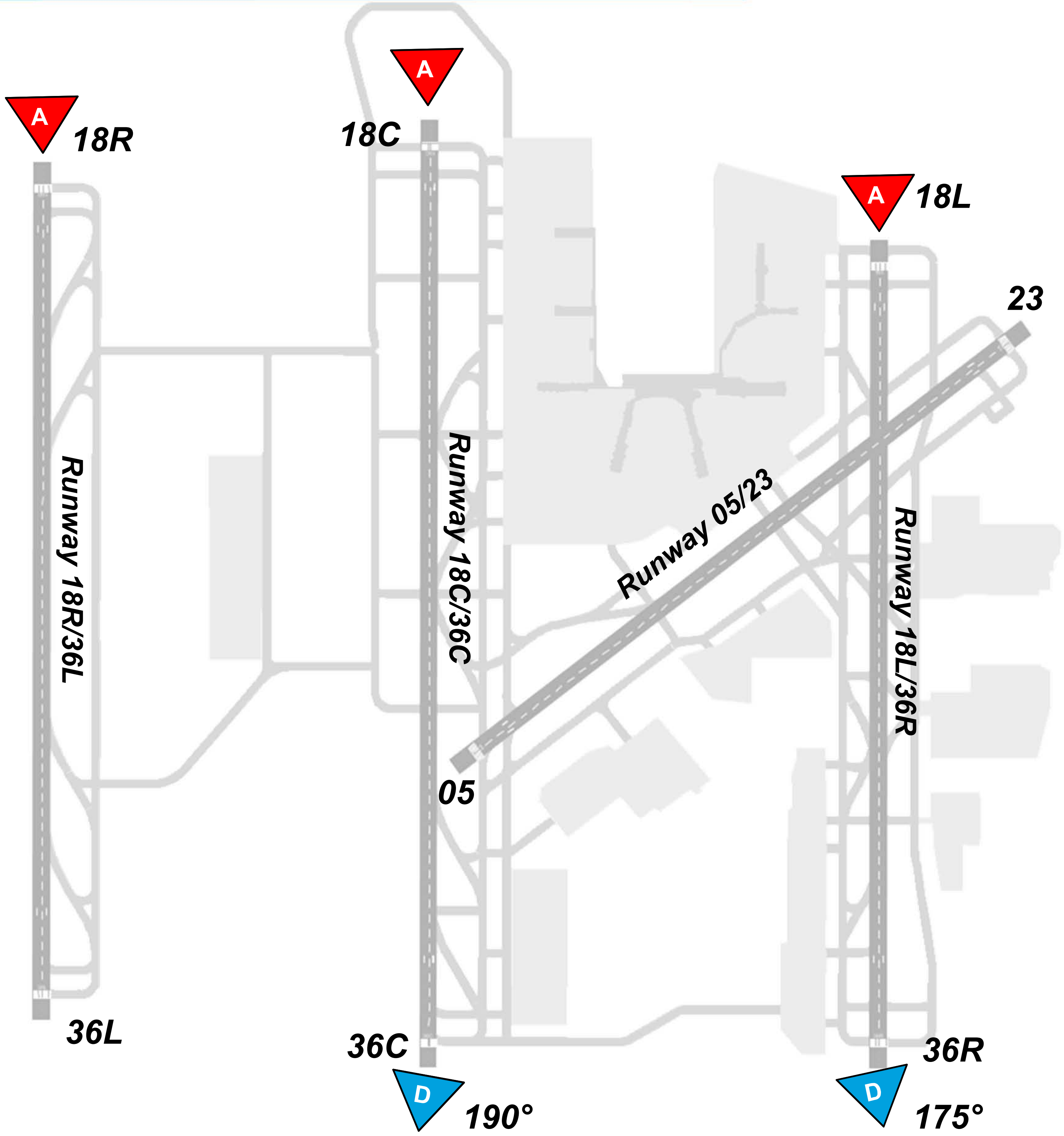
Configuration	36L, 36C, 36R	36C, 36R
	AAR	ADR
VMC	87	69
IMC	80	69



South VMC/IMC Runway Configuration

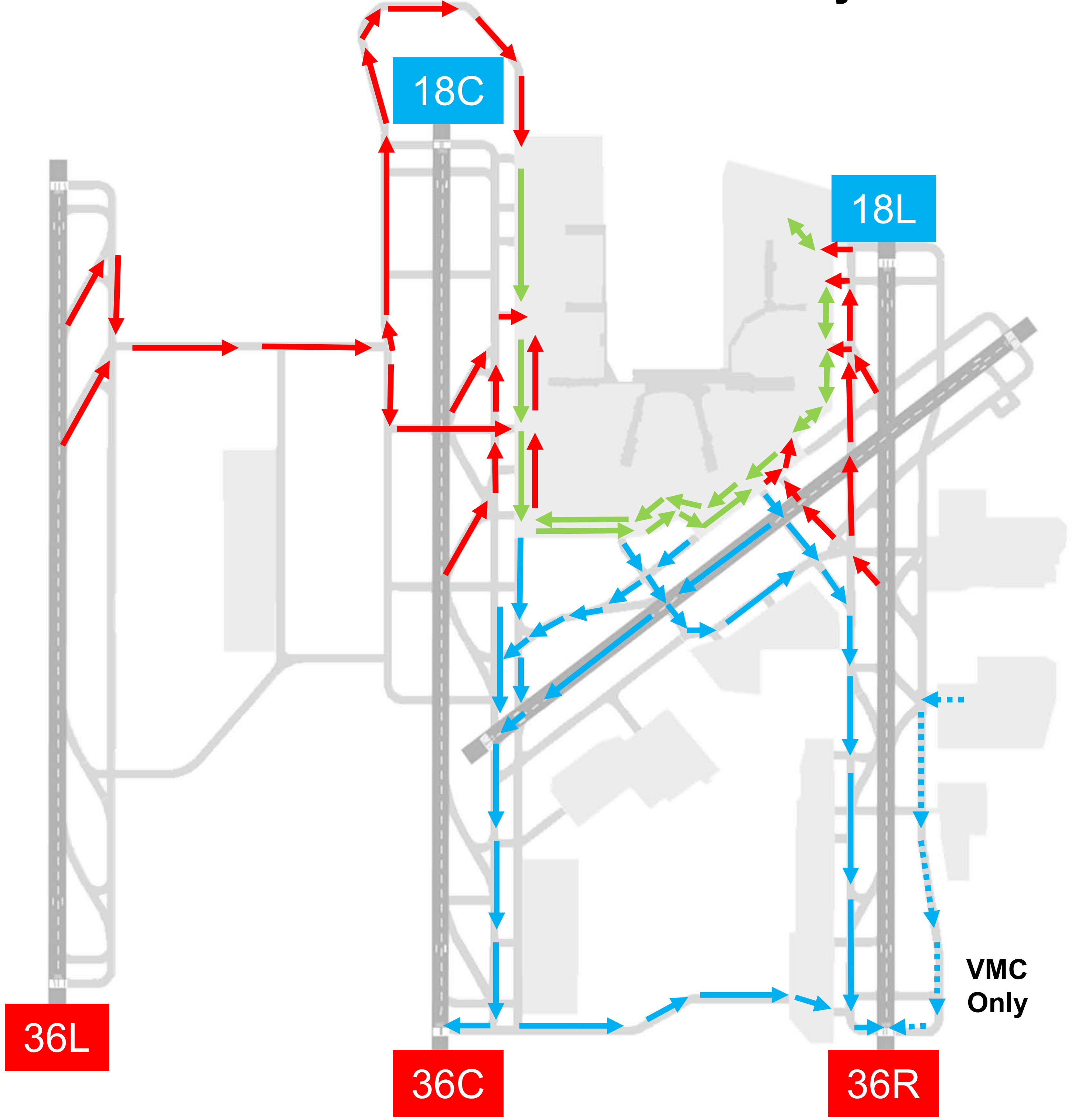
- Primary Arrival Runways:
  - Runways 18L & 18R
  - Runway 18C (Trips)/Offload
- Primary Departure Runways:
  - Runway 18C – North & West
  - Runway 18C – International Heavy Eastbound
  - Runway 18L – East & South
- Runway 05/23 is used as a taxiway

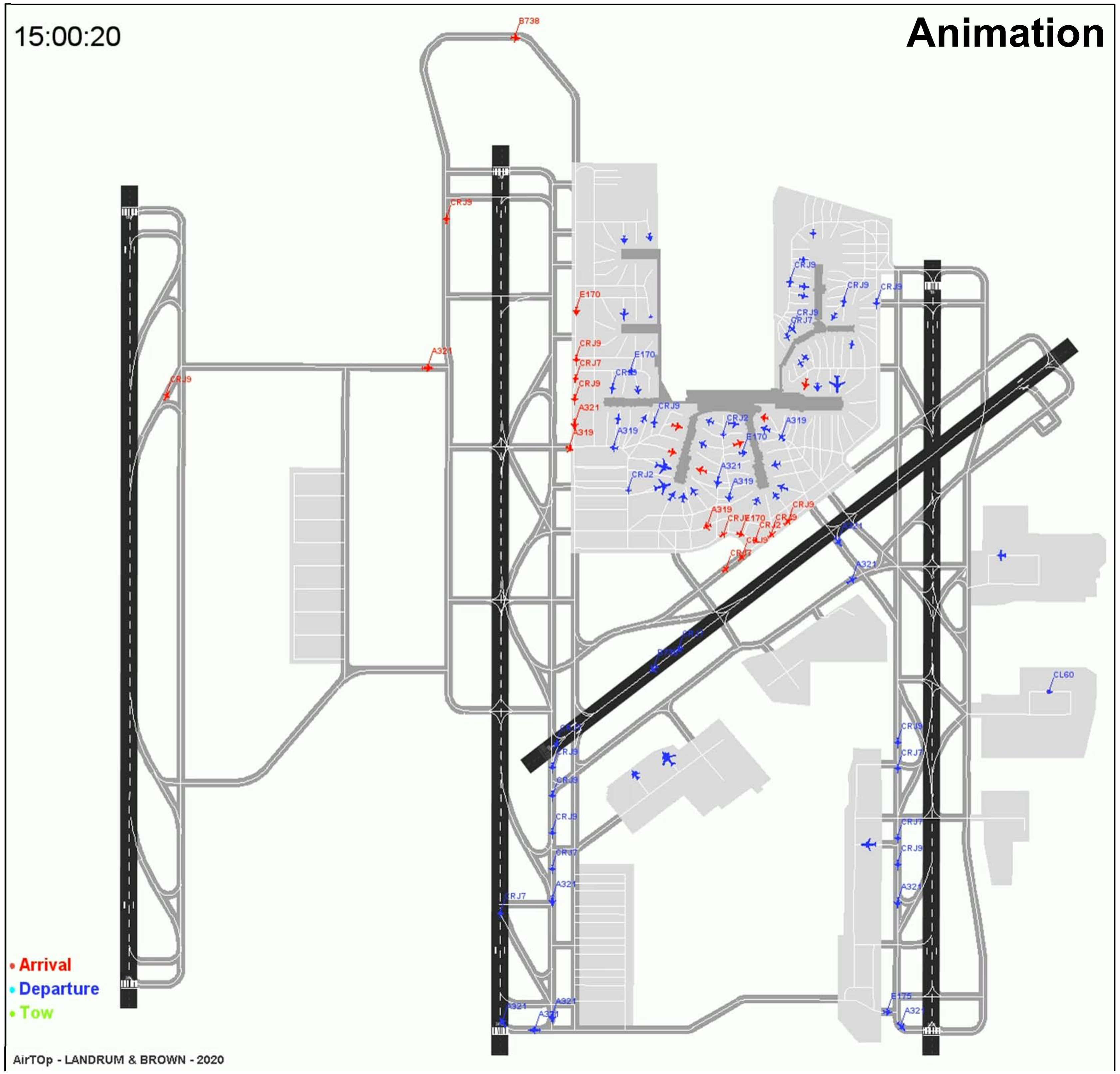
Configuration	18L, 18C, 18R	18C, 18L
	AAR	ADR
VMC	87	69
IMC	80	69



North Flow Aircraft Taxi Flow Animation

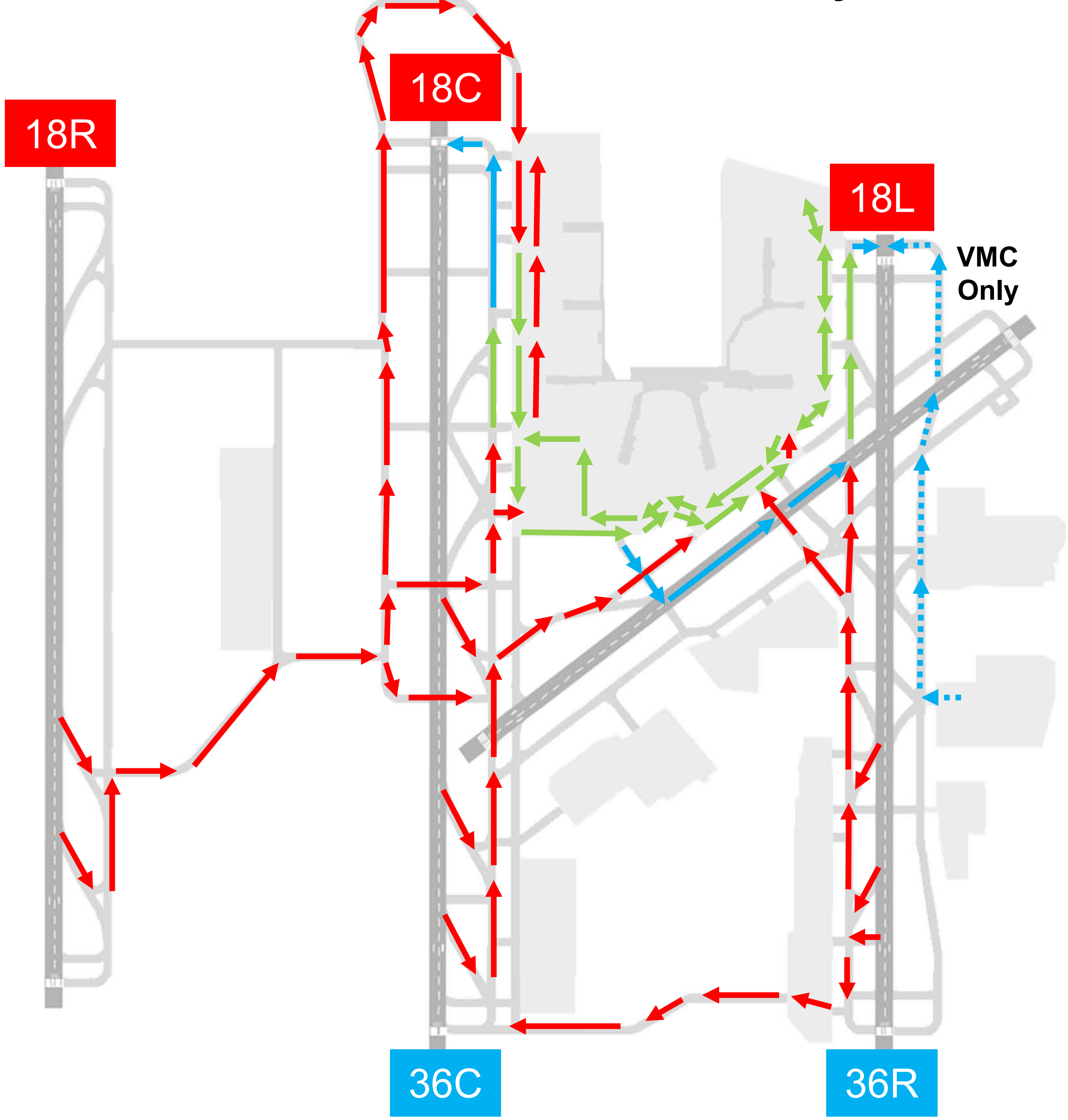
2028/2033 Future No Action Airfield Layout



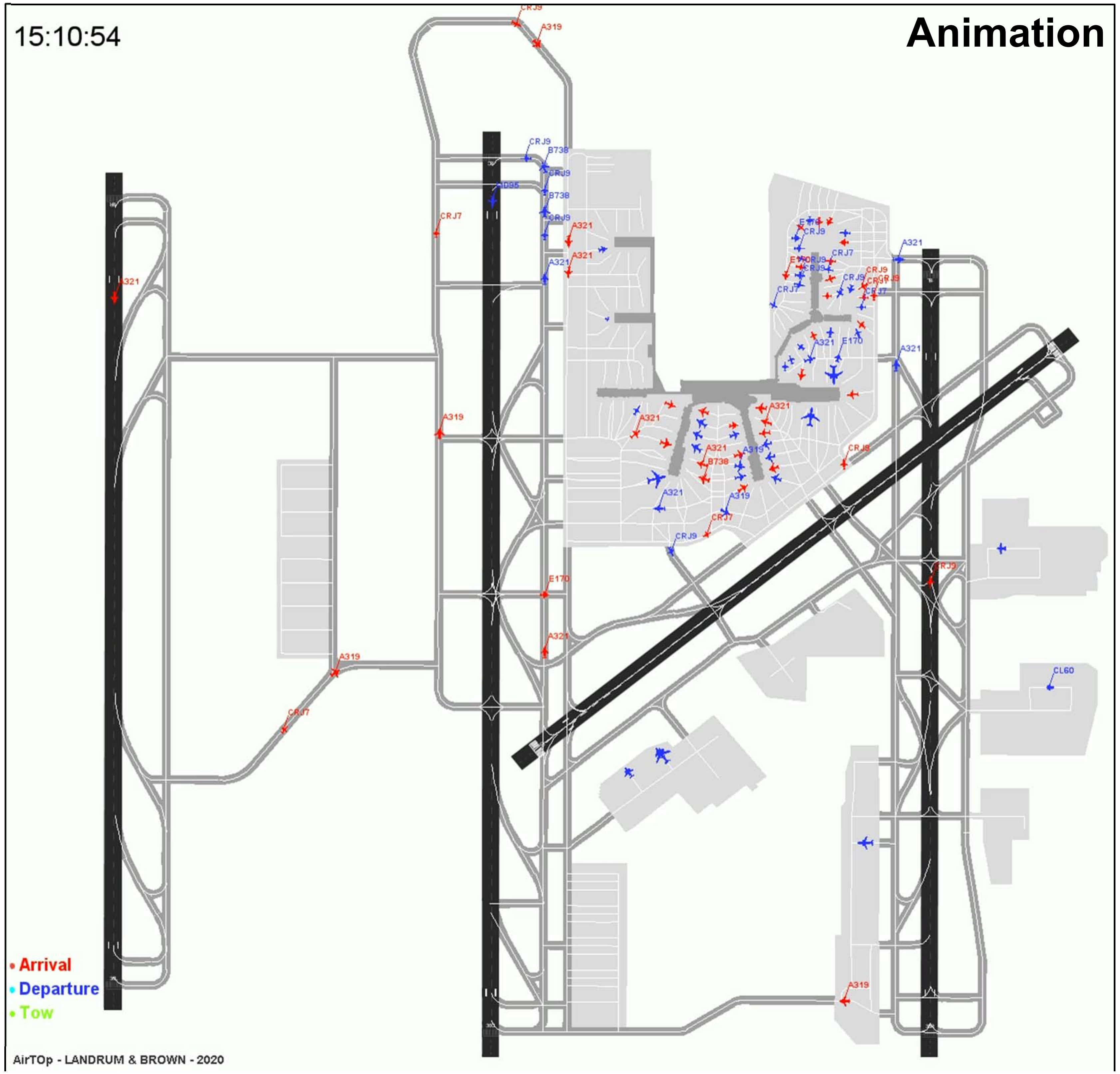


South Flow Aircraft Taxi Flow Animation

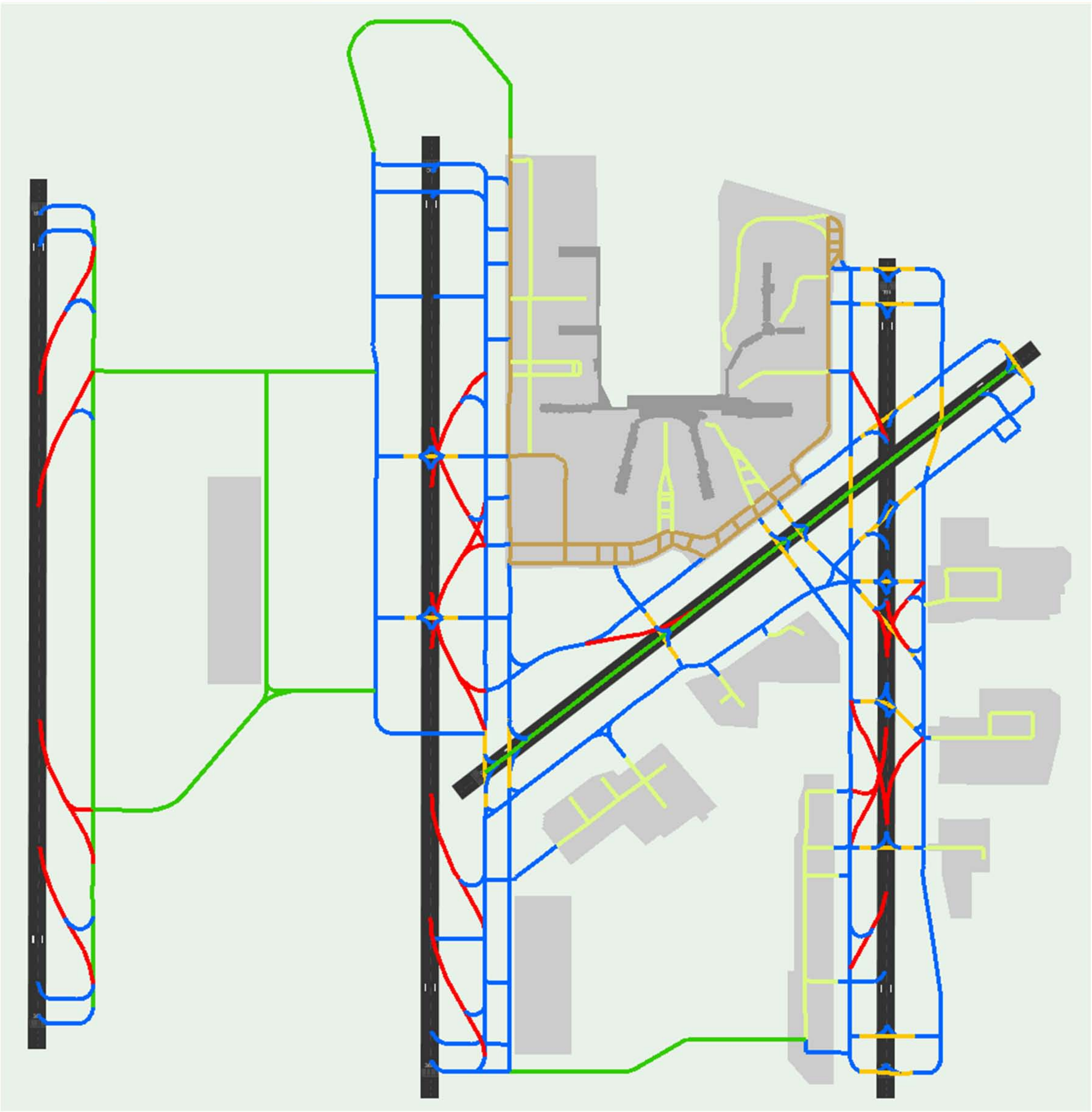
2028/2033 Future No Action Airfield Layout



Animation



Airfield Ground Speed Assumptions – Future No Action



High Speed Exits	🟥	32 knots
Outer Perimeter Taxiways*	🟩	20 knots
Runway Crossings	🟧	18 knots
Taxiways	🟦	15 knots
Ramp Area Taxilanes	🟫	12 knots
Ramp Area Taxilanes	🟨	10 knots

*North EAT and south cross field taxiway are also assumed to have 20 knot speed limits

No Action Airspace Operating Assumptions

Airspace Operating Assumptions/Overview

– Simulated airspace is the CLT Metroplex airspace that was modeled in the simulation calibration modeling analysis

– Existing radar data was analyzed and used to determine origin/destination city pair airspace fix assignments for input into the simulation flight schedule

– 6 nm intrail separations were applied at arrival corner post fixes for transition from the center airspace to the terminal environment

– When operating a mixed used runway operation, arrivals block departures 2.3 nm from the runway threshold

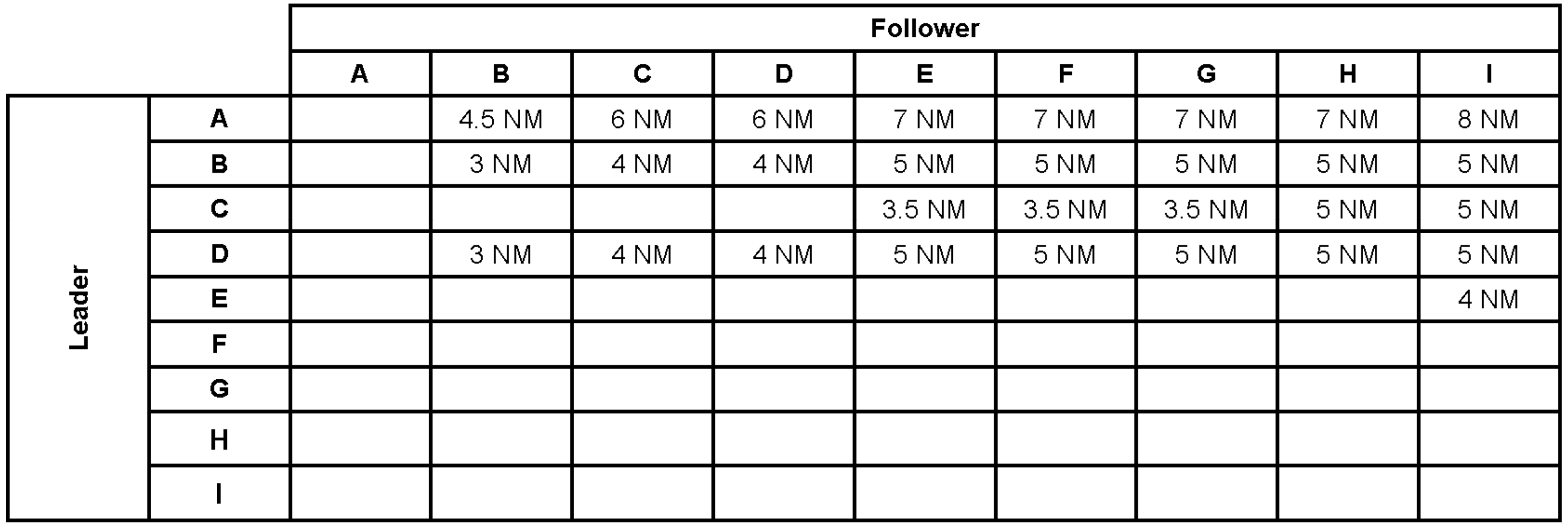
– During mixed arrival/departure operation, minimum of 4.5 nm arrival intrail separation is kept to ensure one departure between every arrival

Intrail Separation Minimums – Wake RECAT

- Simulation of FAA Wake RECAT separation criteria will be applied to the Baseline and Future No Action scenarios
- Previous simulation modeling and intrail separation analyses indicate minimum arrival separations on final approach range between 3.3nm (VMC) and 3.8nm (IMC)

TBL 5–5–1

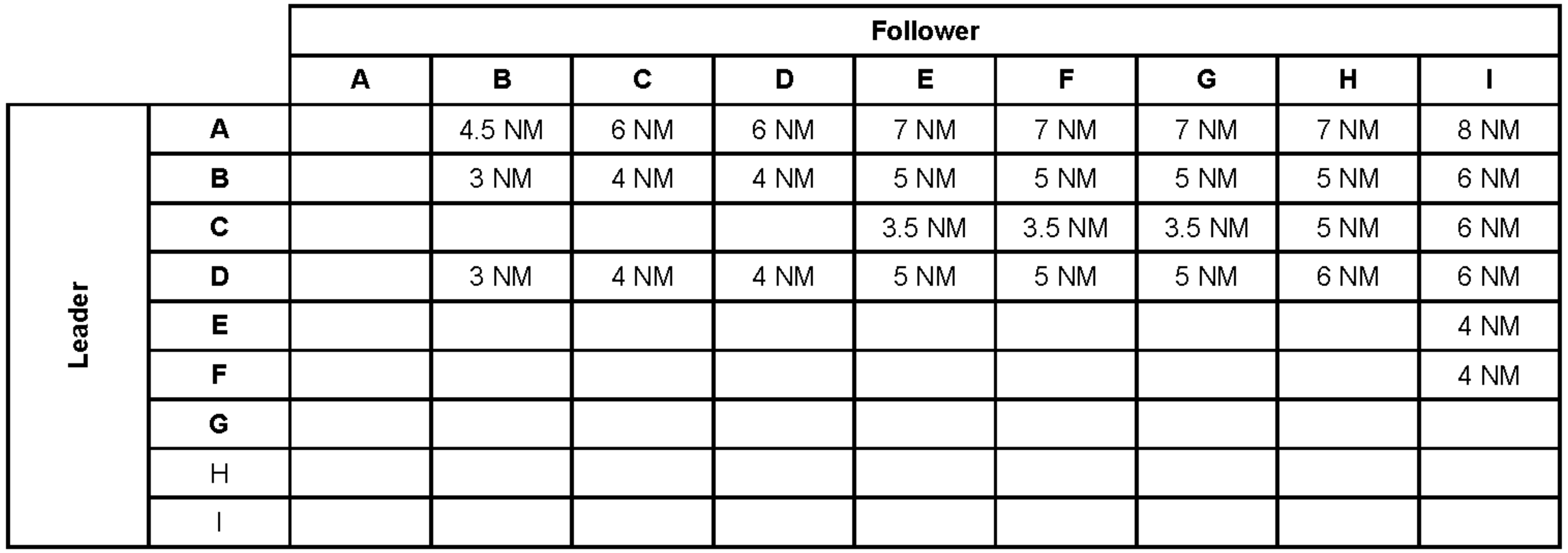
Wake Turbulence Separation for Directly Behind



		Follower								
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Leader	**A**		4.5 NM	6 NM	6 NM	7 NM	7 NM	7 NM	7 NM	8 NM
	B		3 NM	4 NM	4 NM	5 NM	5 NM	5 NM	5 NM	5 NM
	C					3.5 NM	3.5 NM	3.5 NM	5 NM	5 NM
	D		3 NM	4 NM	4 NM	5 NM	5 NM	5 NM	5 NM	5 NM
	E									4 NM
	F									
	G									
	H									
	I									

TBL 5–5–2

Wake Turbulence Separation for On Approach



		Follower								
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Leader	**A**		4.5 NM	6 NM	6 NM	7 NM	7 NM	7 NM	7 NM	8 NM
	B		3 NM	4 NM	4 NM	5 NM	5 NM	5 NM	5 NM	6 NM
	C					3.5 NM	3.5 NM	3.5 NM	5 NM	6 NM
	D		3 NM	4 NM	4 NM	5 NM	5 NM	5 NM	6 NM	6 NM
	E									4 NM
	F									4 NM
	G									
	H									
	I									

Source: JO 7110.126A - Consolidated Wake Turbulence (CWT) Separation Standards
Effective Date: September 28, 2019

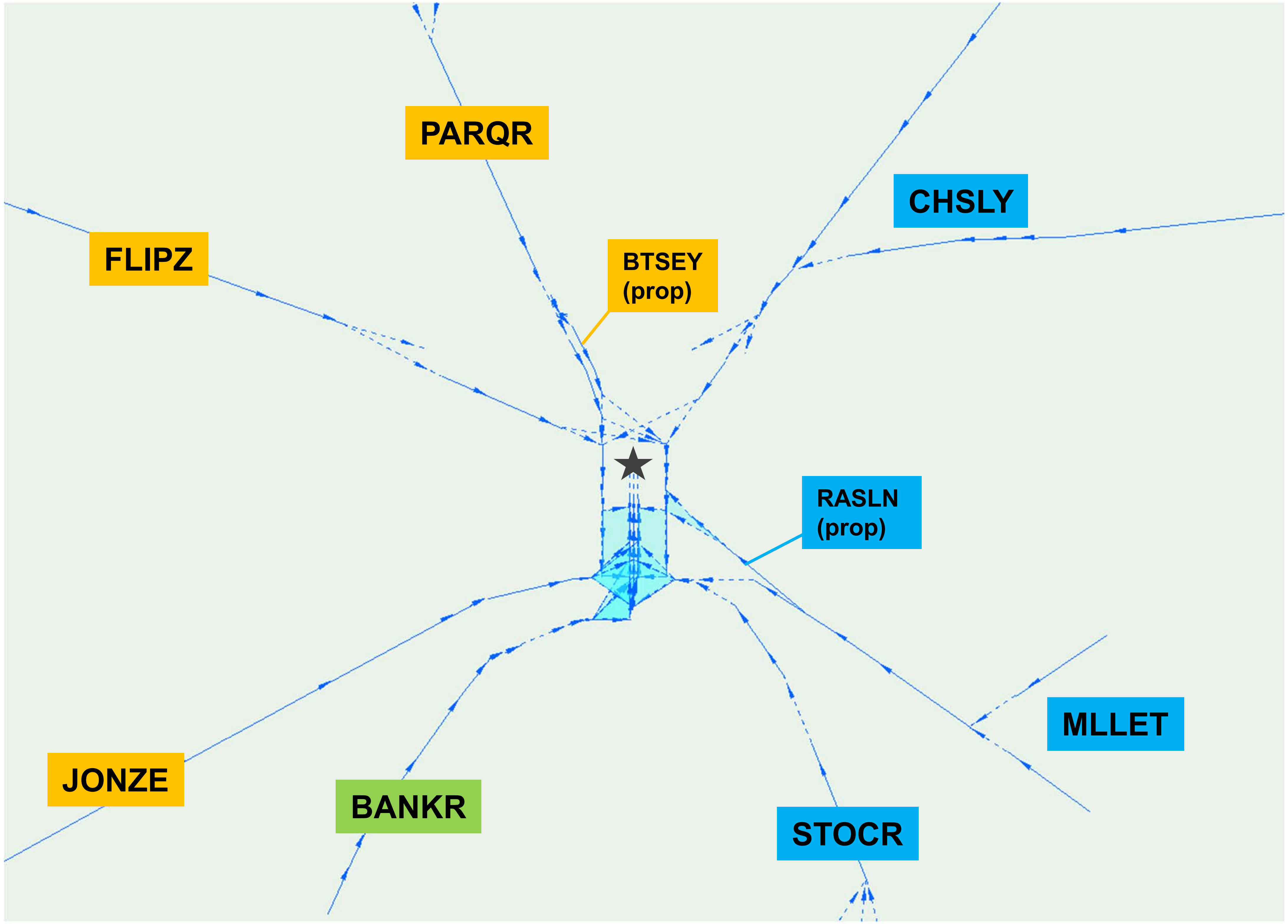
Sample Airport Route/City Pairs

Arrival Route	Origin Examples*
North	
PARQR TAFTT	MDW, CLE, MSP, ORD, SEA
East	
CHSLY LYH	BOS, EWR, FRA, JFK, LHR
South	
BANKR	JAX, MIA
West	
JONZE BESTT	ATL, IAH, MEX
FLIPZ COMDY	DEN, DFW, LAX, PDX, SFO

Departure Route	Destination Examples*
North	
JOJJO DODGE	MDW, ORD, PDX, SEA
KRITR FILDS	BUF, PIT, YYZ
East	
KILNS	BWI, IAD, EWR, PHL
BARMY RDU	BOS, FRA, LGA
South	
ICONS	JAX, MIA
West	
ESTRR	AUS, DAL, IAH, MEX
BOBZY BNA	DEN, DFW, LAX, PHX, SFO

*Note that these lists are not all-inclusive. They merely contain examples of some of the major airports that use each route.

North Flow Arrival Airspace



🟧 **Runway 36L**

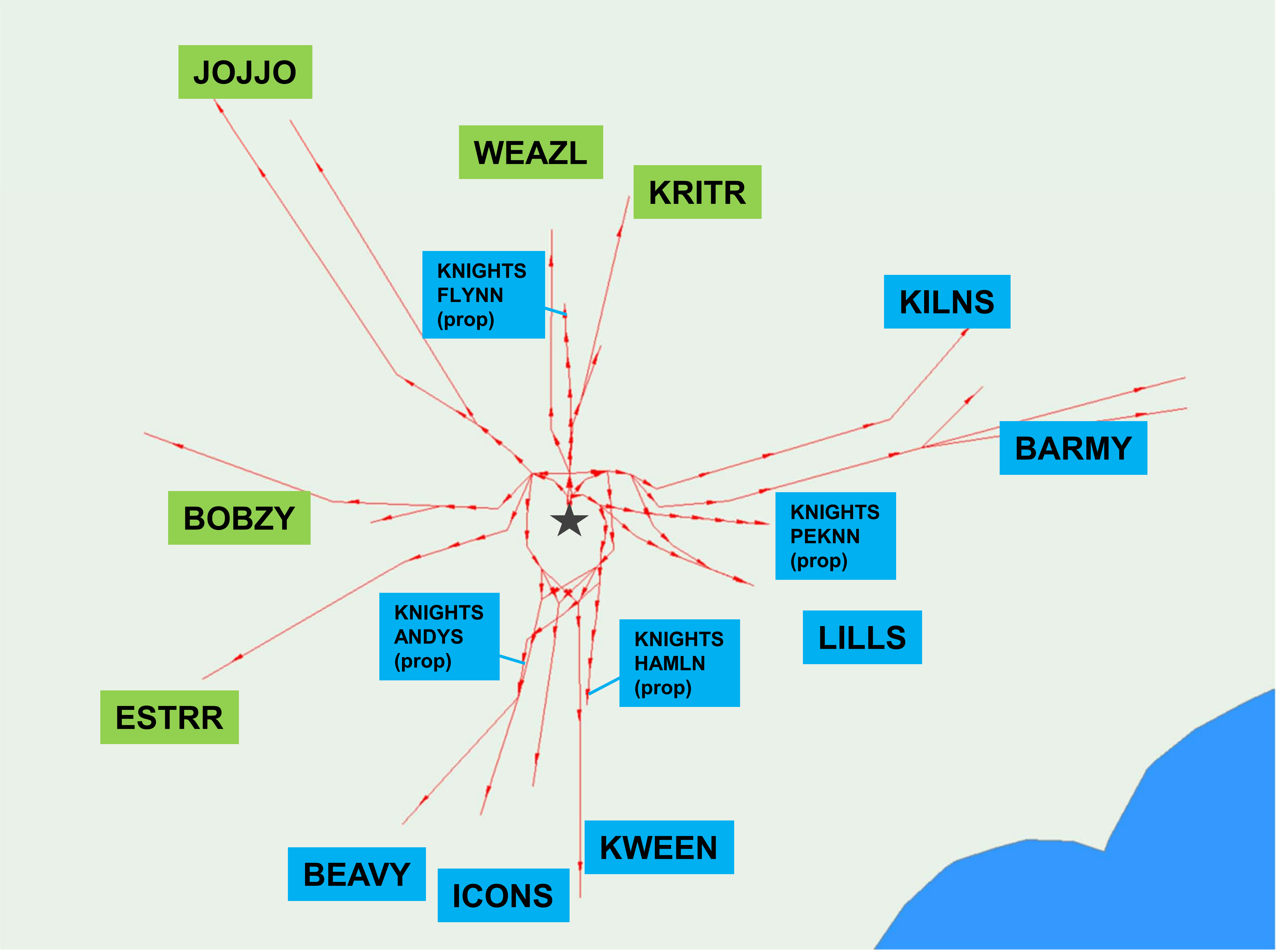
🟦 **Runway 36R**

🟩 **Runway 36C**

★ **CLT**

Note: Arrivals can be offloaded to other runways during busy periods

North Flow Departure Airspace



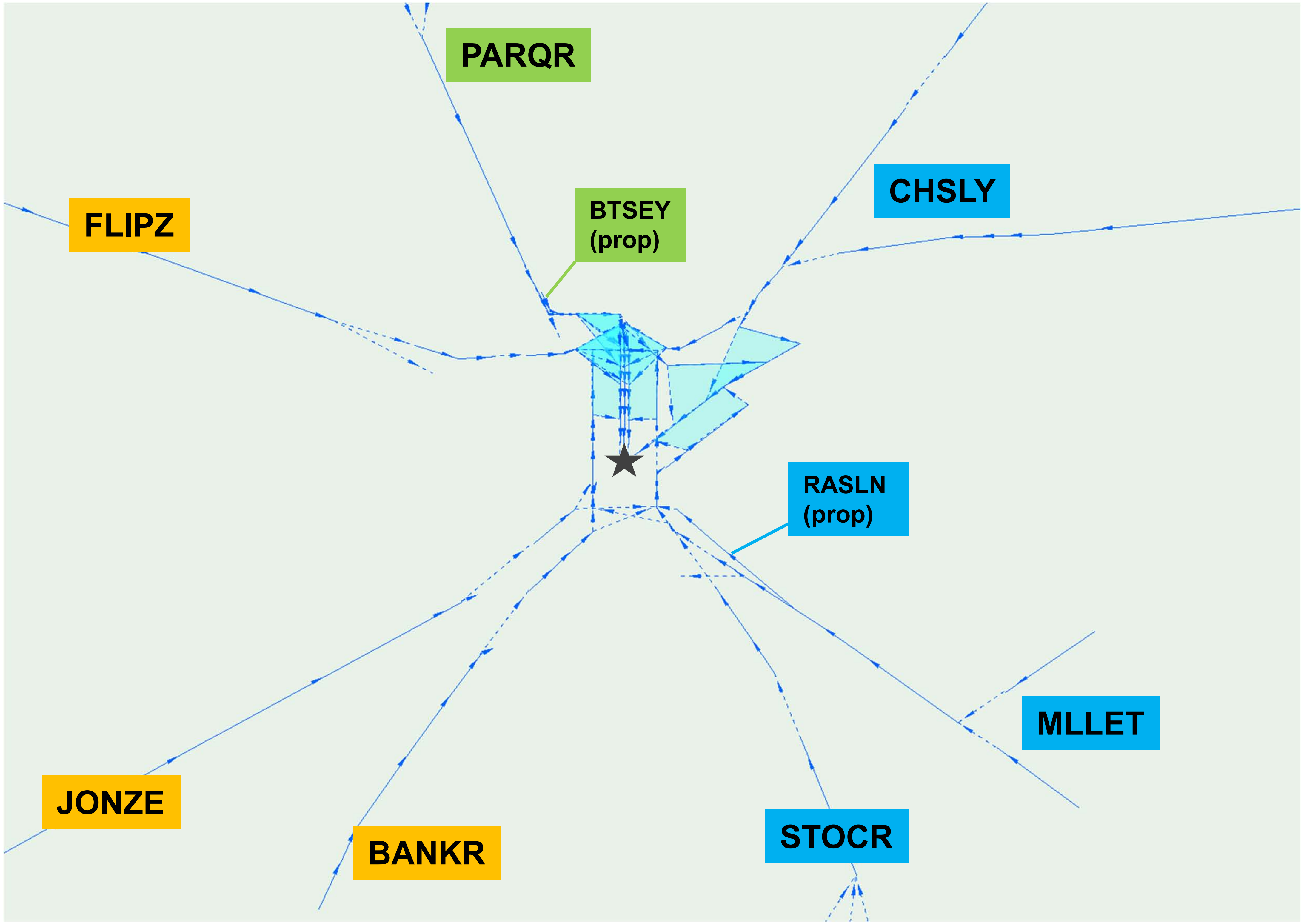
🟦 **Runway 36R**

🟩 **Runway 36C**

★ **CLT**

Note: BEAVY and ICONS departures can be offloaded to 36C during busy periods

South Flow Arrival Airspace



🟨 **Runway 18R**

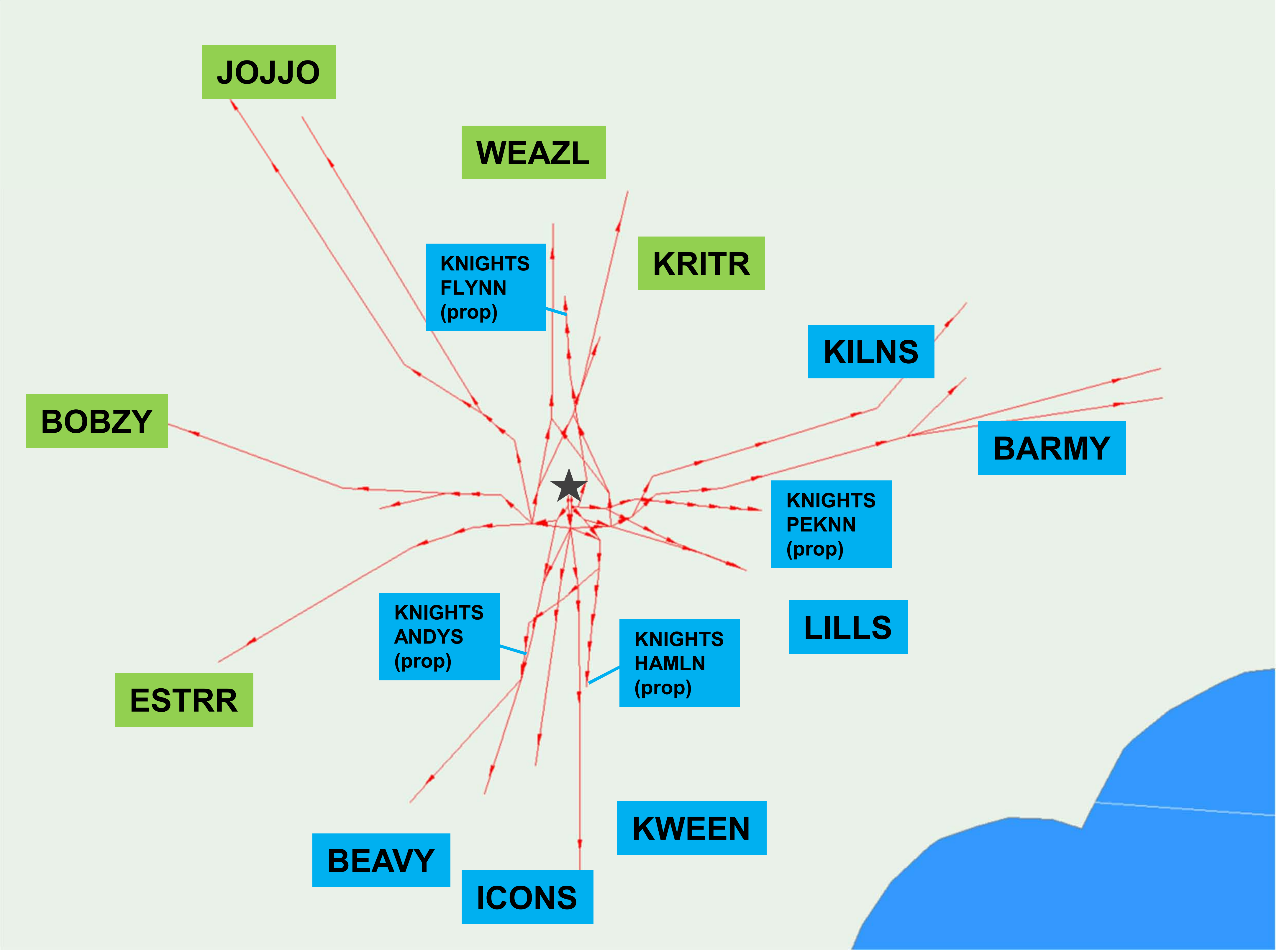
🟦 **Runway 18L**

🟩 **Runway 18C**

★ **CLT**

Note: Arrivals can be offloaded to other runways during busy periods

South Flow Departure Airspace



🟦 **Runway 18L**

🟩 **Runway 18C**

★ **CLT**

Note: BEAVY and ICONS departures can be offloaded to 18C during busy periods

No Action Simulation Modeling Results

No Action Simulated Airport Throughput

- A key metric in the simulation analysis is an assessment of the peak hour and total airport throughput achieved in each scenario simulated
- While the maximum throughput is achievable under certain circumstances, it is not a good indication of capacity. Therefore, the 90th percentile hourly rates is used as a measure of capacity per previous DORA stakeholder group recommendations

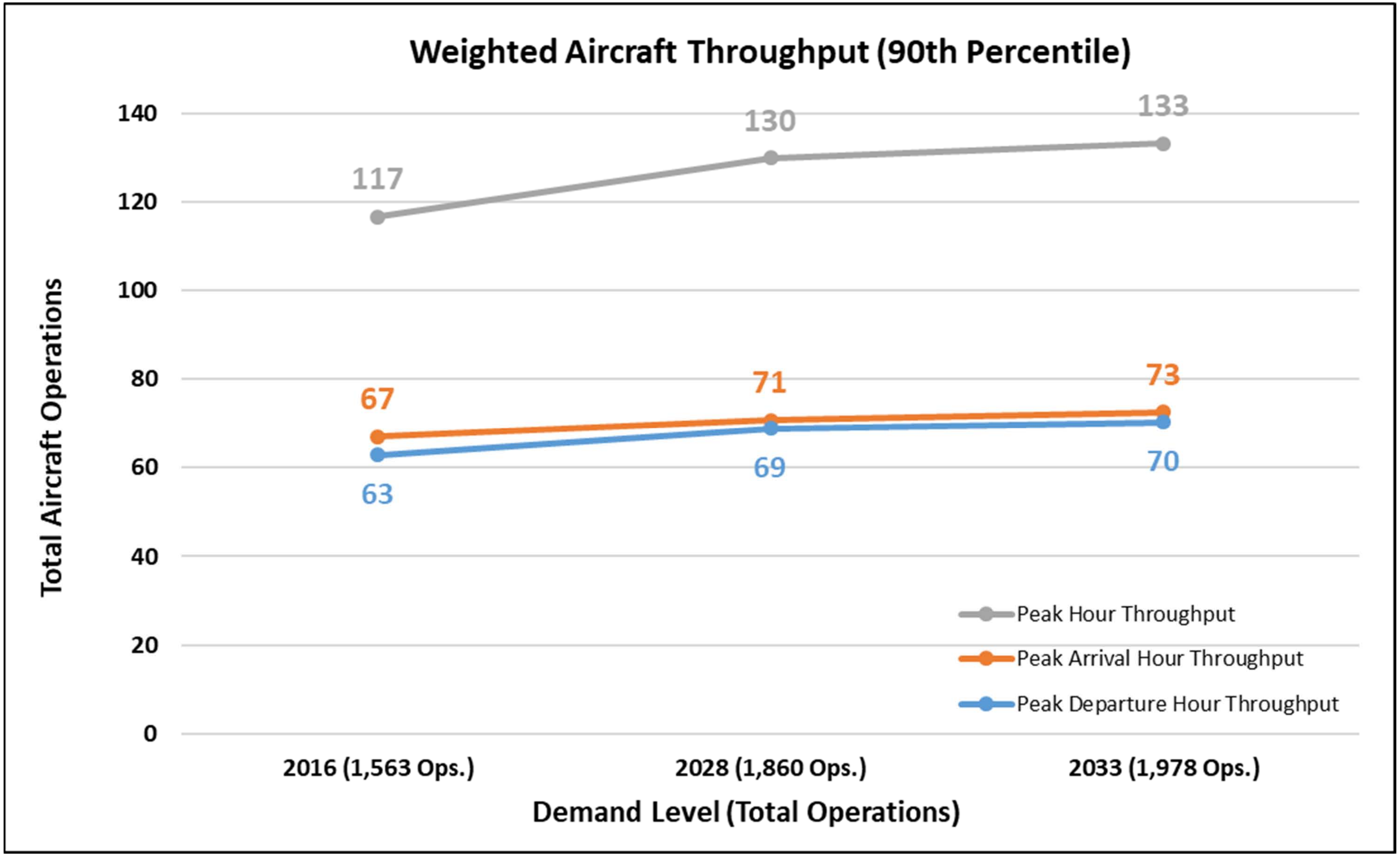
90th Percentile Simulated Throughput			
	2016 (1,563 ops.)	2028 (1,860 ops.)	2033 (1,978 ops.)
Peak Hour (Arr. & Deps.)	117	130	133
Peak Hour Arrival	67	71	73
Peak Hour Departure	63	69	70

Maximum Simulated Throughput			
	2016	2028	2033
Peak Hour (Arr. & Deps.)	127	140	140
Peak Hour Arrival	76	78	79
Peak Hour Departure	82	85	86

Annualized Call Rates*	
AAR	86
ADR	69

* Annualized based on the most frequent called rate for each ASPM configurations and configuration use percentage for 2019

No Action Weighted Aircraft Throughput



No Action Simulation Modeling Results

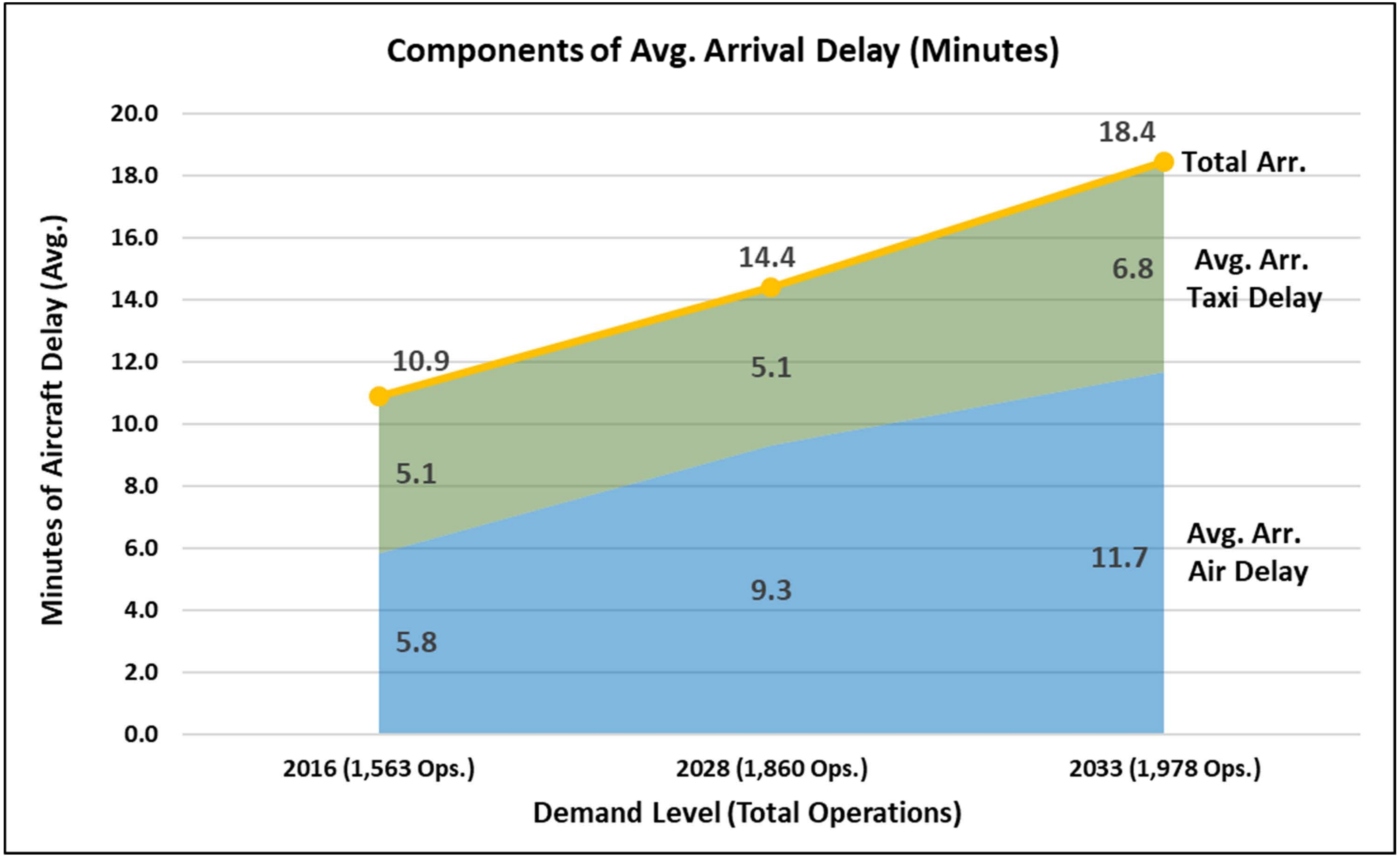
- Aircraft delay and taxi time metrics are presented for each simulated demand level and runway configuration
- Annualization is calculated by averaging the metrics using the runway configuration use percentage for 2019
  - North VMC: 51.8%
  - North IMC: 11.7%
  - South VMC: 27.5%
  - South IMC: 9.0%

* Based on ASPM configurations and called rates

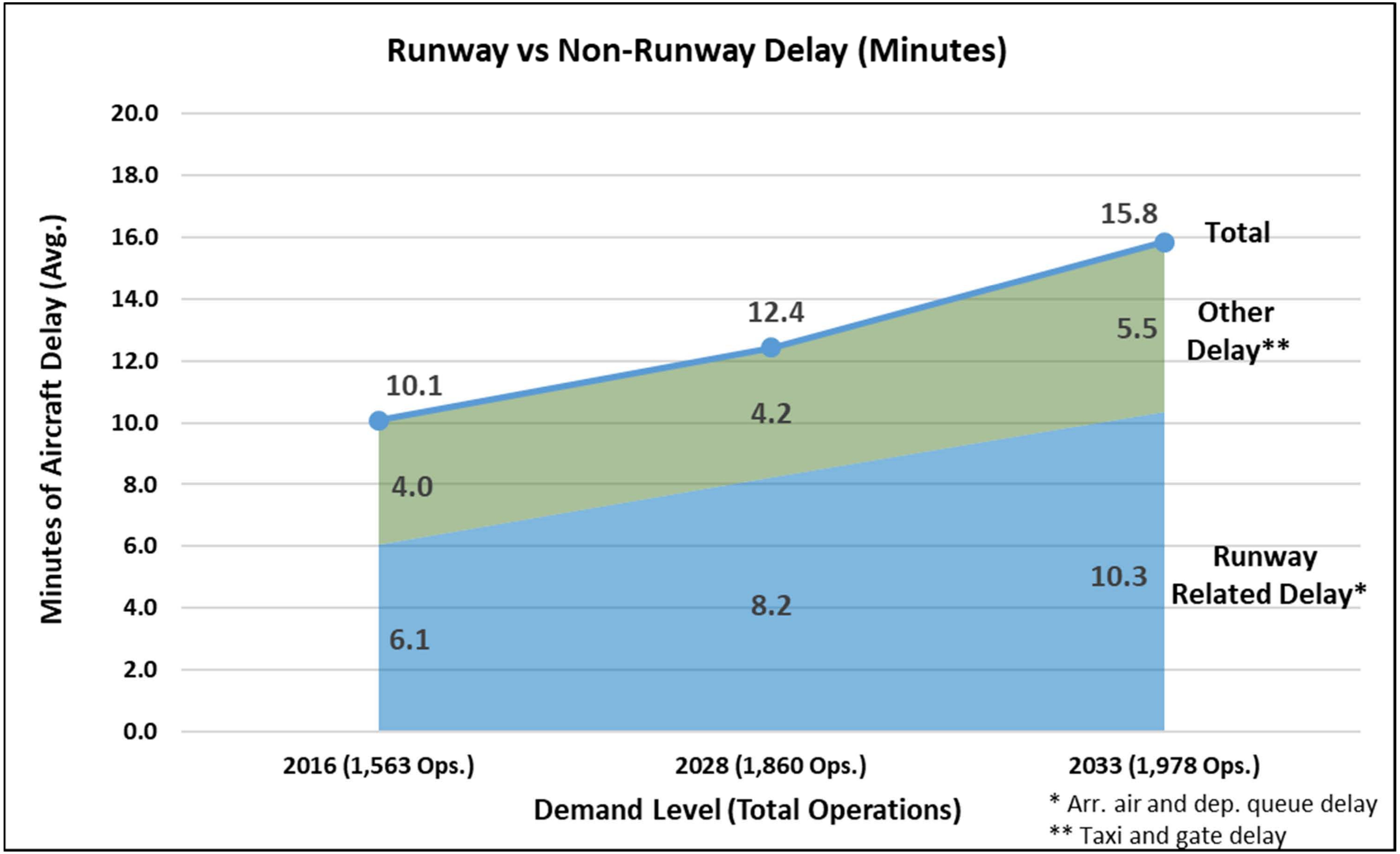
	2028 Demand Level (1,860 Daily Ops.)				
Metrics	**North VMC**	**North IMC**	**South VMC**	**South IMC**	***Annualization***
Avg. arrival taxi time (total)	13.7	14.6	15.0	15.8	14.4
Avg. arrival taxi time (unimpeded)	8.7	8.6	10.4	10.4	9.3
Avg. arrival taxi delay	5.1	6.0	4.6	5.4	5.1
Avg. departure taxi time (total)	21.5	25.6	18.3	21.8	21.1
Avg. departure taxi time (unimpeded)	13.5	13.6	11.5	11.6	12.8
Avg. departure taxi delay	8.0	12.0	6.8	10.1	8.3
Avg. taxi time	**17.6**	**20.1**	**16.6**	**18.8**	**17.7**
Avg. arrival air delay	8.4	10.7	10.1	10.6	9.3
Avg. arrival delay	13.5	16.8	14.6	16.0	14.4
Avg. departure ground delay	9.8	14.3	9.3	12.8	10.5
Avg. aircraft delay	**11.6**	**15.5**	**12.0**	**14.4**	**12.4**

	2033 Demand Level (1,978 Daily Ops.)				
Metrics	**North VMC**	**North IMC**	**South VMC**	**South IMC**	***Annualization***
Avg. arrival taxi time (total)	15.4	15.8	17.6	17.9	16.3
Avg. arrival taxi time (unimpeded)	8.9	8.8	10.7	10.7	9.5
Avg. arrival taxi delay	6.6	7.0	6.9	7.3	6.8
Avg. departure taxi time (total)	23.6	28.7	19.8	25.0	23.3
Avg. departure taxi time (unimpeded)	13.5	13.7	11.6	11.8	12.9
Avg. departure taxi delay	10.1	14.9	8.1	13.2	10.4
Avg. taxi time	**19.5**	**22.2**	**18.7**	**21.5**	**19.8**
Avg. arrival air delay	9.8	15.1	12.7	14.5	11.7
Avg. arrival delay	16.4	22.1	19.7	21.7	18.4
Avg. departure ground delay	12.5	17.9	11.4	17.1	13.2
Avg. aircraft delay	**14.5**	**20.0**	**15.5**	**19.4**	**15.8**

No Action Average Arrival Delay



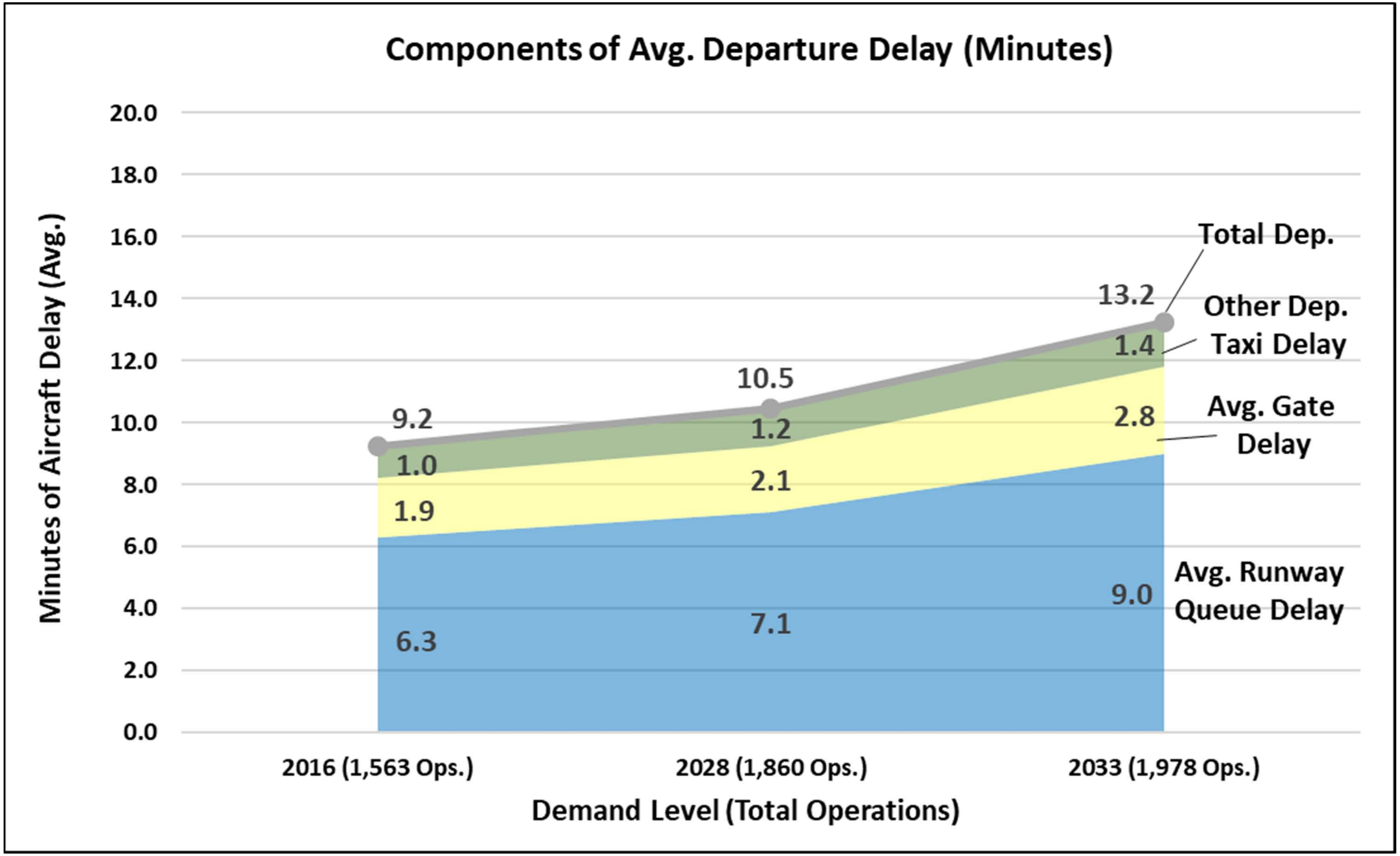
No Action Average Aircraft Delay



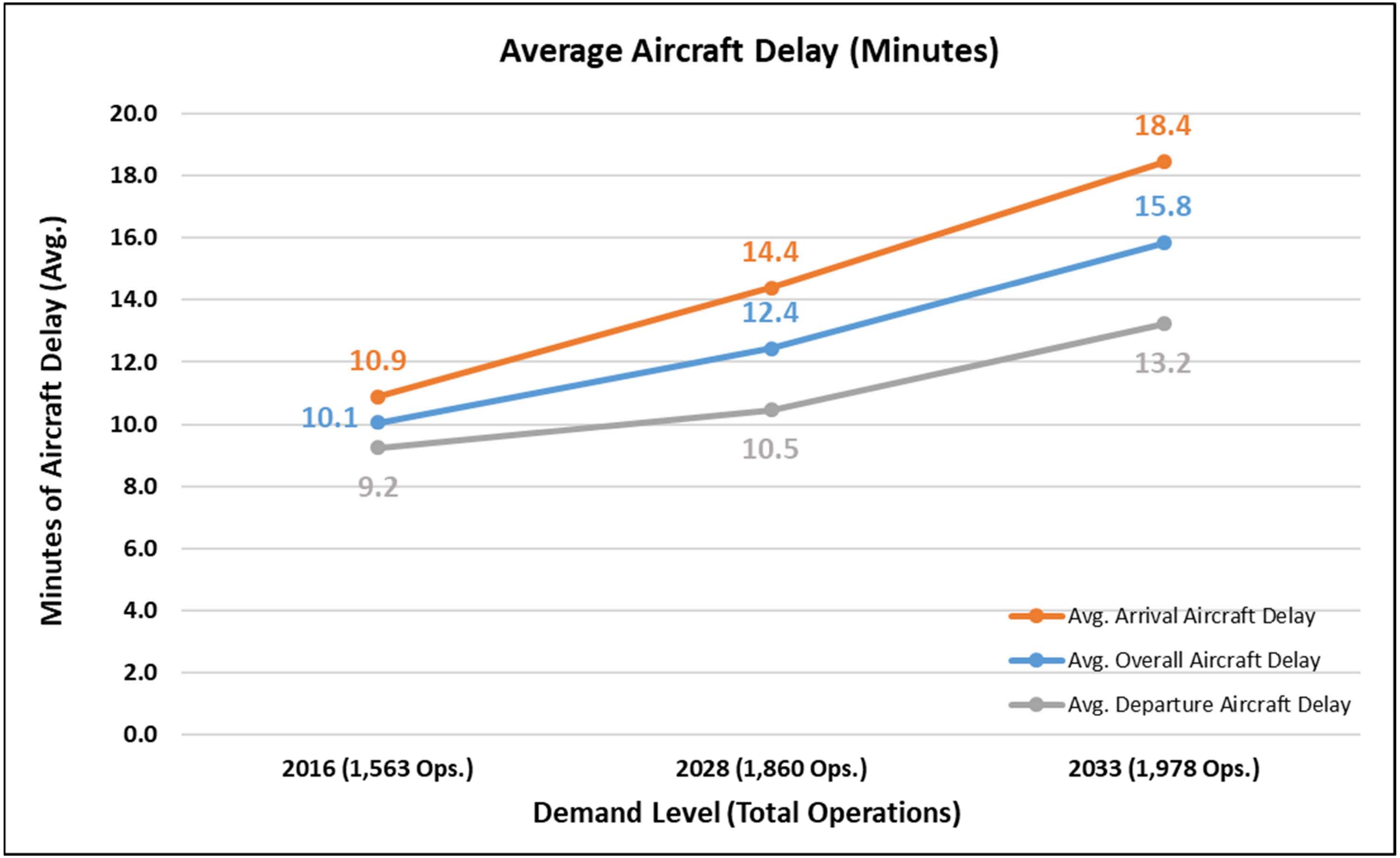
* Arr. air and dep. queue delay

** Taxi and gate delay

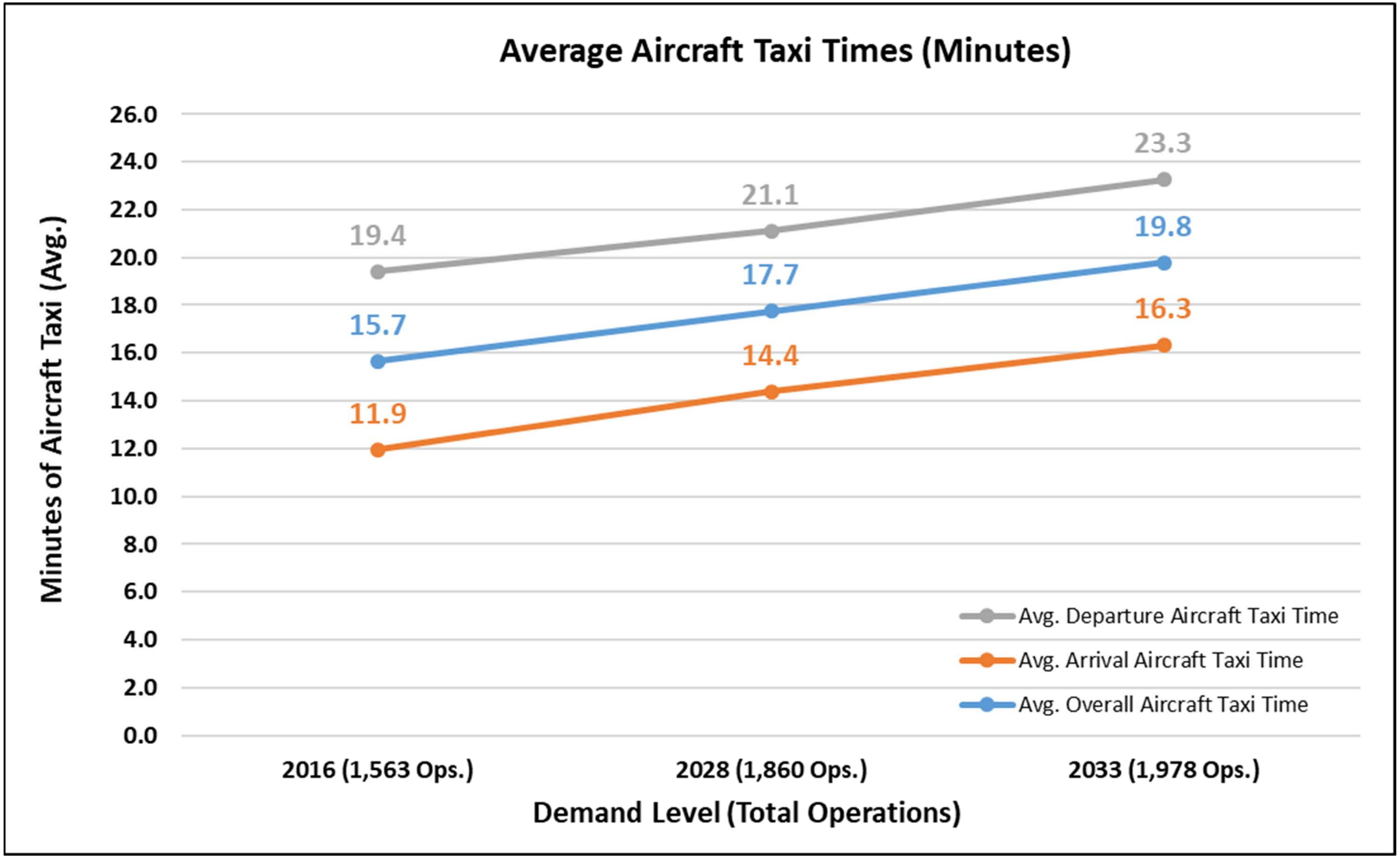
No Action Average Departure Delay



No Action Average Aircraft Delay



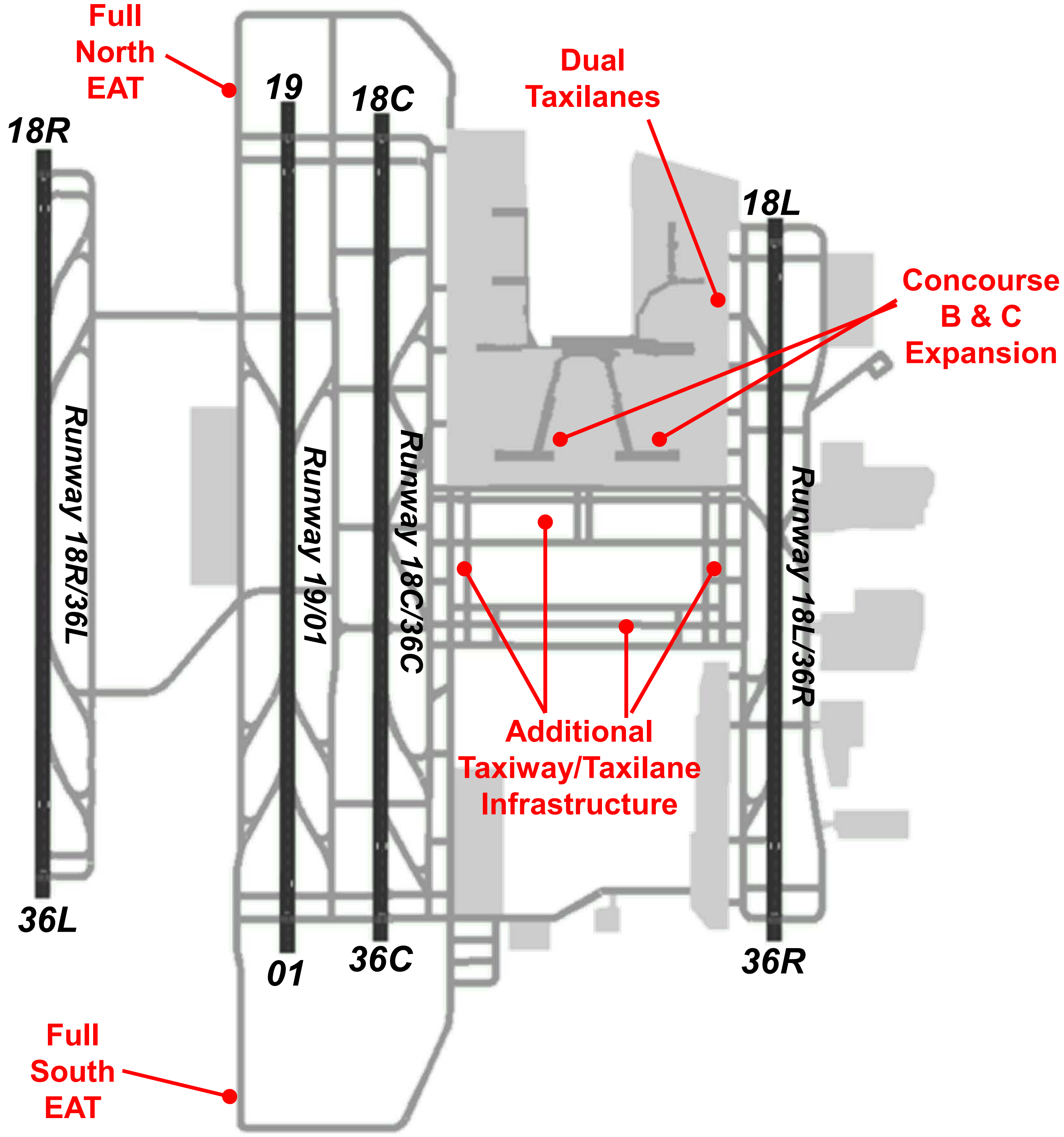
No Action Average Aircraft Taxi Times



Proposed Action
Modeling Assumptions

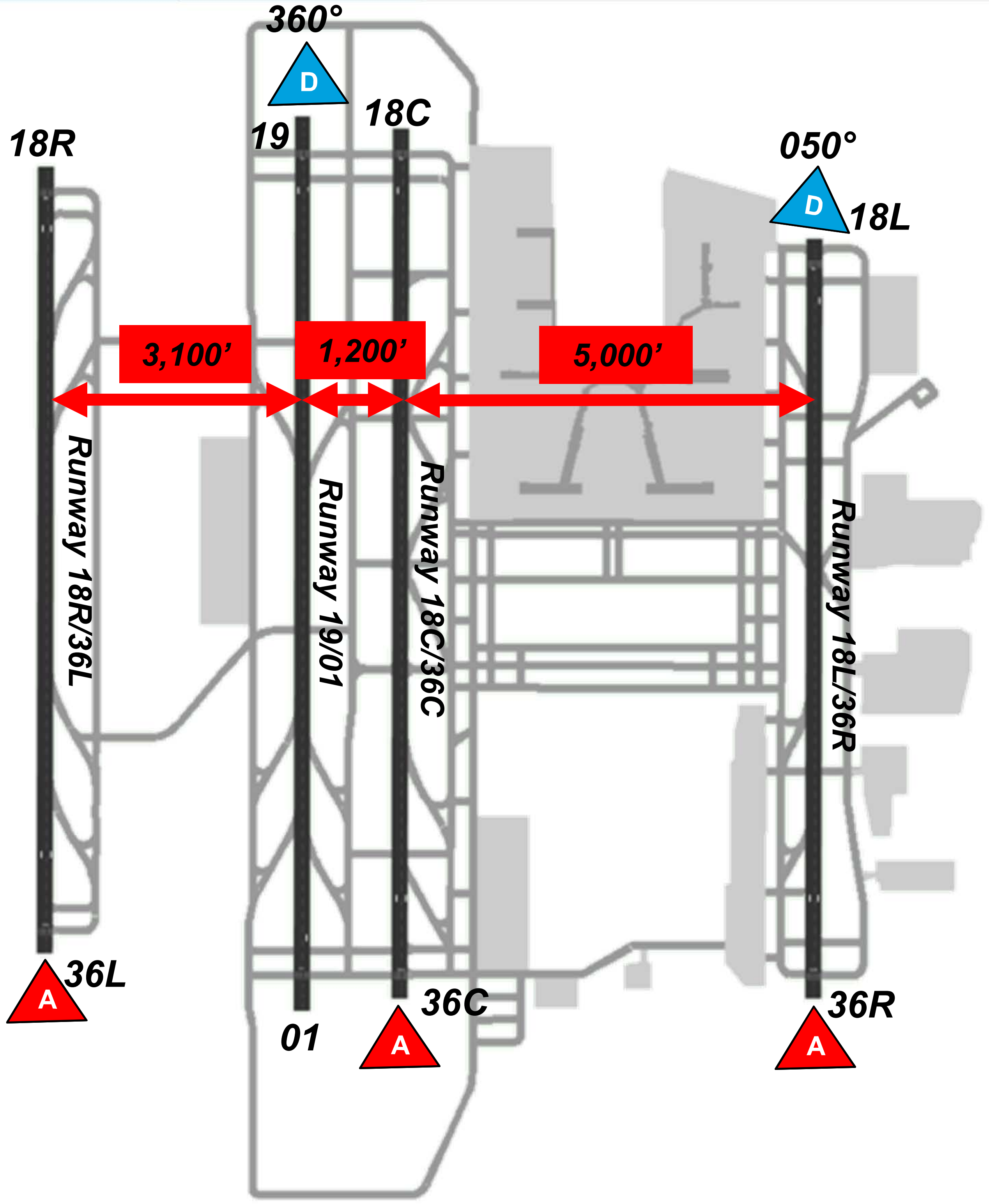
Proposed Action Airfield Layout

- Proposed Action Airfield includes all facilities in the No Action airfield as well as new facilities including:
  - Proposed Runway 01/19
  - Full End-Around Taxiway (EAT)
  - Removal of existing Runway 05/23
  - Additional aircraft gates
  - Additional taxilanes/taxiways
- EAT usage assumes that arrivals over-the-top of departures is not permitted
- The 2028 and 2033 demand levels will be simulated for the four airport operating configurations



North VMC/IMC Runway Configuration

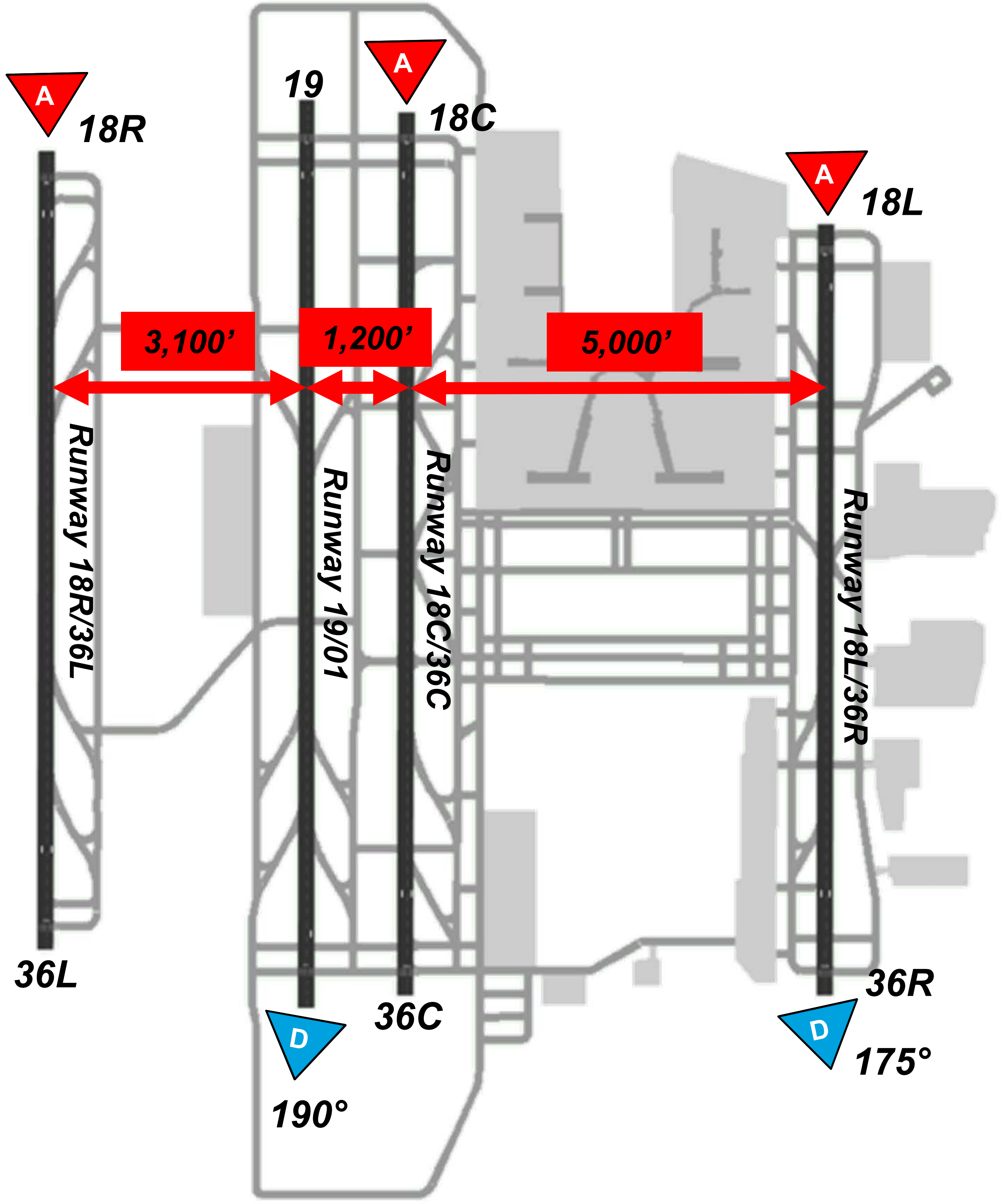
- Primary Arrival Runways:
  - Runways 36L, 36C & 36R
- Primary Departure Runways:
  - Runway 01 – North & West
  - Runway 01 – International Heavy Eastbound
  - Runway 36R – East & South
- Maintain current departure headings



South VMC/IMC Runway Configuration

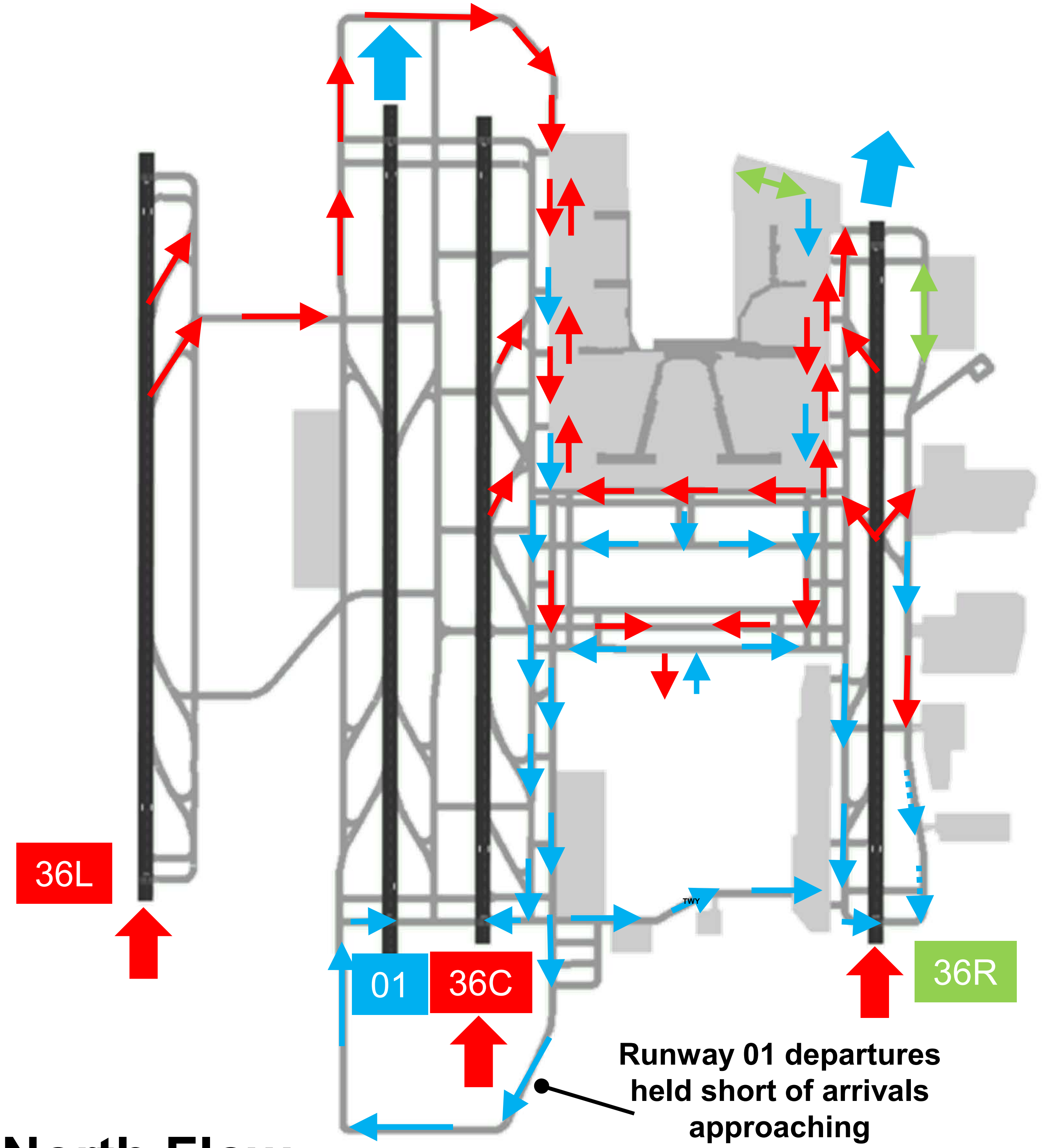
▲ Arrivals
▲ Departures

- Primary Arrival Runways:
  - Runways 18L, 18C & 18R
- Primary Departure Runways:
  - Runway 19 – North & West
  - Runway 19 – International Heavy Eastbound
  - Runway 18L – East & South
- Maintain current departure headings



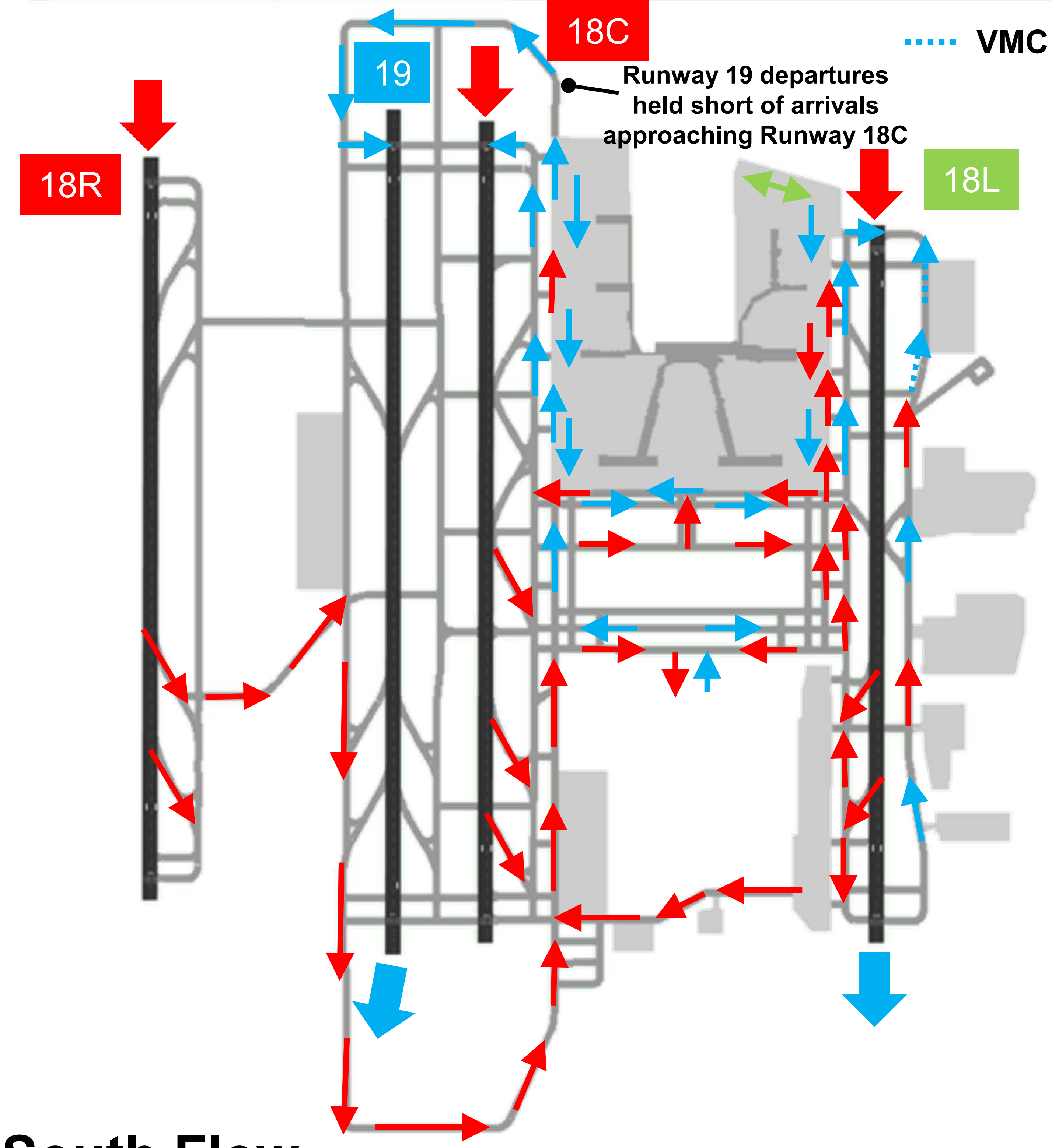
Aircraft Taxi Flows – Proposed Action

▲ Arrivals
▲ Departures
▲ Mixed-Use
····· VMC Only



Runway 01 departures held short of arrivals approaching Runway 36

North Flow



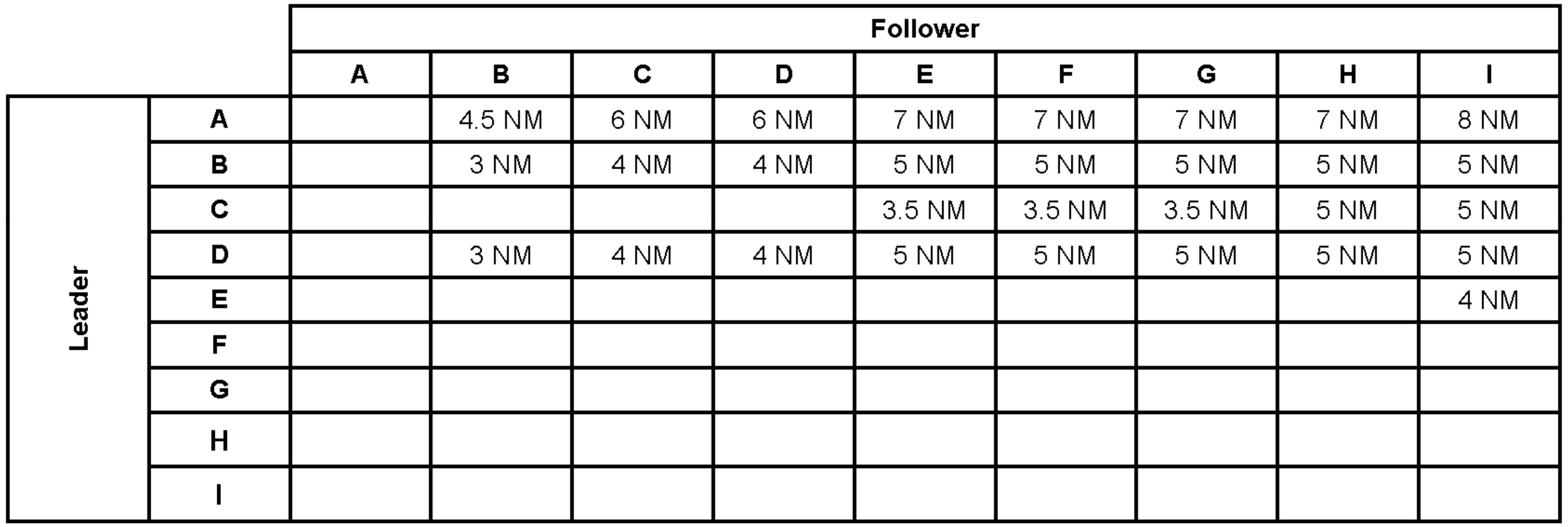
Runway 19 departures held short of arrivals approaching Runway 18C

South Flow

Proposed Action Airspace Modeling Assumptions

Intrail Separation Minimums – Wake RECAT

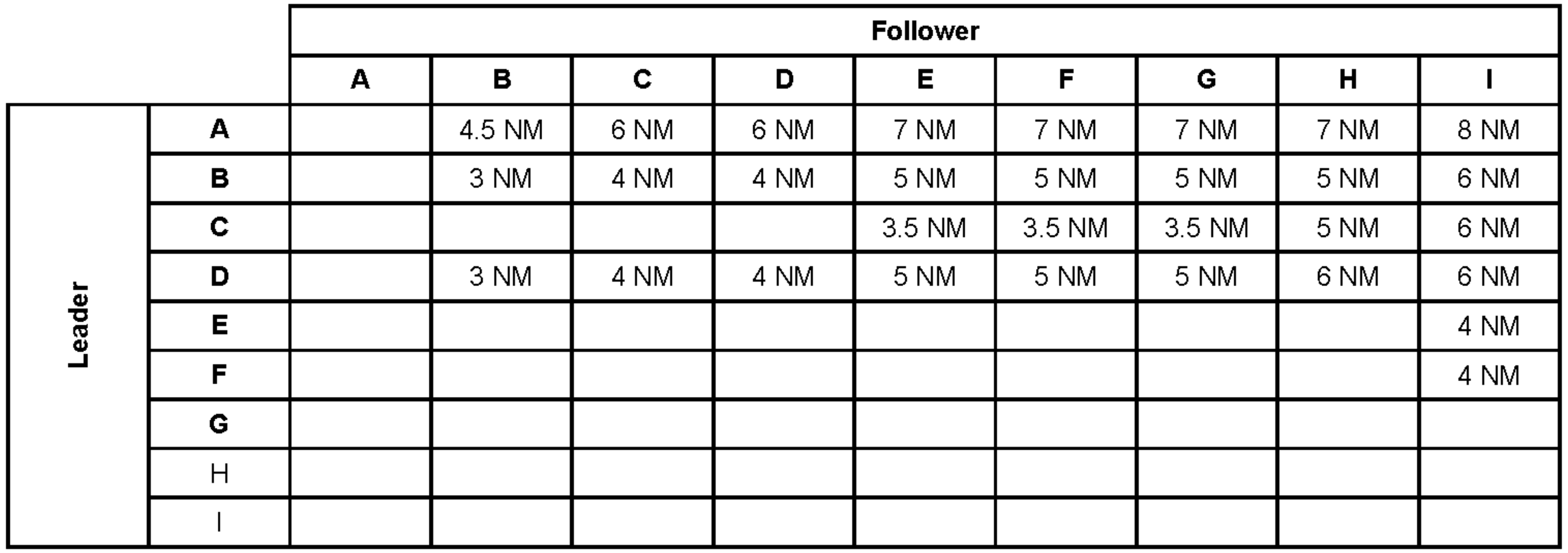
- Simulation of FAA Wake RECAT separation criteria will be applied to the Baseline and Future No Action scenarios
- Previous simulation modeling and intrail separation analyses indicate minimum arrival separations on final approach range between 3.3nm (VMC) and 3.8nm (IMC)



TBL 5–5–1

Wake Turbulence Separation for Directly Behind

		Follower								
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Leader	**A**		4.5 NM	6 NM	6 NM	7 NM	7 NM	7 NM	7 NM	8 NM
	B		3 NM	4 NM	4 NM	5 NM	5 NM	5 NM	5 NM	5 NM
	C					3.5 NM	3.5 NM	3.5 NM	5 NM	5 NM
	D		3 NM	4 NM	4 NM	5 NM	5 NM	5 NM	5 NM	5 NM
	E									4 NM
	F									
	G									
	H									
	I									



TBL 5–5–2

Wake Turbulence Separation for On Approach

		Follower								
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Leader	**A**		4.5 NM	6 NM	6 NM	7 NM	7 NM	7 NM	7 NM	8 NM
	B		3 NM	4 NM	4 NM	5 NM	5 NM	5 NM	5 NM	6 NM
	C					3.5 NM	3.5 NM	3.5 NM	5 NM	6 NM
	D		3 NM	4 NM	4 NM	5 NM	5 NM	5 NM	6 NM	6 NM
	E									4 NM
	F									4 NM
	G									
	H									
	I									

Source: JO 7110.126A - Consolidated Wake Turbulence (CWT) Separation Standards
Effective Date: September 28, 2019

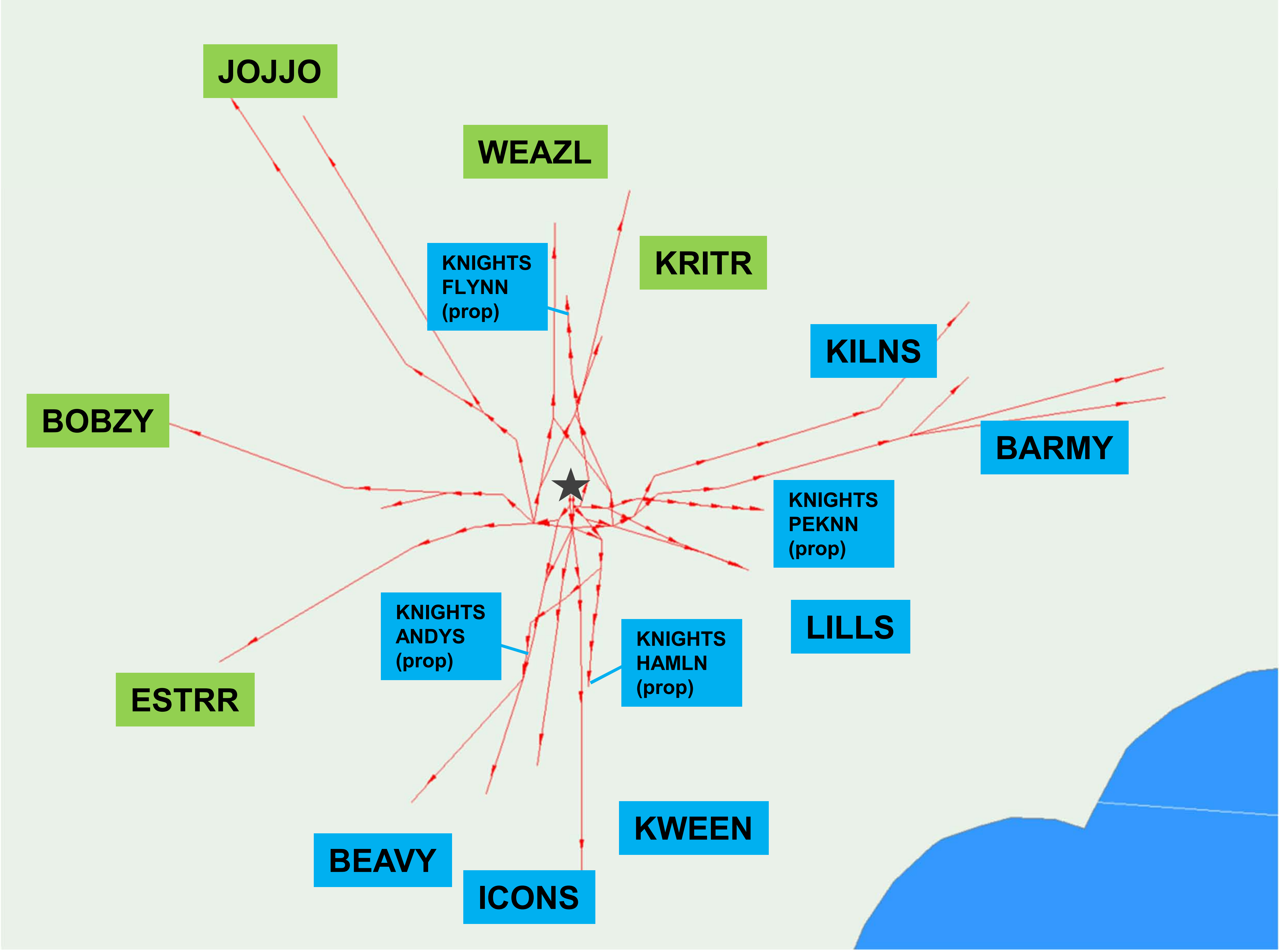
Sample Airport Route/City Pairs

Arrival Route	Origin Examples*
	North
PARQR TAFTT	MDW, CLE, MSP, ORD, SEA
	East
CHSLY LYH	BOS, EWR, FRA, JFK, LHR
	South
BANKR	JAX, MIA
	West
JONZE BESTT	ATL, IAH, MEX
FLIPZ COMDY	DEN, DFW, LAX, PDX, SFO

Departure Route	Destination Examples*
	North
JOJJO DODGE	MDW, ORD, PDX, SEA
KRITR FILDS	BUF, PIT, YYZ
	East
KILNS	BWI, IAD, EWR, PHL
BARMY RDU	BOS, FRA, LGA
	South
ICONS	JAX, MIA
	West
ESTRR	AUS, DAL, IAH, MEX
BOBZY BNA	DEN, DFW, LAX, PHX, SFO

*Note that these lists are not all-inclusive. They merely contain examples of some of the major airports that use each route.

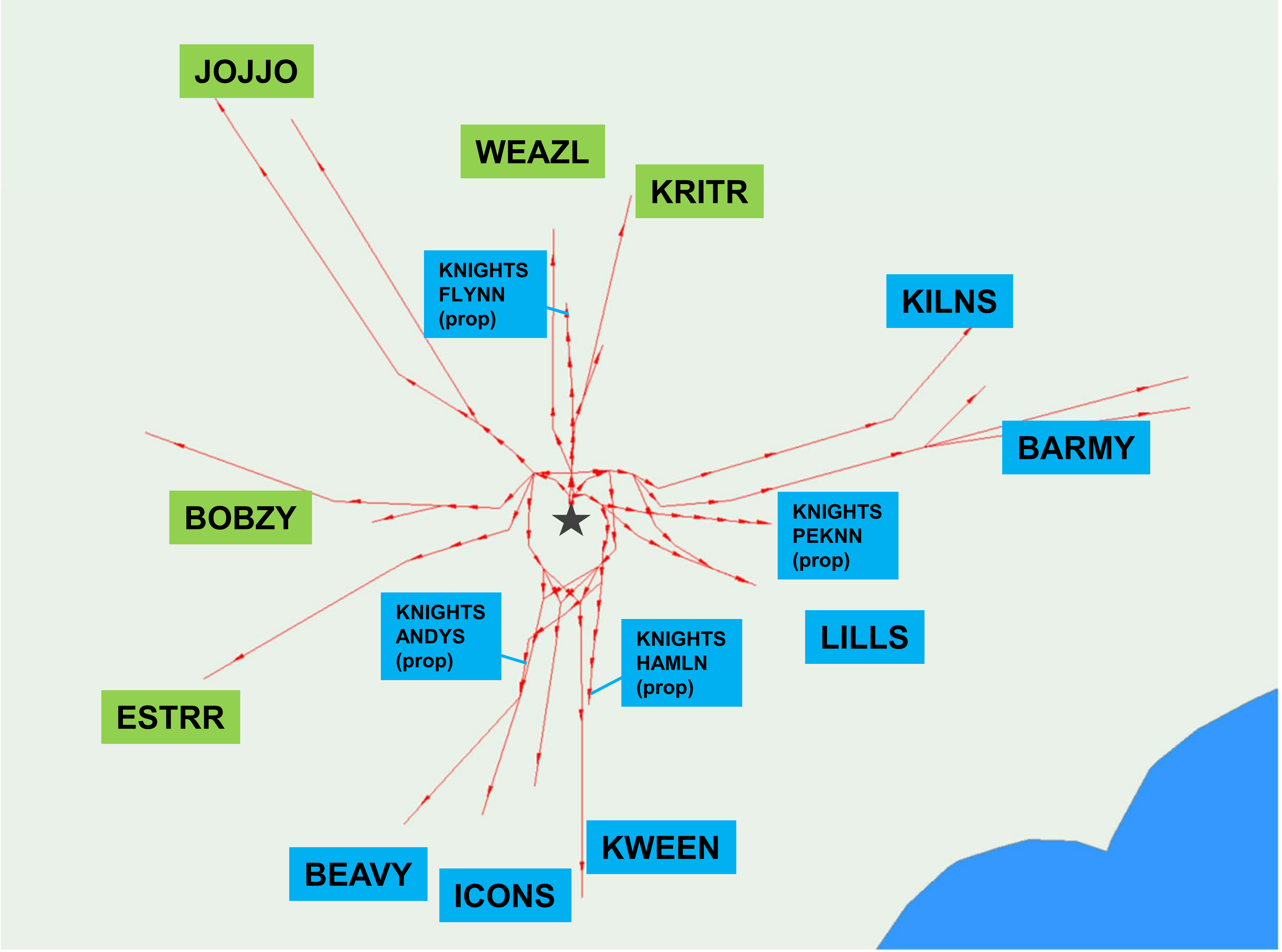
South Flow Departure Airspace – Proposed Action



🟦	**Runway 18L**
🟩	**Runway 19**
★	**CLT**

Note: Departures to north and south fixes can be swapped between runways to balance the airfield

North Flow Departure Airspace – Proposed Action



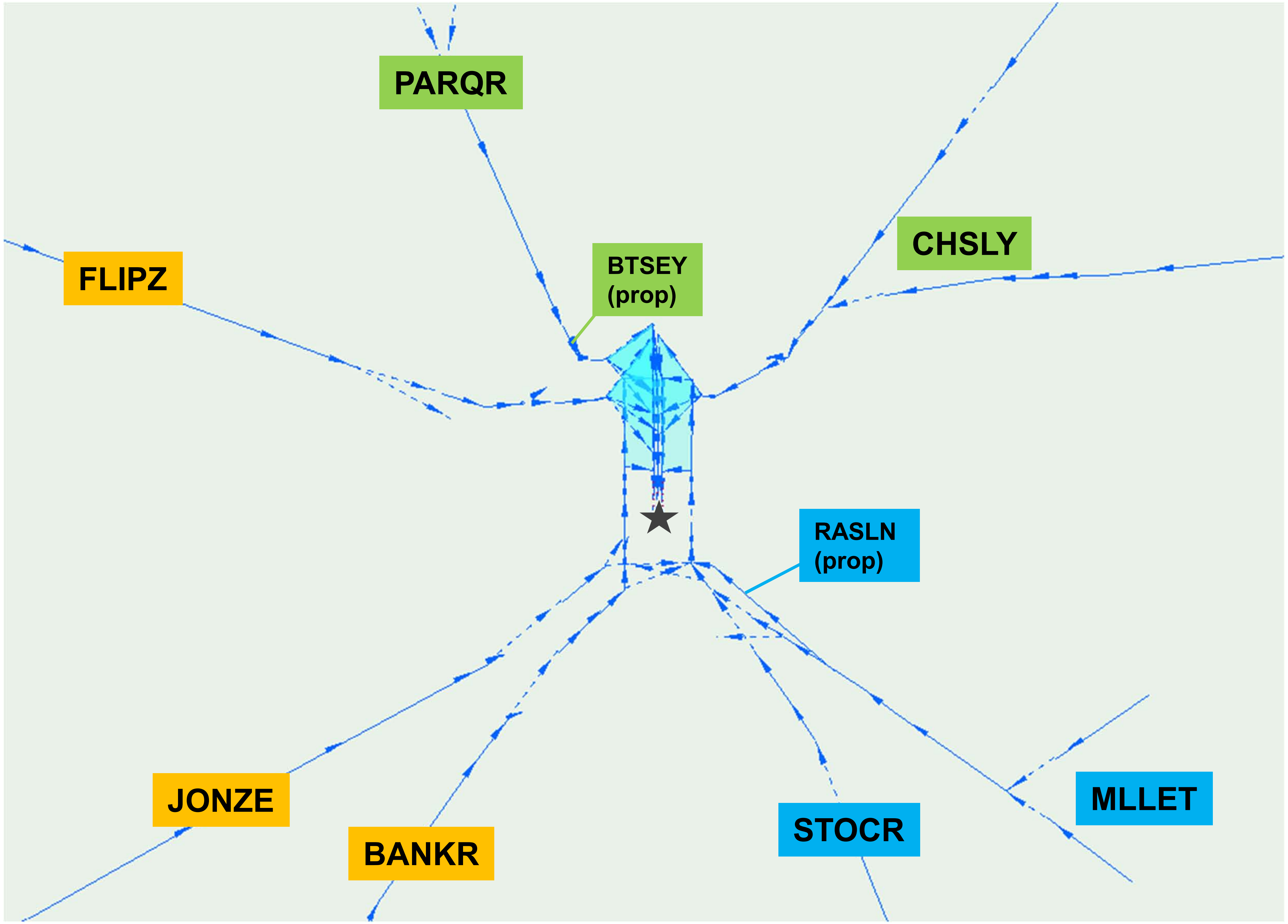
🟦 **Runway 36R**

🟩 **Runway 01**

★ **CLT**

Note: Departures to north and south fixes can be swapped between runways to balance the airfield

South Flow Arrival Airspace – Proposed Action



🟨 **Runway 18R**

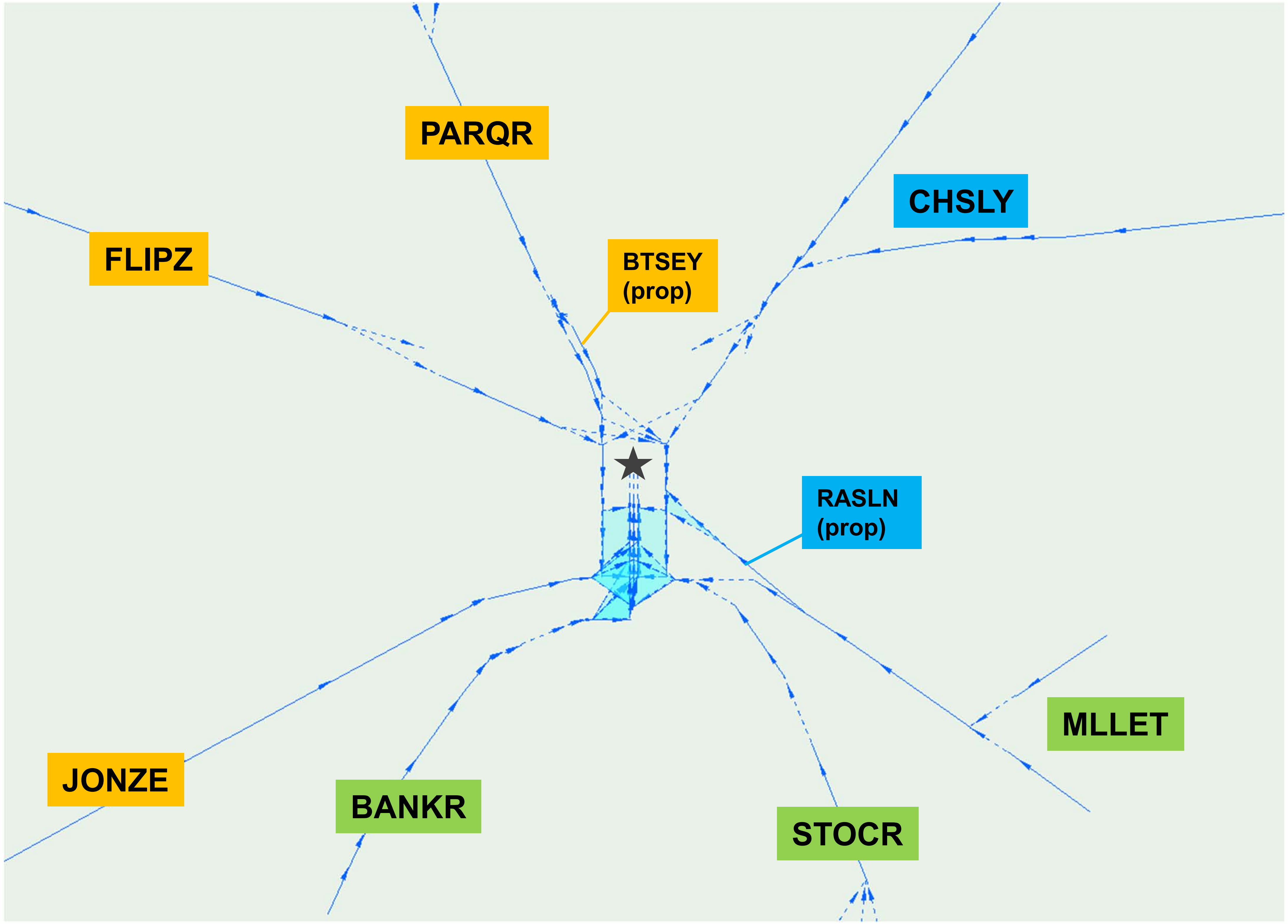
🟦 **Runway 18L**

🟩 **Runway 18C**

★ **CLT**

Note: Arrivals can be offloaded to other runways during busy periods

North Flow Arrival Airspace – Proposed Action



🟨 Runway 36L

🟦 Runway 36R

🟩 Runway 36C

★ CLT

Note: Arrivals can be offloaded to other runways during busy periods

Next Steps

- Provide comments to EA Team by June 18th, 2020
  - Send comments to spotter@landrum-brown.com
- Incorporate comments from DORA Team
- Conduct the Proposed Action modeling analysis
- Conduct alternatives evaluation
- DORA Meeting #3 – present results of the Proposed Action and Alternatives modeling analysis (tentative mid-July 2020)
- Continue preparation of the Draft EA

CLT DORA (Direction, Oversight, Review & Agree) Meeting #3

November 6, 2020

Agenda

- Role Call
- Meeting Objectives
- DORA Process
- EA Process Overview
- Proposed Action Modeling Results
- Alternatives Modeling Assumptions
  - Alternatives Development and Screening
  - Alternatives Airspace Assumptions
  - Alternatives Taxi Flow Assumptions
- Next Steps

Meeting Objectives

Meeting Objectives

- To present the Proposed Action simulation modeling results
- To present the alternatives modeling assumptions
- To present the next steps in the overall project

DORA Process

Charlotte Douglas International Airport EA

DORA Process Overview

Prepared for: **CLT EA DORA Meeting #3**

By: **Kent Duffy**

Date: **November 6, 2020**

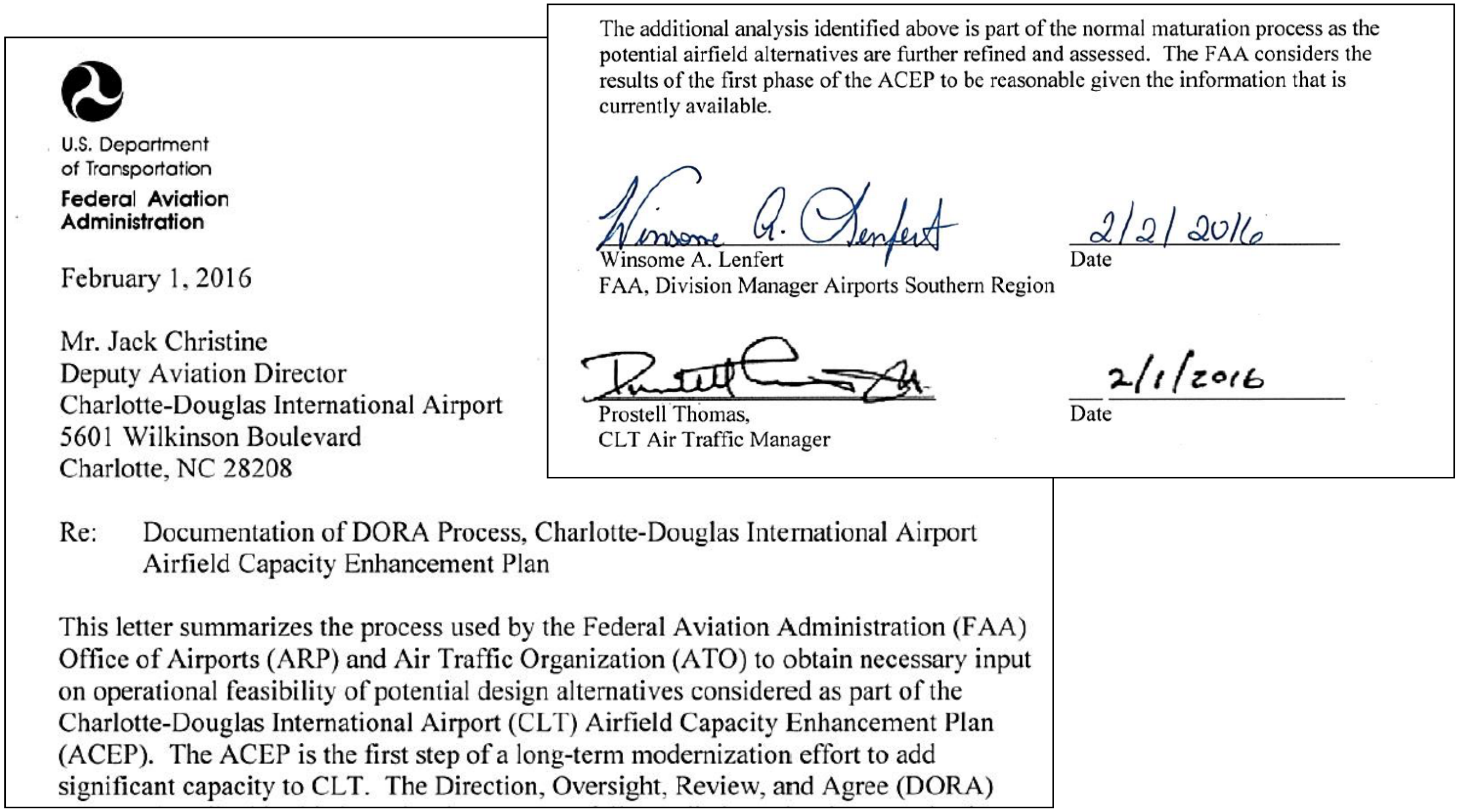
What is DORA?

- **DORA** =
  Direction, **O**versight, **R**eview and **A**gree
- Obtaining and understanding controller input on operational issues and viability of proposed alternatives is a key to airport capacity development
- DORA has been applied successfully to other large-scale airport and airspace modernization efforts (e.g., O’Hare Modernization Program)

Objectives: Why are we here?

- **Ensure collaboration w/ATO on simulation activities as needed to complete EA**
  - Obtain input development of the simulation model
  - Revise and refine simulation model, rather than develop new alternatives
- **Build from successful process used during planning phase**
  - Update with recent changes: forecast trends, CRO, metroplex, heading usage, Atlantic coast routes, etc.
  - Validate operating assumptions used in the simulation model
    - Airspace flows and procedures, Runway usage and balancing, Aircraft separation and buffers, Taxi-flows and ground movement, etc.
  - Review and validate airspace's ability to accommodate new runway throughput
- **Collaboration ensures the simulation results can be used in the EA analyses with confidence**

Planning Phase DORA Letter



U.S. Department
of Transportation
**Federal Aviation
Administration**

February 1, 2016

Mr. Jack Christine
Deputy Aviation Director
Charlotte-Douglas International Airport
5601 Wilkinson Boulevard
Charlotte, NC 28208

Re: Documentation of DORA Process, Charlotte-Douglas International Airport Airfield Capacity Enhancement Plan

This letter summarizes the process used by the Federal Aviation Administration (FAA) Office of Airports (ARP) and Air Traffic Organization (ATO) to obtain necessary input on operational feasibility of potential design alternatives considered as part of the Charlotte-Douglas International Airport (CLT) Airfield Capacity Enhancement Plan (ACEP). The ACEP is the first step of a long-term modernization effort to add significant capacity to CLT. The Direction, Oversight, Review, and Agree (DORA)

The additional analysis identified above is part of the normal maturation process as the potential airfield alternatives are further refined and assessed. The FAA considers the results of the first phase of the ACEP to be reasonable given the information that is currently available.

Winsome A. Lenfert
Winsome A. Lenfert
FAA, Division Manager Airports Southern Region

2/2/2016
Date

Prostell Thomas,
CLT Air Traffic Manager

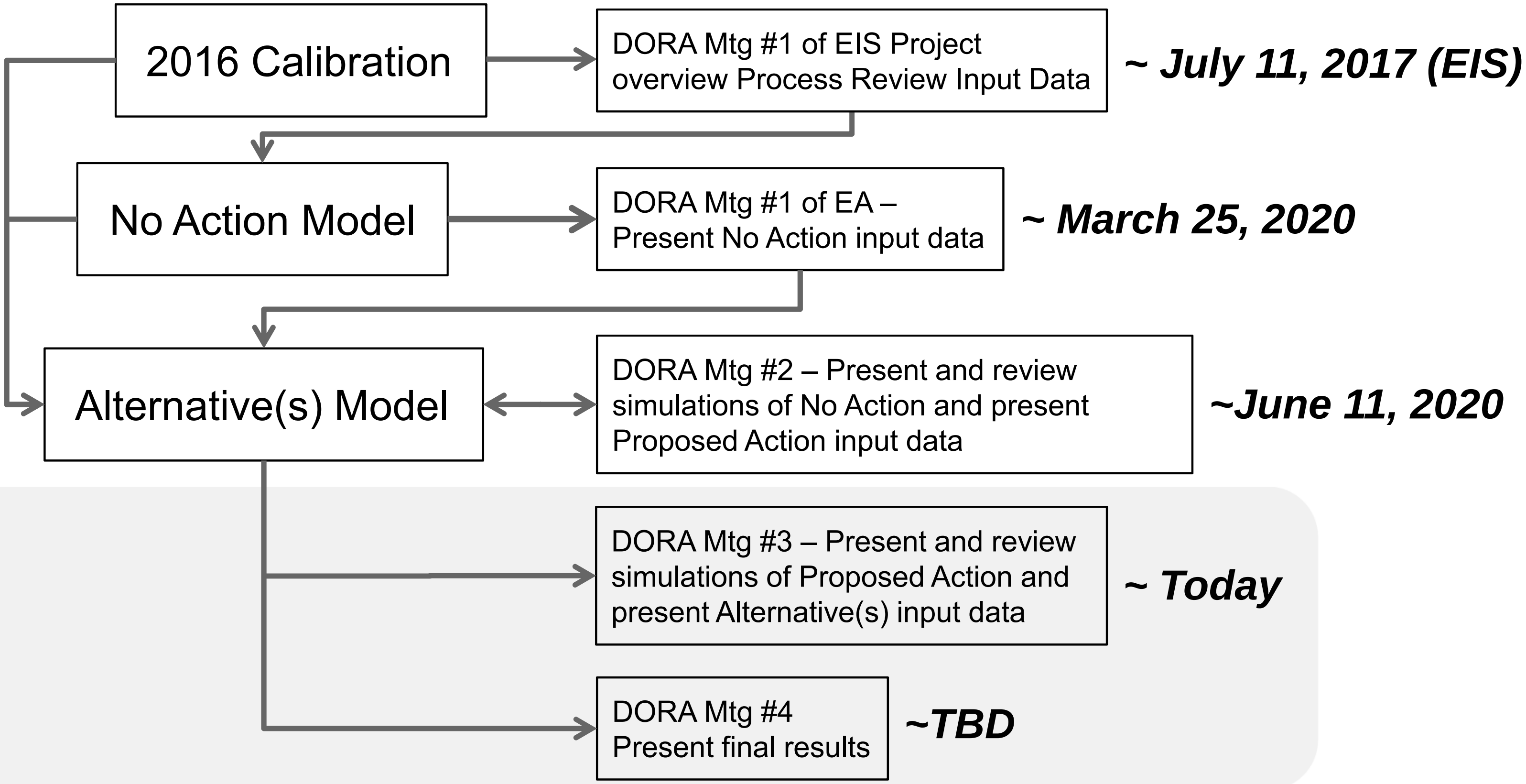
2/1/2016
Date

Desired Result: 2nd DORA Letter

Active ATC participation

- **FAA Letter signed by ATO and ARP**
- **Explains process and summarizes meetings**
- **Identifies further analyses required in subsequent phases (e.g., design/ implementation), as needed**
- **Desired findings:**
  - Modeling approach is <u>reasonable</u>
  - Modeling assumptions accurately reflects <u>operational perspectives</u>
  - Subsequent capacity, throughput and delay <u>results are reasonable</u> representations of the proposed airfield and airspace designs

DORA Process Relationship to Modeling



2016 Calibration

DORA Mtg #1 of EIS Project overview Process Review Input Data

~ *July 11, 2017 (EIS)*

No Action Model

DORA Mtg #1 of EA – Present No Action input data

~ *March 25, 2020*

Alternative(s) Model

DORA Mtg #2 – Present and review simulations of No Action and present Proposed Action input data

~*June 11, 2020*

DORA Mtg #3 – Present and review simulations of Proposed Action and present Alternative(s) input data

~ *Today*

DORA Mtg #4 Present final results

~*TBD*

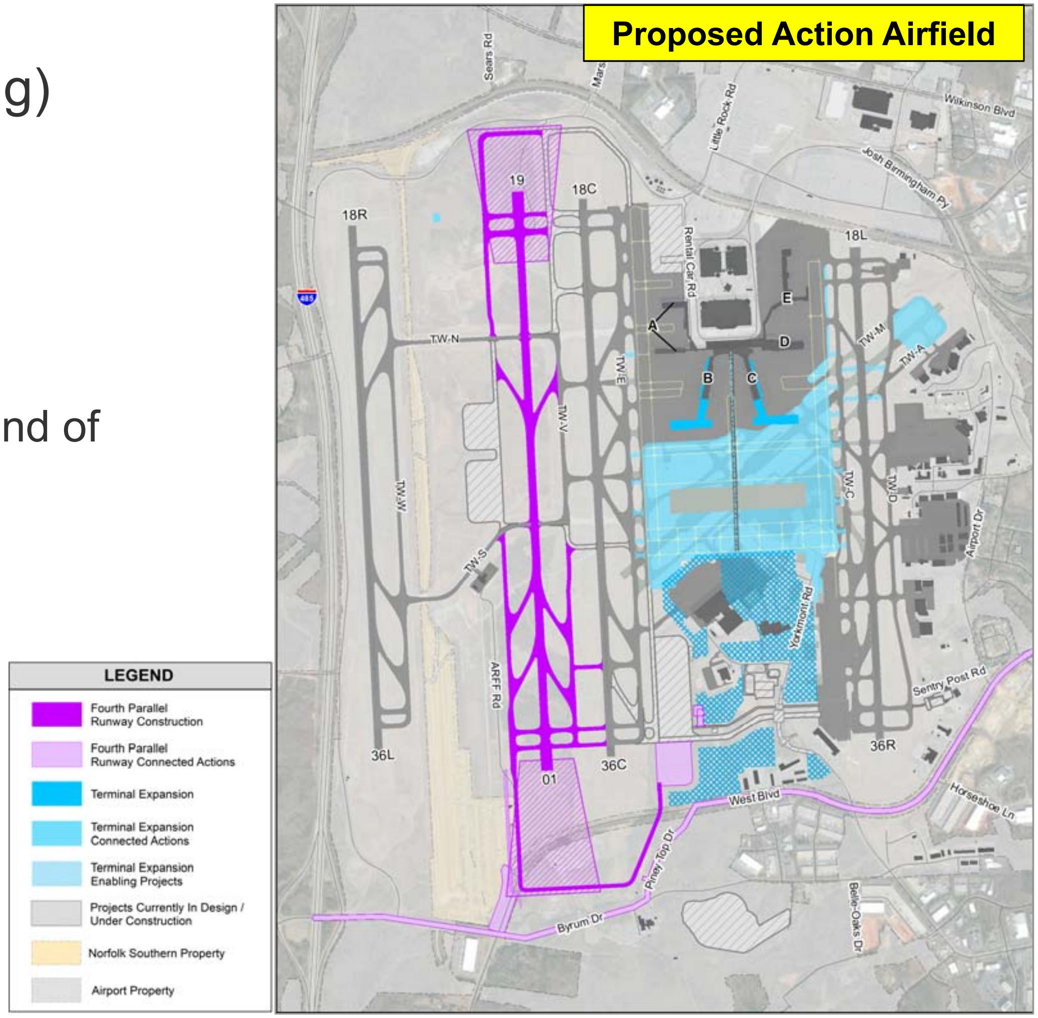
EA Process Overview

EA Process Overview - Background

- The CLT Environmental Impact Statement (EIS) that the Federal Aviation Administration (FAA) began was cancelled on February 27, 2019.
- The FAA cancelled the EIS because a runway length analysis determined only a 10,000 foot runway is required to meet the purpose and need.
- The FAA determined that this was a sufficient change to warrant cancellation of the EIS and conversion to an Environmental Assessment (EA).
- The City of Charlotte (Airport Sponsor) is responsible for preparing the EA.
- FAA is still the lead agency.
- Similar to the EIS, the EA will evaluate the potential direct, indirect, and cumulative environmental impacts that may result from the Proposed Action.

EA Process Overview – Proposed Action

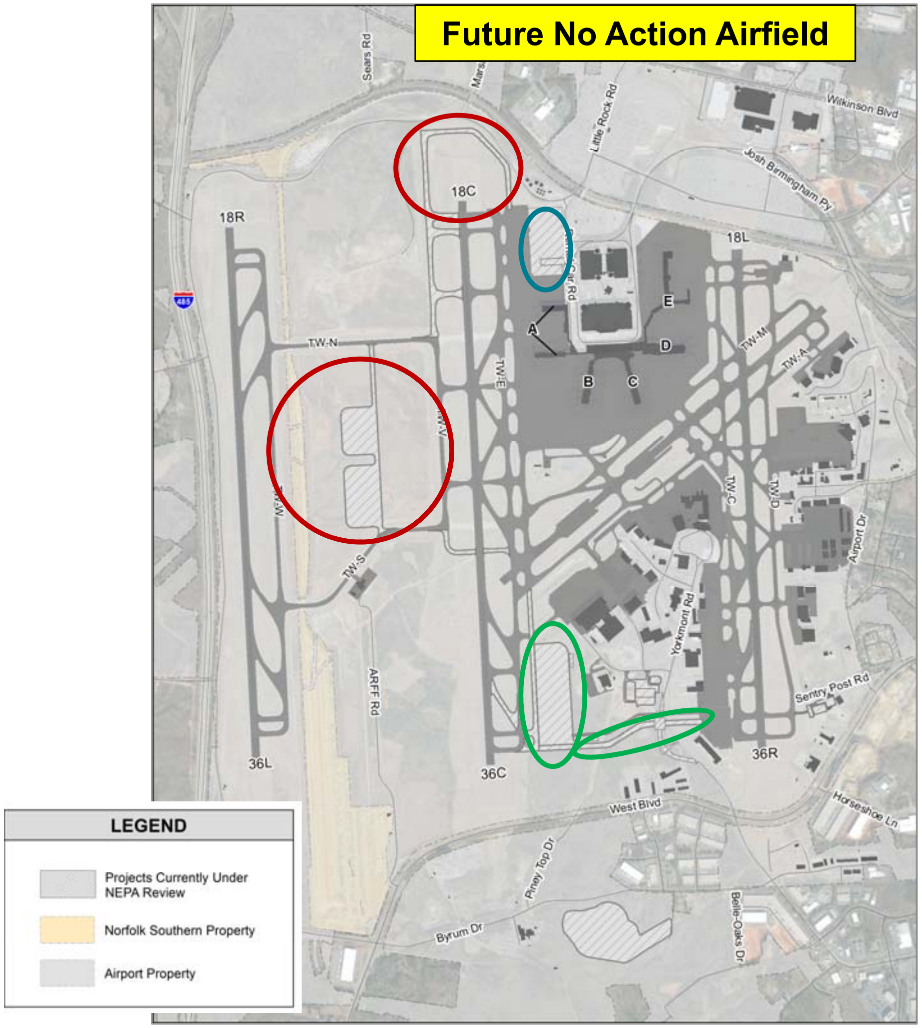
- 4th Parallel Runway (10,000 feet long)
  - North and South End Around Taxiways
- Extensions of Concourse B and C
  - Decommissioning Runway 5/23
- Dual Taxilanes Around Ramp
  - Requires the removal of gates off the end of Concourse D and E
- Crossfield Corridors



Proposed Action Airfield

EA Process Overview - Simulations

- Simulations will:
  - Be used in developing the Purpose and Need, noise modeling, and air quality modeling.
  - Conducted for the following scenarios:
    - 2016 Calibration - Complete
    - 2019 Baseline - Complete
    - 2028 Future No Action - Complete
    - 2033 Future No Action - Complete
    - **2028 Alternative(s) - Underway**
    - **2033 Alternative(s) - Underway**
  - Use forecast of operations approved by the FAA.
  - Include 3 independent projects as part of the Future No Action.
    - Deice Pad and crossfield taxiway
    - North End Around Taxiway around Runway 18C/36C, hold pads and threshold displacement (1,235 feet)
    - Concourse A Phase II



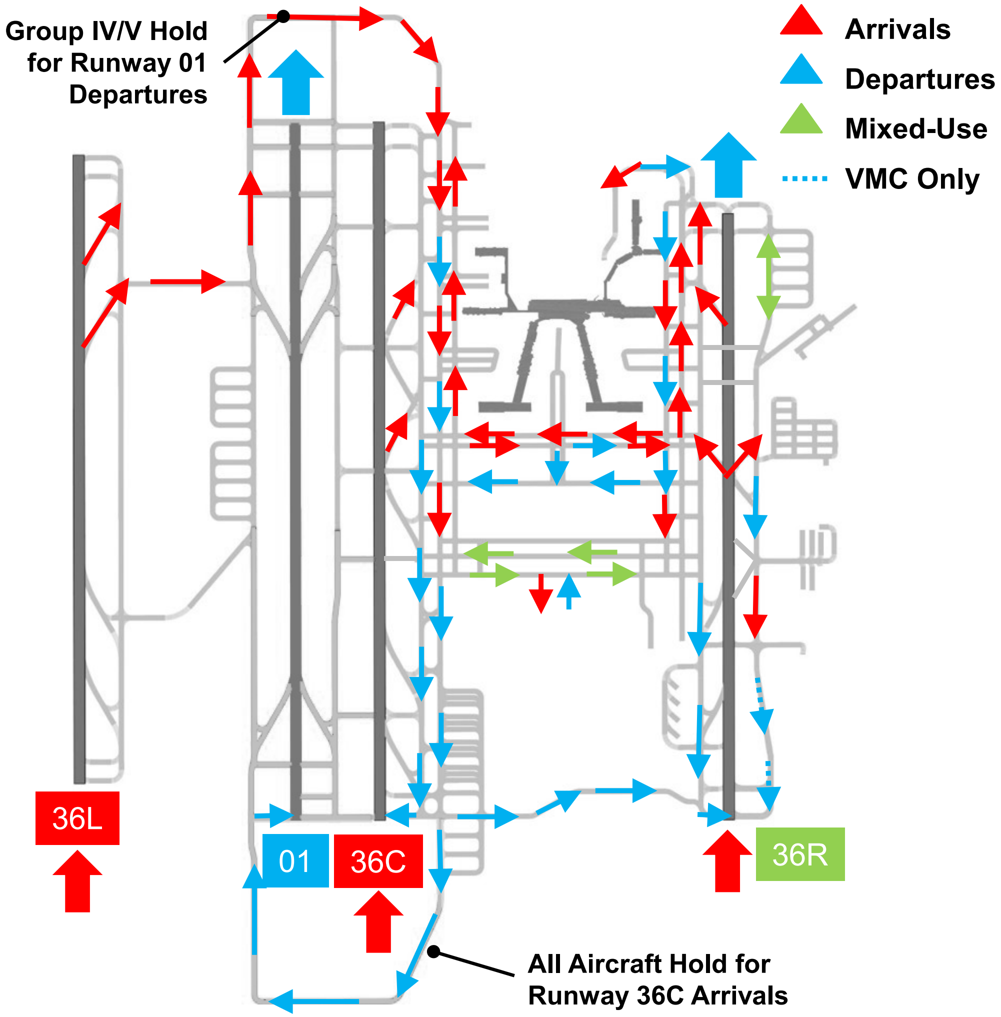
Proposed Action Simulation Modeling Results

Proposed Action EAT Usage Assumption

- Aircraft taxiing on the North and South EATs require large arrival gaps on Runway 18C/36C approach
  - 8nm gap for NEAT
  - 9nm gap for SEAT
- Arrival gap requirement may hinder efficient operations
  - Reduced arrival capacity on Runway 18C/36C
  - Increased ground holding times for aircraft holding short of the EAT as arrivals over-the-top of taxiing aircraft is not currently permitted
- Therefore, two EAT scenarios were evaluated
  - Scenario 1: All operations use EATs (no runway crossings)
  - Scenario 2: Departures use Taxiway V and arrivals use EATs

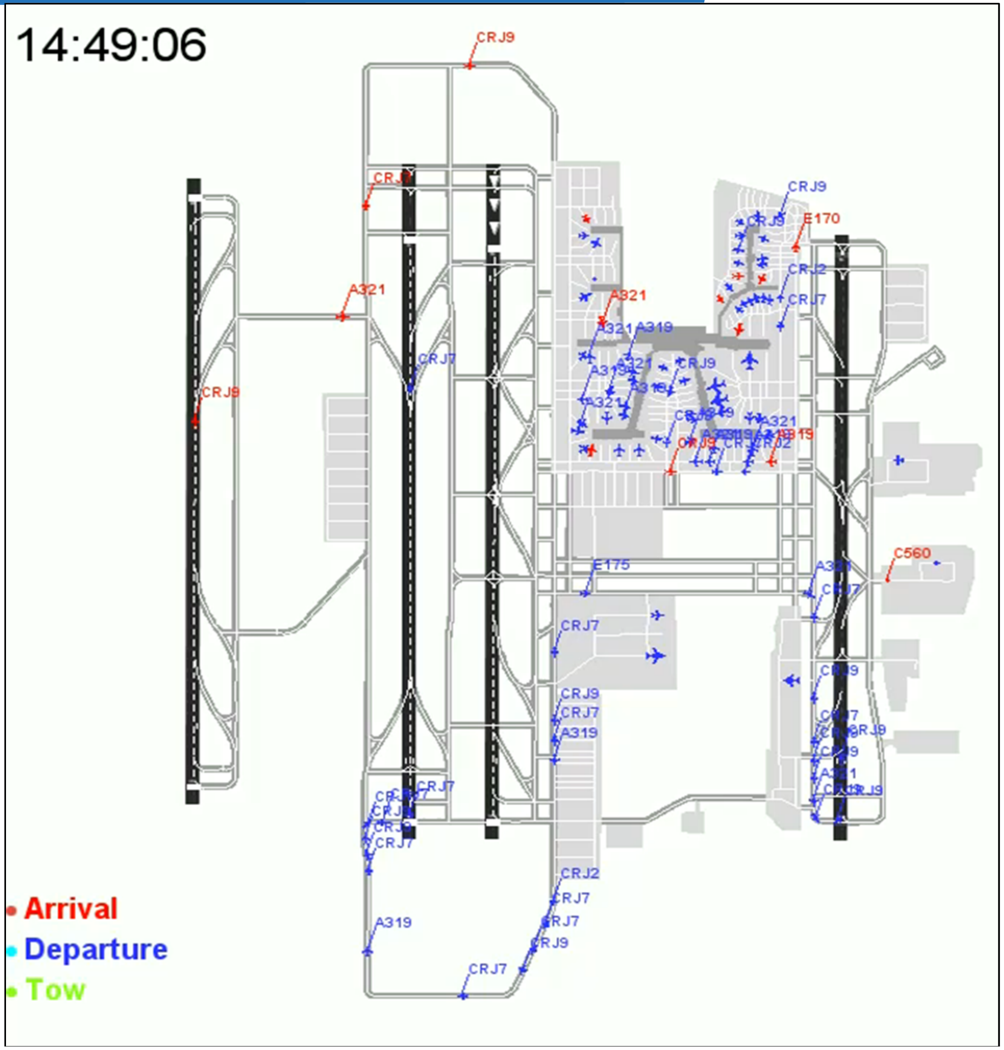
Proposed Action Scenario	Advantages	Disadvantages
Scenario 1	• Avoid runway crossings	• Long departure taxi distance • Departures on EAT hold short of approach • Gap needed in arrival stream
Scenario 2	• Short departure taxi distance	• Runway crossings • Queue for crossing extends into apron area during peak in south flow

Proposed Action – North Flow, Scenario 1

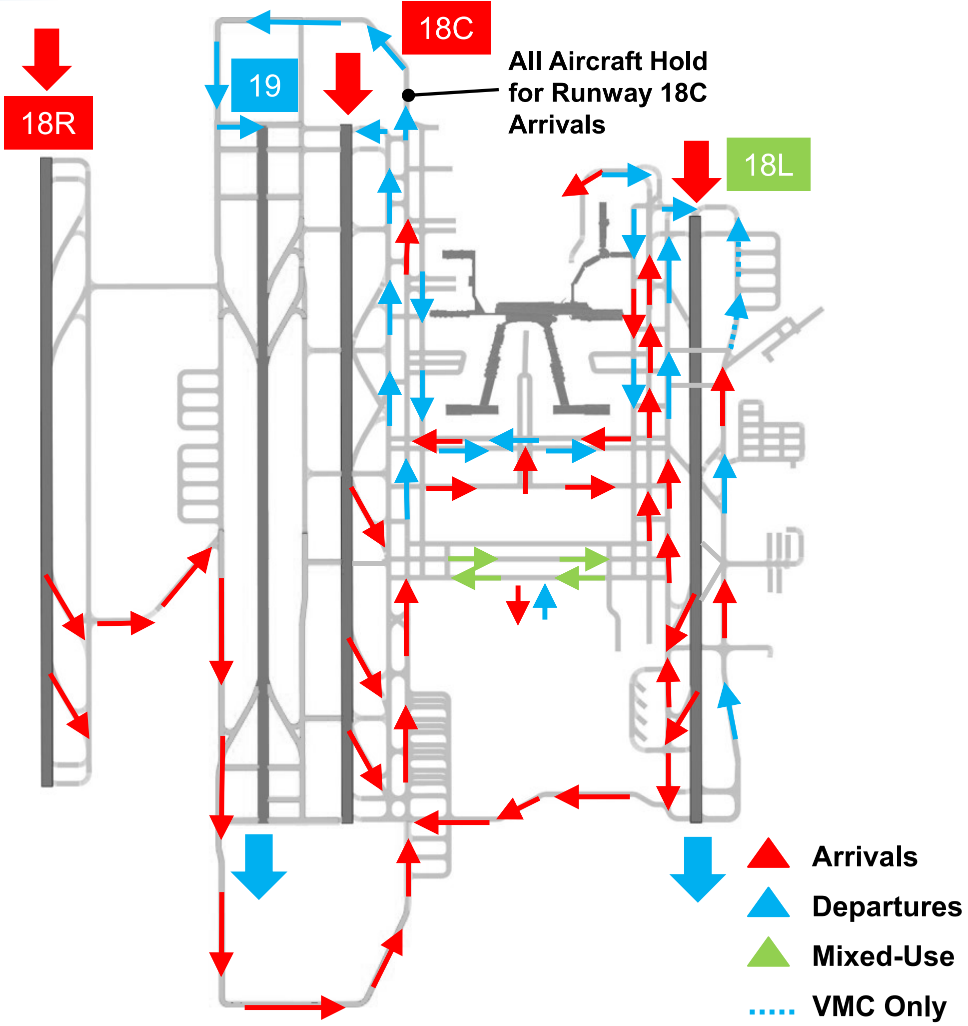


Group IV/V Hold for Runway 01 Departures

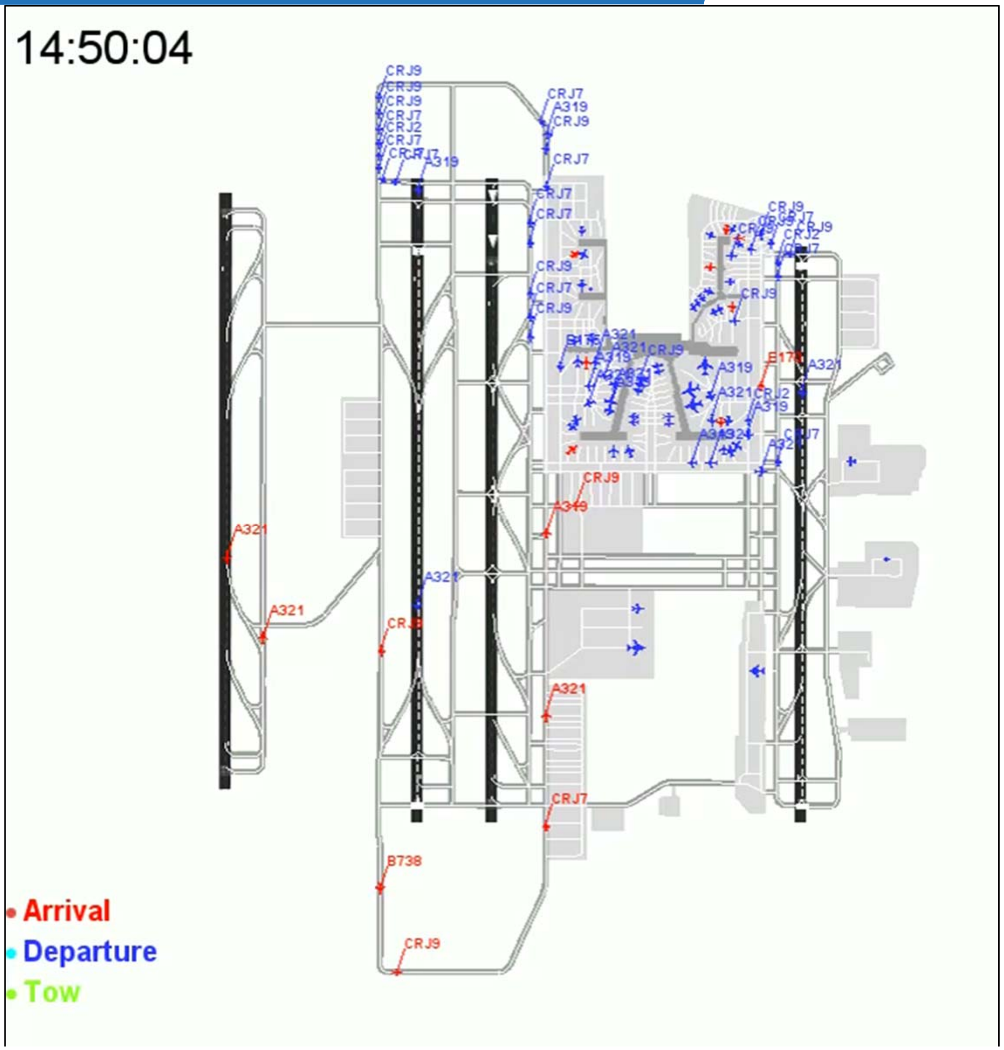
All Aircraft Hold for Runway 36C Arrivals



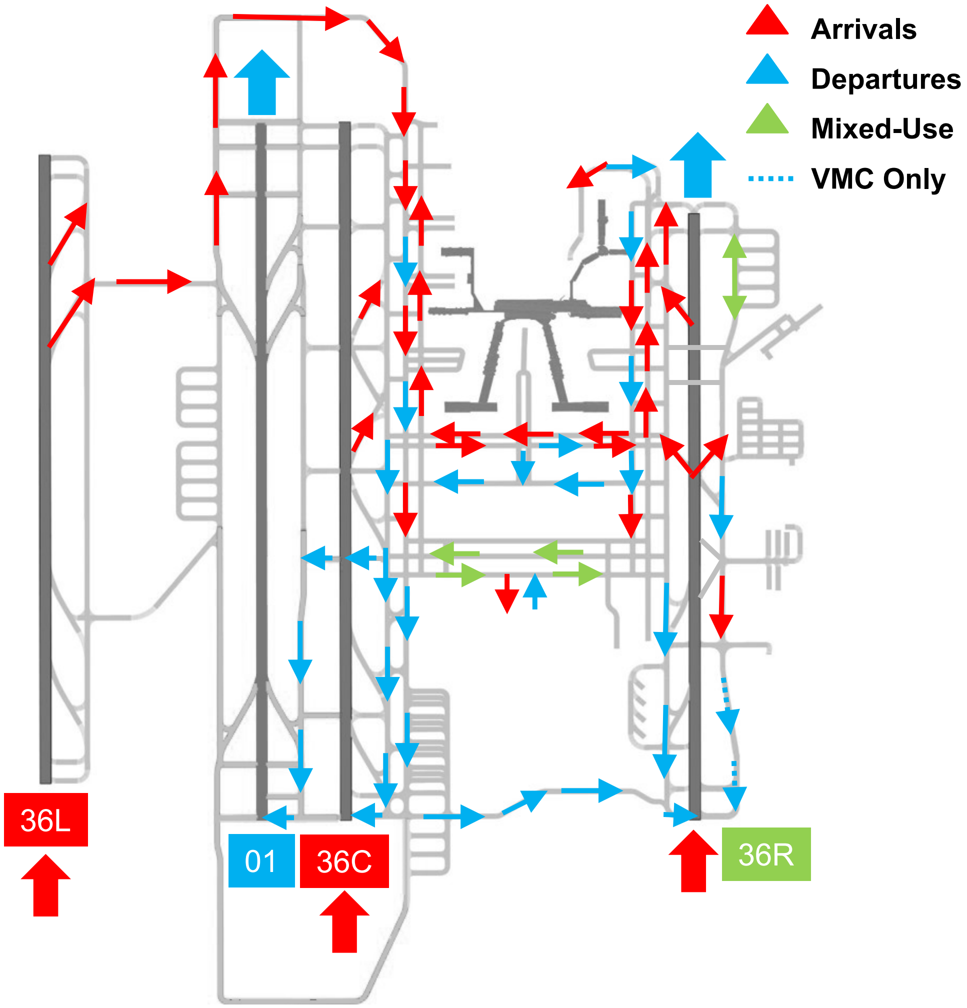
Proposed Action – South Flow, Scenario 1

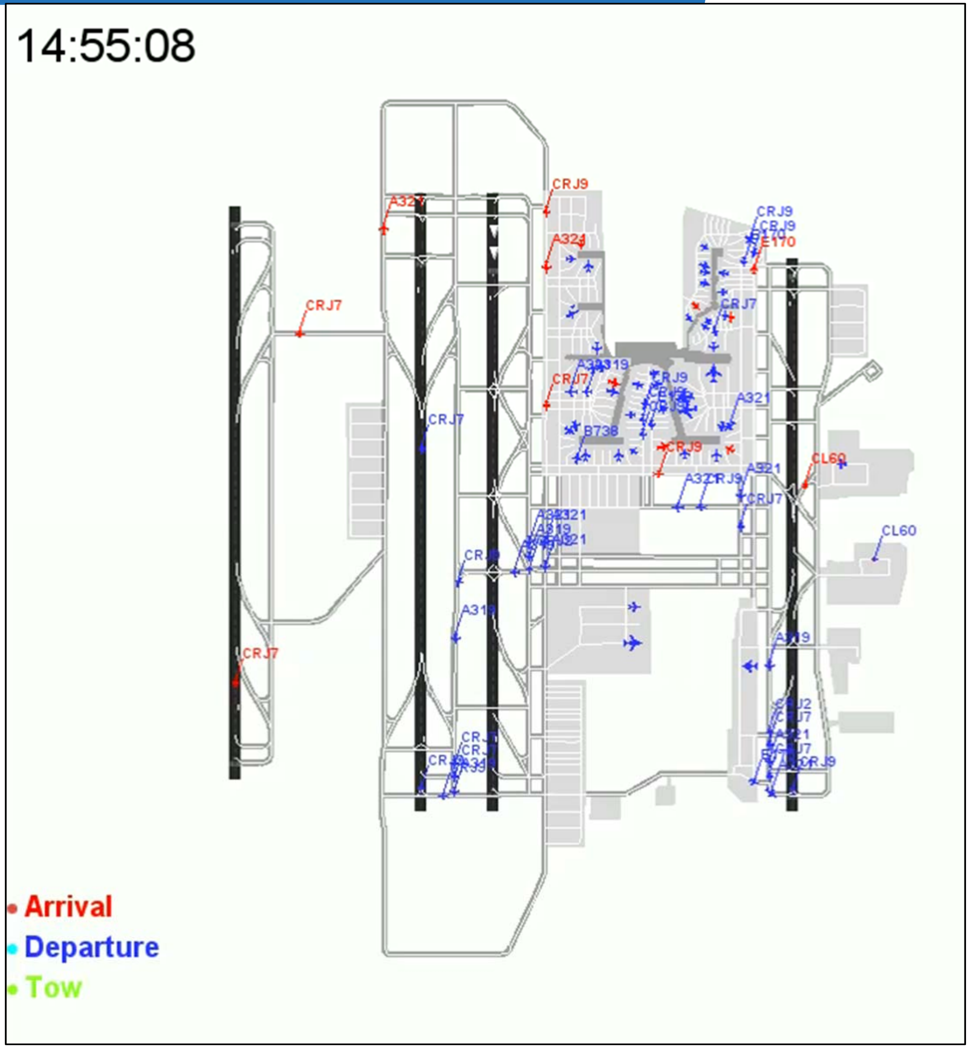


All Aircraft Hold for Runway 18C Arrivals

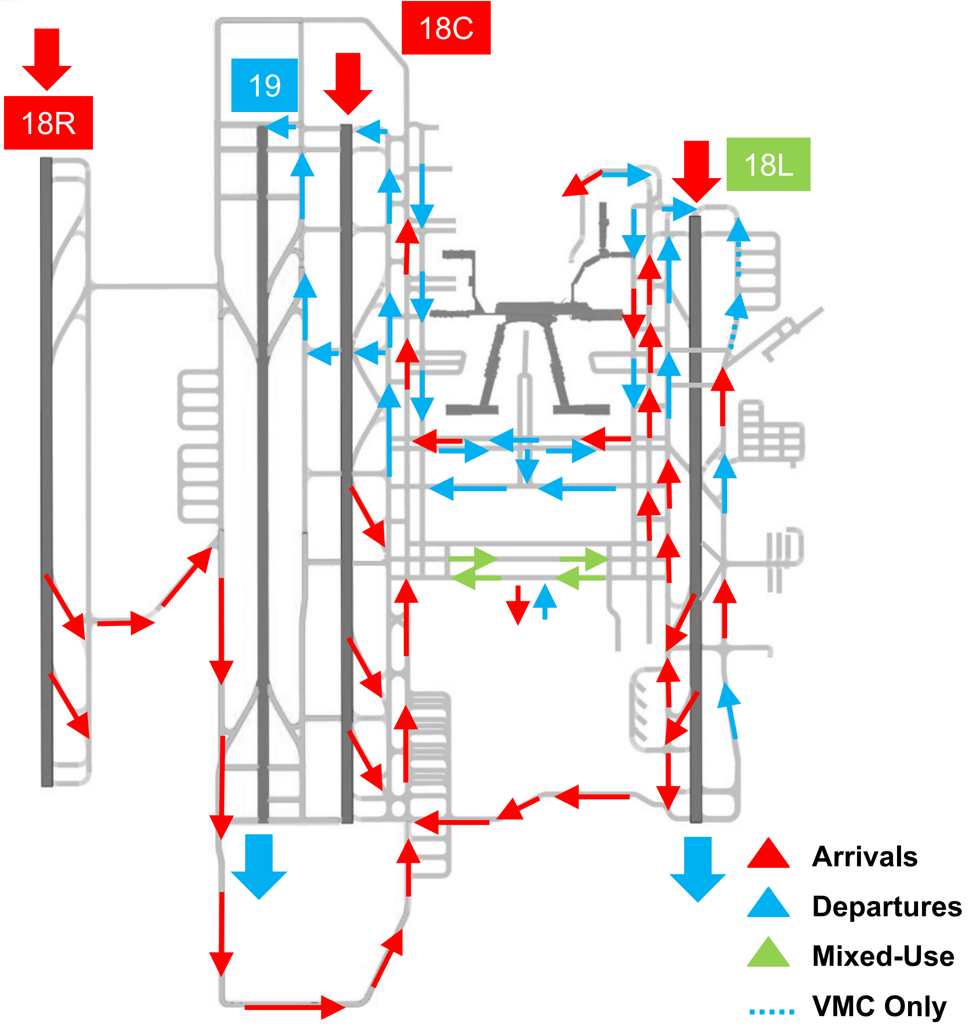


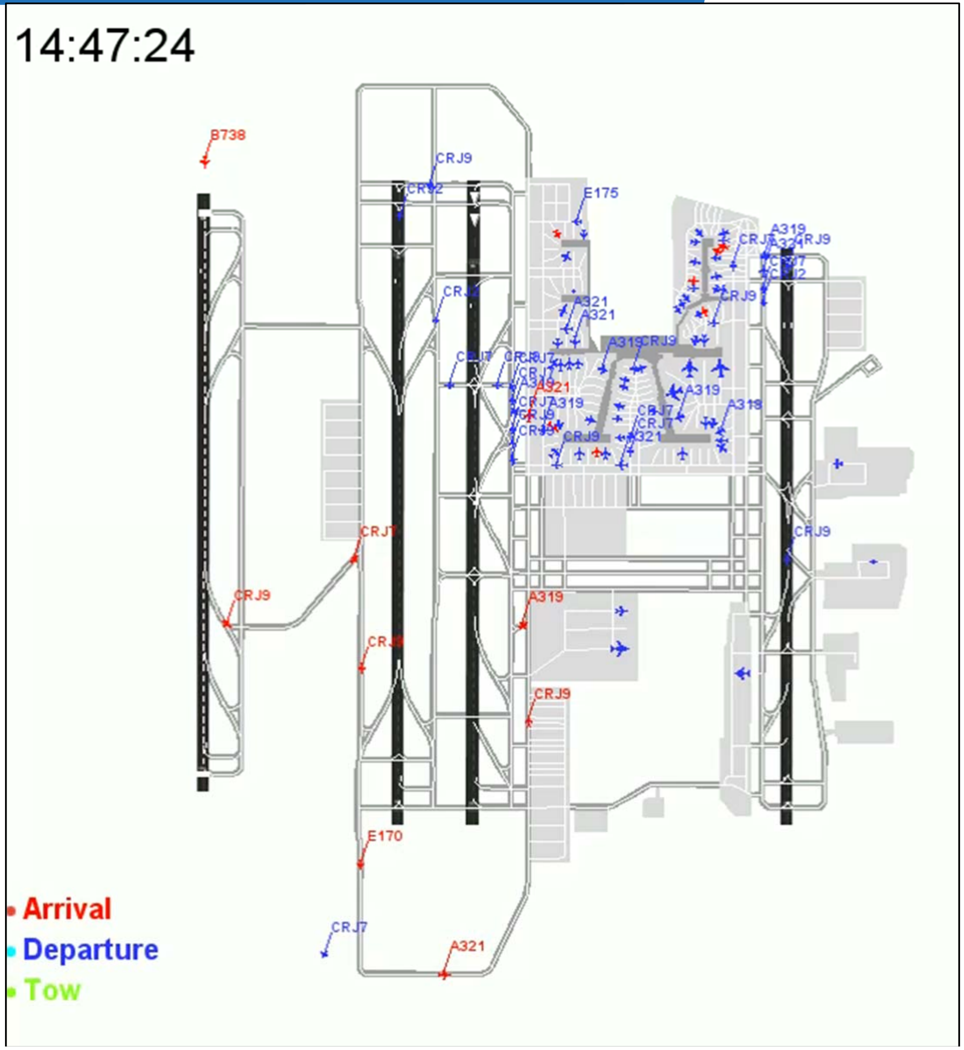
Proposed Action – North Flow, Scenario 2



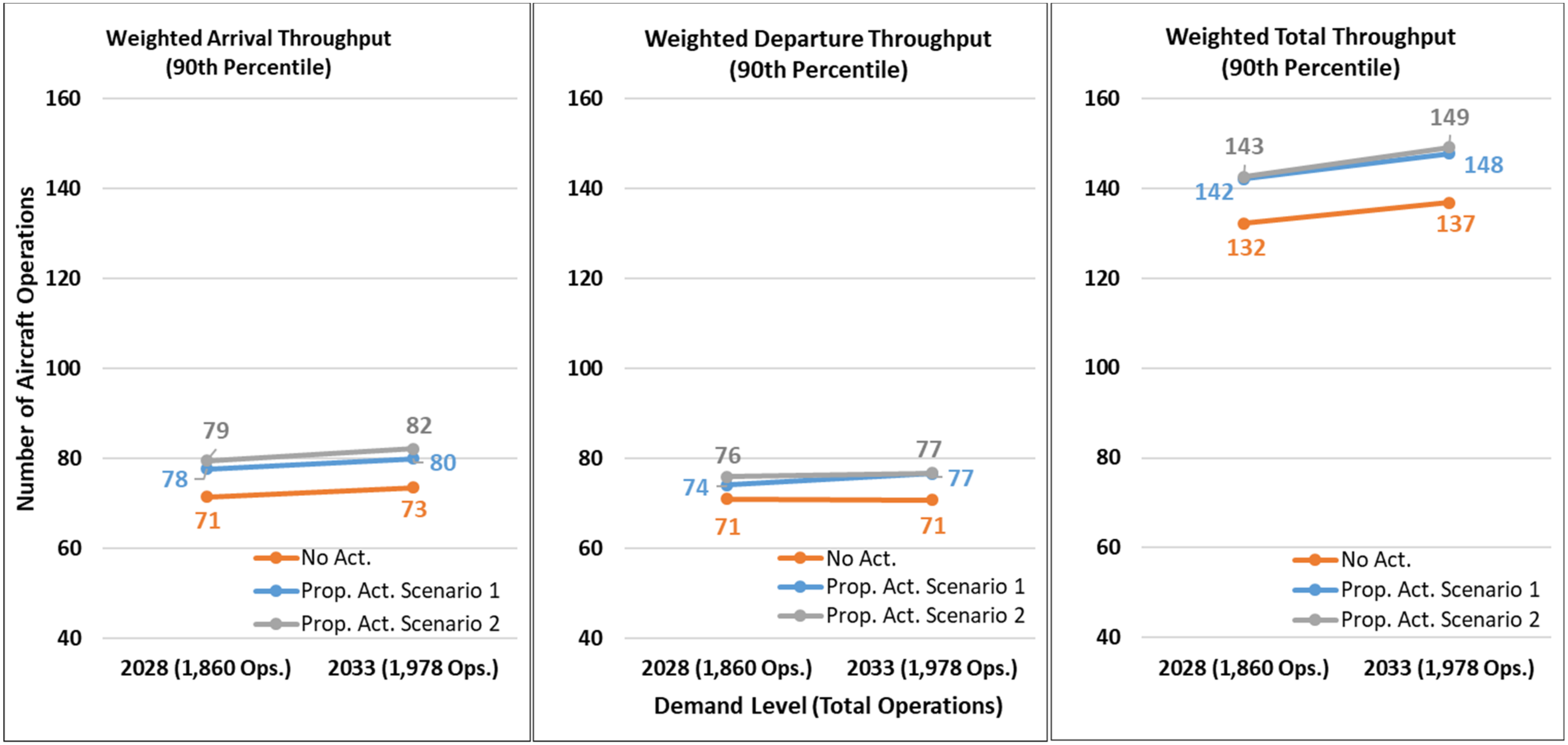


Proposed Action – South Flow, Scenario 2



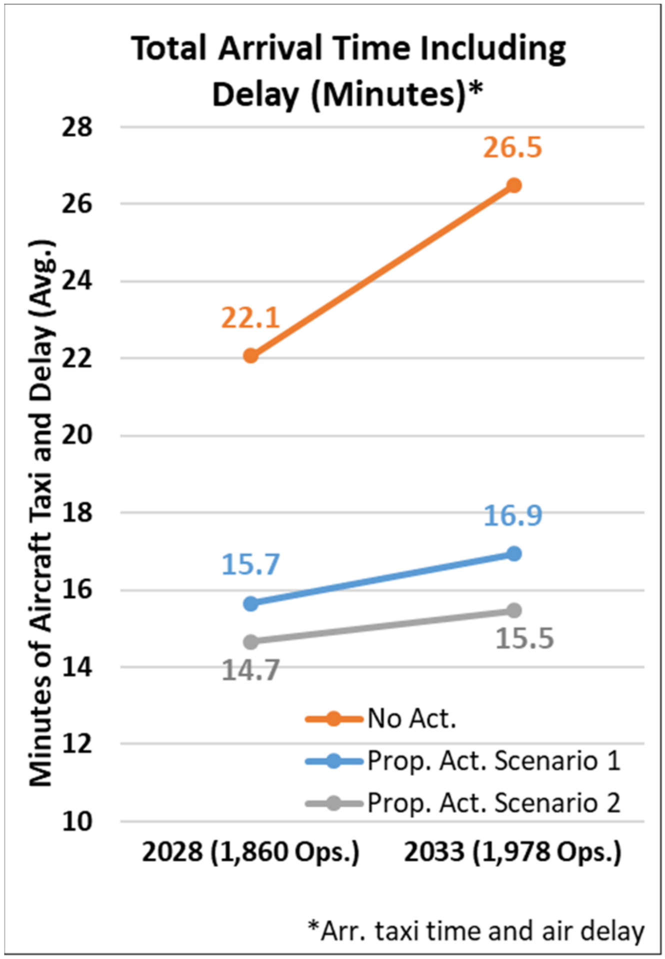


Proposed Action Weighted Aircraft Throughput



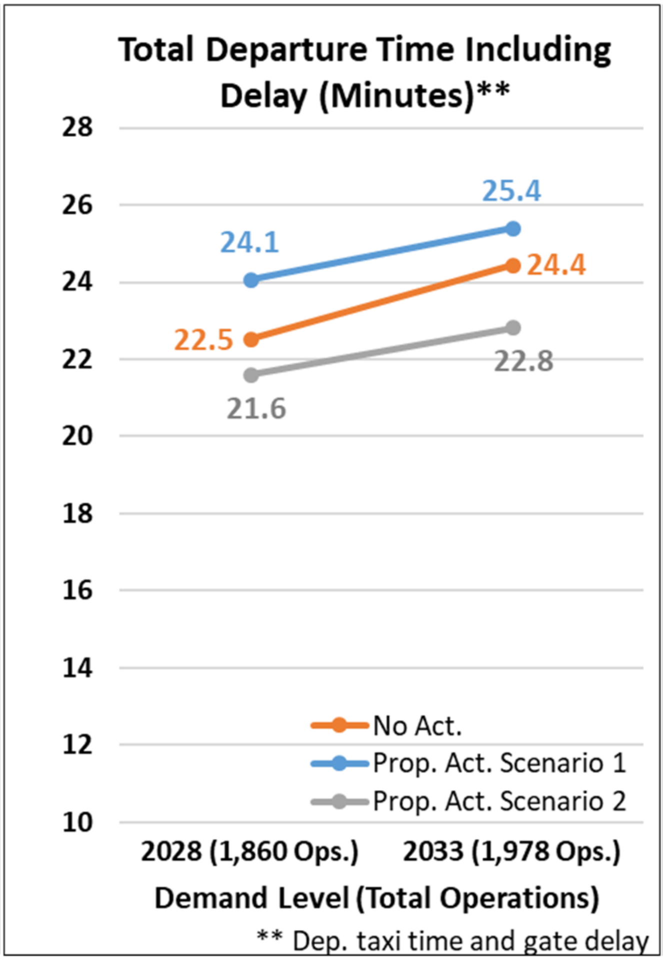
Prop. Act. Scenario 1: All operations use EATs (no runway crossings)
Prop. Act. Scenario 2: Departures use Taxiway V and arrivals use EATs

Proposed Action Total Time Including Delay



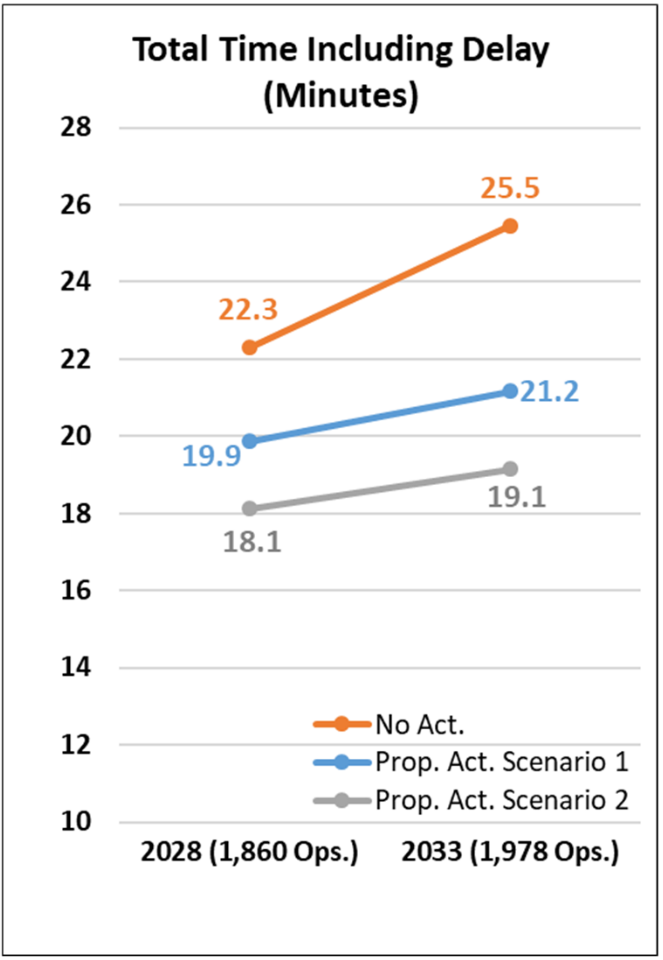
Total Arrival Time Including Delay (Minutes)*

*Arr. taxi time and air delay



Total Departure Time Including Delay (Minutes)**

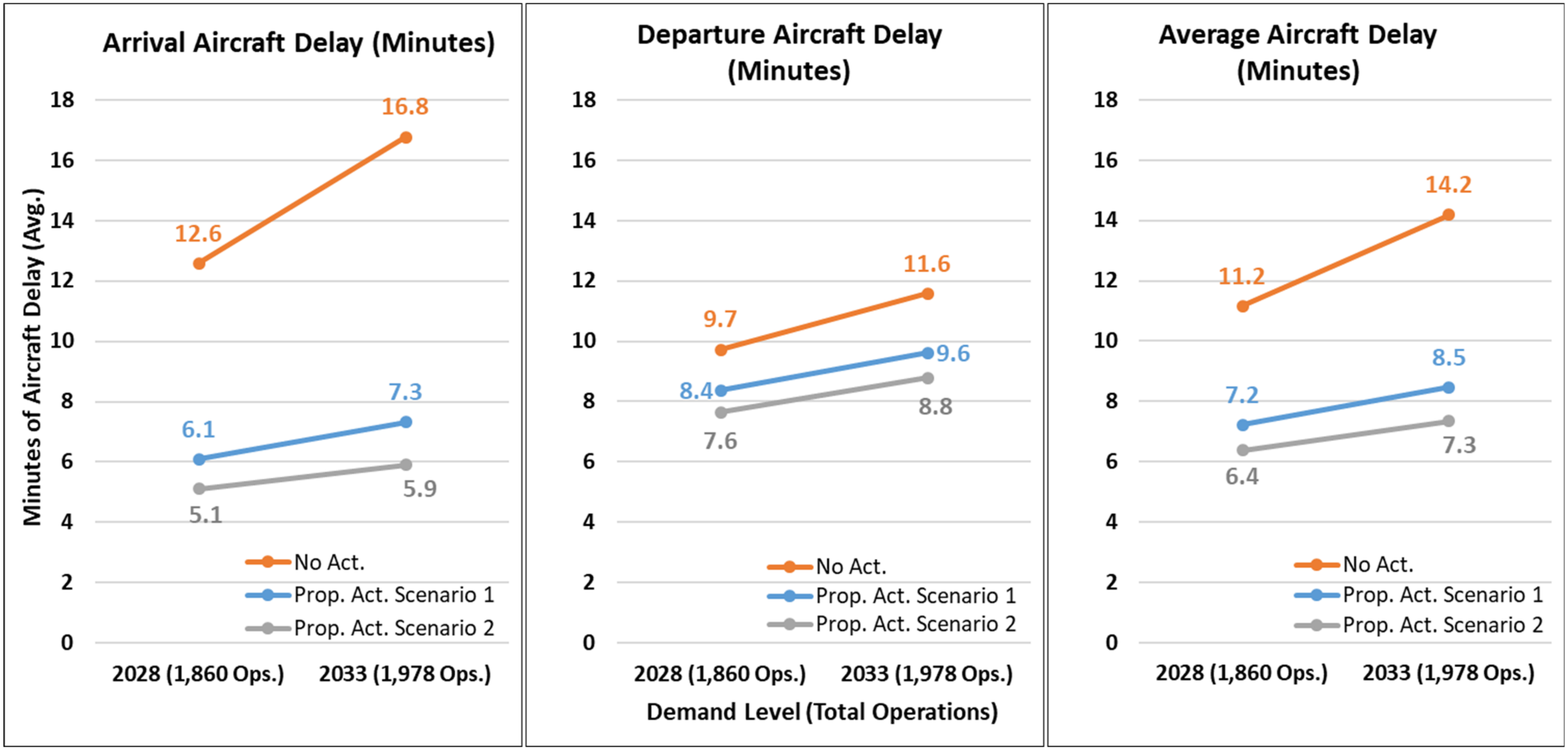
** Dep. taxi time and gate delay



Total Time Including Delay (Minutes)

Prop. Act. Scenario 1: All operations use EATs (no runway crossings)
Prop. Act. Scenario 2: Departures use Taxiway V and arrivals use EATs

Proposed Action Average Aircraft Delay



Prop. Act. Scenario 1: All operations use EATs (no runway crossings)
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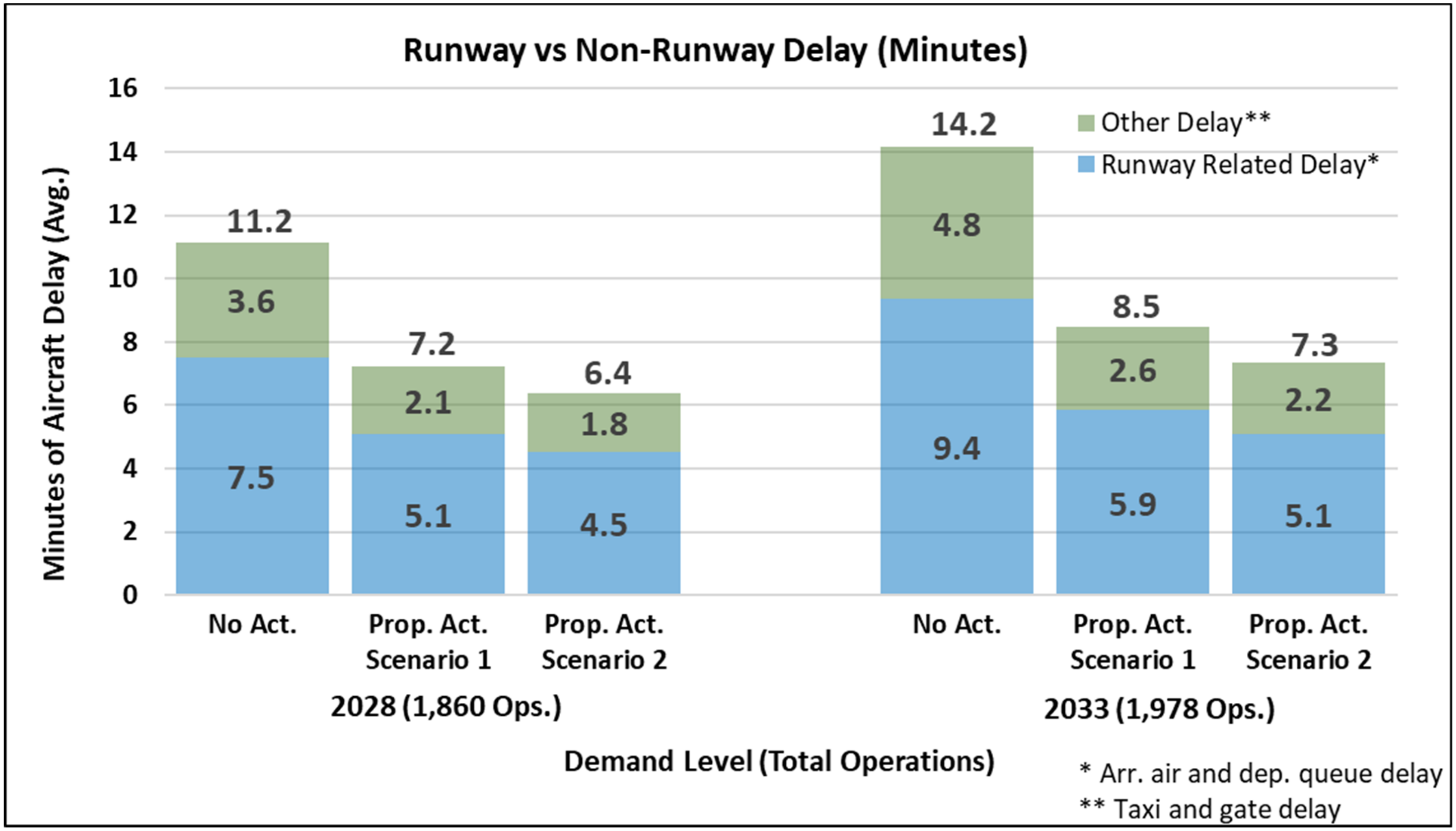
Proposed Action Average Aircraft Delay



* Arr. air and dep. queue delay

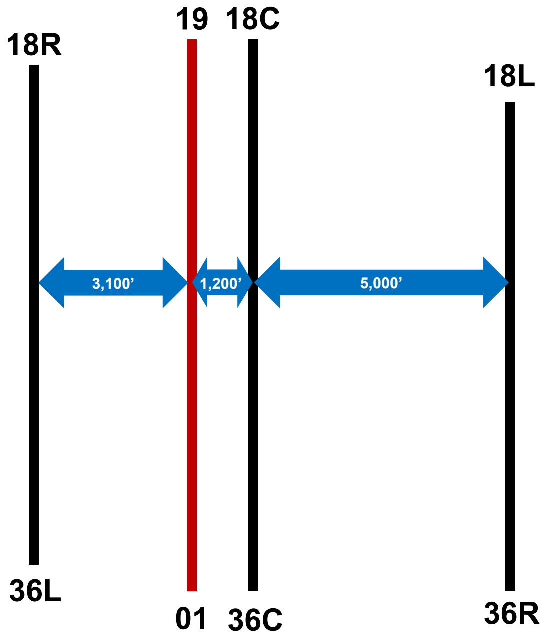
** Taxi and gate delay

Prop. Act. Scenario 1: All operations use EATs (no runway crossings)
Prop. Act. Scenario 2: Departures use Taxiway V and arrivals use EATs

Alternatives Development and Screening

Proposed Action

- Proposed action alternative developed based on existing FAA Order 7110.65 criteria for parallel runways:
  - 3,900’ of separation required for simultaneous triple approaches
  - 700’-1,200’ of separation required for simultaneous VFR operations by ADG V aircraft
- 4,300’ of separation exists between 18L/36R and 18C/36C
  - Insufficient to allow triple approaches to new runway
  - New runway sited to provide 1,200’ of separation to Runway 18C/36C
- New runway would therefore be used for departures and arrivals would occur on Runway 18C/36C
  - Results in arrivals on runway to “inboard” runway and departures to “outboard” – not a typical operation

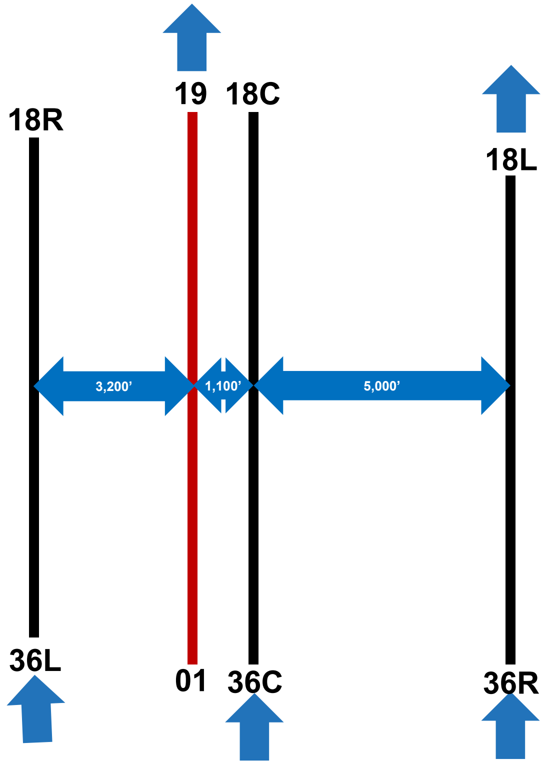


New FAA Rules for Parallel Runways

- New FAA operating rules for lateral separation between parallel runways expected in spring 2021 revision for FAA Order 7110.65
  - Allow 3,200 feet for simultaneous dual approaches (vs current 3,600 feet)
  - Allow 3,400 feet for simultaneous triple approaches (vs current 3,900 feet)
- Allows for different runway separations to be considered between CLT's new runway and Runway 18R/36L
  - Affects intended runway use (primary departure or arrival)
  - Which in turn affects runway length requirements

3,200’ Between Runways 18R/36L and 01/19

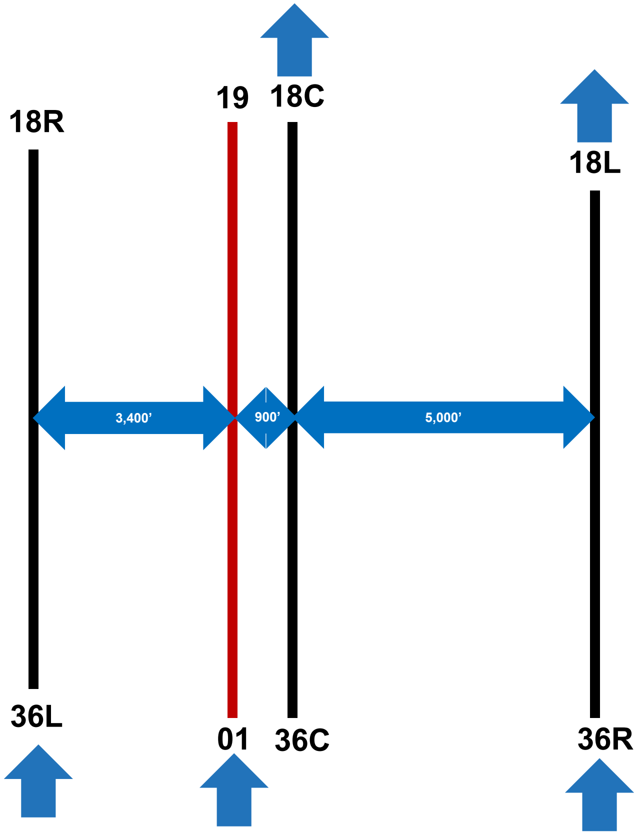
- Same runway use as the Proposed Action
- Potential for simultaneous triples in future (would require rule change)



Notes:
Diagram is not to scale.
Runway length may vary depending on the use of the runway.

3,400’ Between Runways 18R/36L and 01/19

– Allows simultaneous triple approaches to new runway



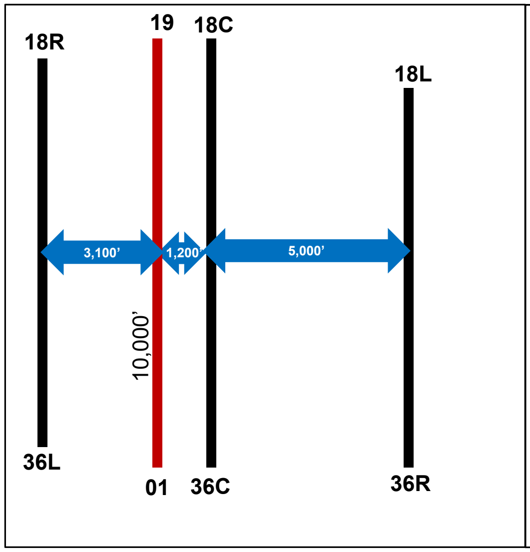
Notes:
Diagram is not to scale.
Runway length may vary depending on the use of the runway.

Runway Length Requirements

- Runway length will vary depending on how the runway is being used
- Conducted a runway length requirements analysis based on
  - CLT future fleet
  - FAA guidelines
  - Airline input
- Length requirements:
  - Departures: 10,000 feet
  - Arrivals: 7,300 feet
- Lengths can be longer if required for other operational reasons

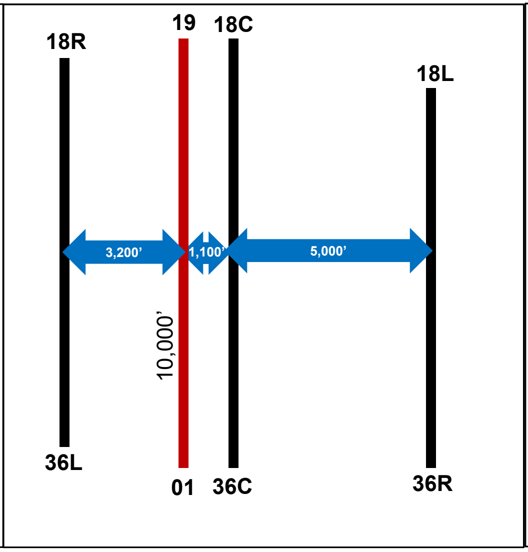
Alternatives with Alternative Runway Separations

Alternative 1
(Proposed Action)



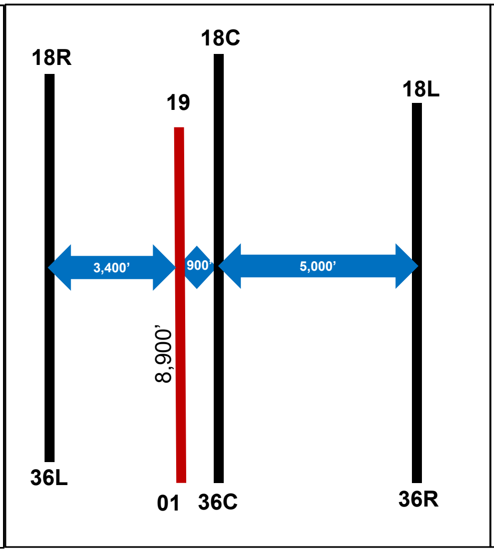
3,100' separation to 18R/36L
10,000' departure runway

Alternative 2



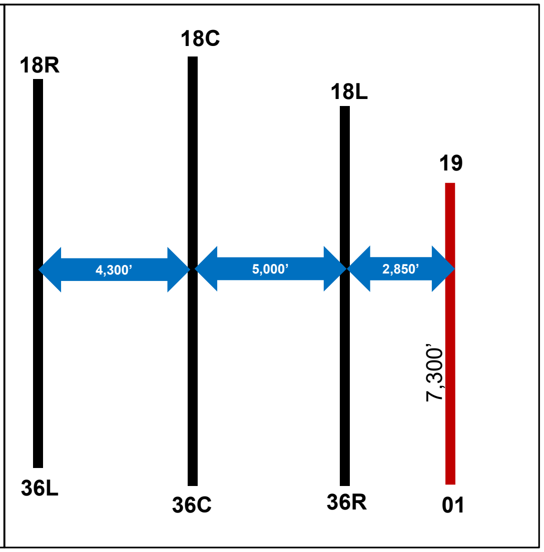
3,200' separation to 18R/36L
10,000' departure runway

Alternative 3



3,400' separation to 18R/36L
8,900' arrival runway

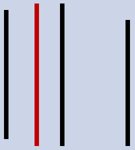
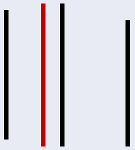
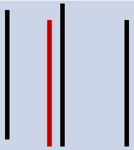
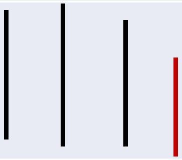
Alternative 4



2,850' separation to 18L/36R
7,300' arrival runway

Note: Diagrams are not to scale.

Runway Alternatives Screening Process

Alternative	Meet Purpose and Need (< 7 Minutes Average Runway Delay)?	Reasonable and Feasible Alternative Based on Timeframe and Cost?	Carried Forward for Further Analysis?
1 	Yes	Yes	Yes
2 	Yes	Yes	Yes
3 	Yes	Yes	Yes
4 	Yes	No	No

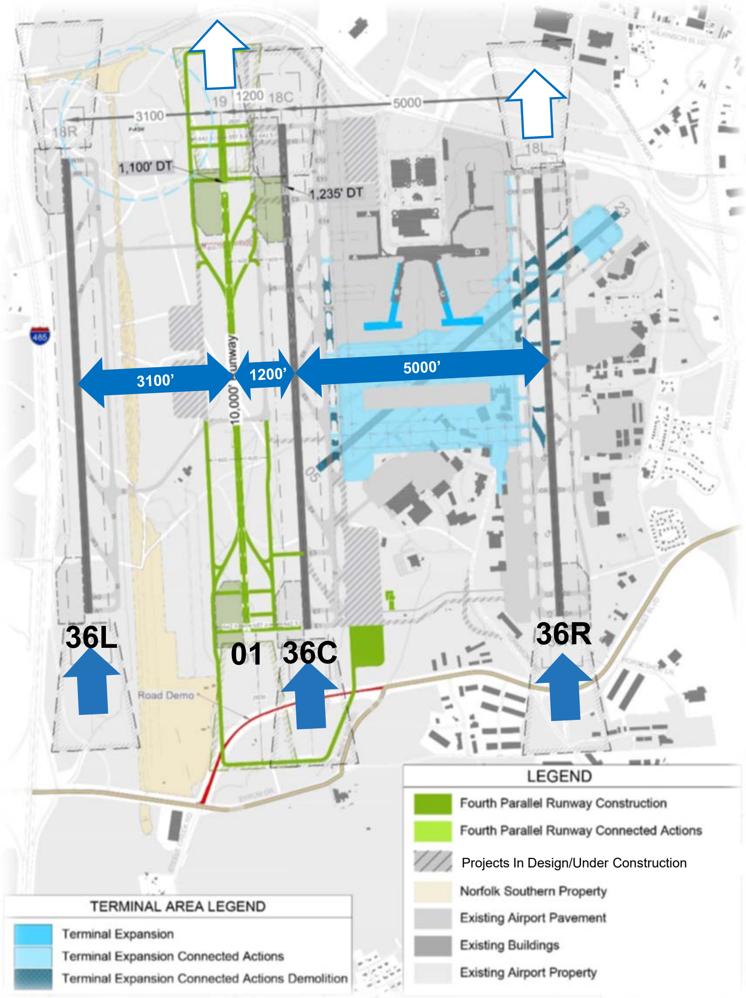
Note: Diagrams are not to scale.

Alternatives Airspace Assumptions

Alternatives Airspace Assumptions

- Alternatives will use same assumptions as Proposed Action:
  - Apply FAA Wake RECAT separation criteria
  - Minimum arrival separations on final approach – 2.5 nautical miles (VMC) and 3.8 nautical miles (IMC)
  - Allocation of city pairs to airport routes
  - Allocation of fixes to runways
  - Straight out departure headings

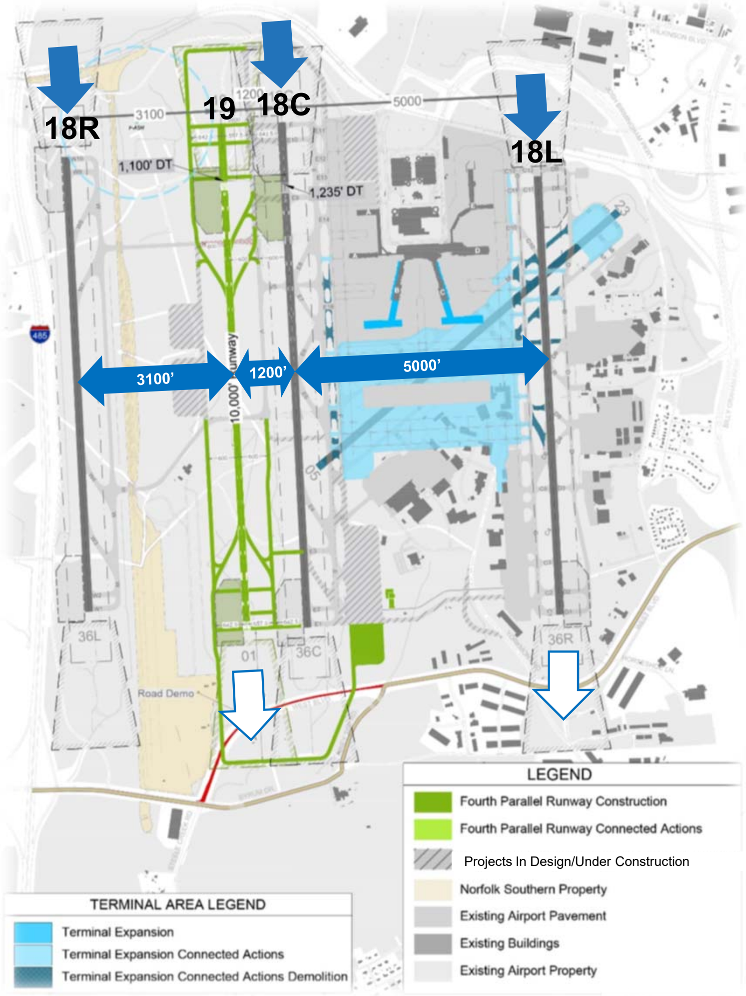
Alternative 1 (Proposed Action) – North Flow 10,000’ Runway / 3,100’ Separation to 18R/36L



Source: L&B, 2020

- Proposed Action
- 3,100 feet of separation between new midfield runway and Runway 18R/36L
- Arrivals:
  - Runways: 36L, 36C, 36R
  - Simultaneous triple independent approaches permissible in all weather conditions
- Departures:
  - Runways 01 and 36R
  - 10,000-foot long Runway 01/19
- Runway capacity:
  - Simultaneous triple approaches

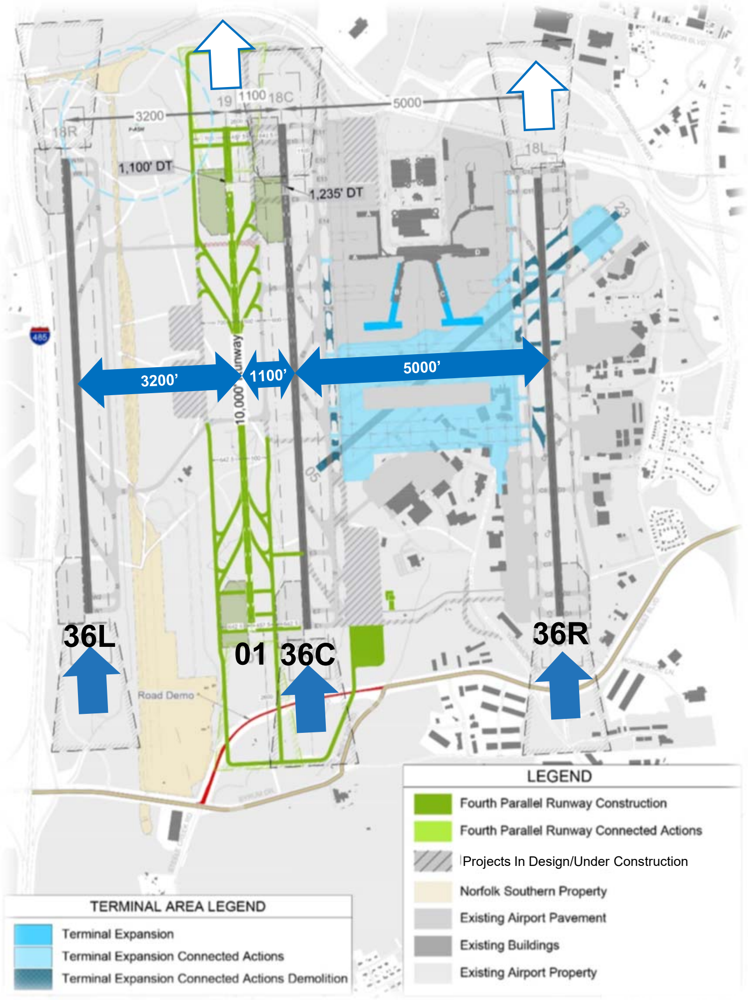
Alternative 1 (Proposed Action) – South Flow
10,000’ Runway / 3,100’ Separation to 18R/36L



Source: L&B, 2020

- Proposed Action
- 3,100 feet of separation between new midfield runway and Runway 18R/36L
- Arrivals:
  - Runways: 18R, 18C, 18L
  - Simultaneous triple independent approaches permissible to RVR 4500
- Departures:
  - Runways 19 and 18L
  - 10,000-foot long Runway 19
- Runway capacity:
  - Simultaneous triple approaches

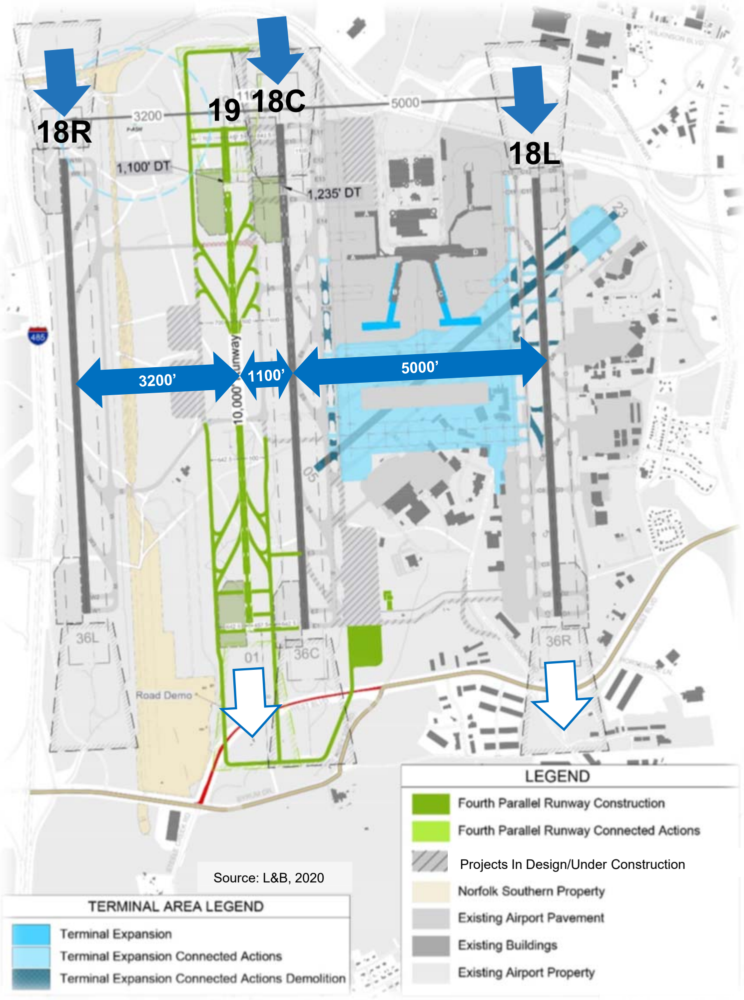
Alternative 2 – North Flow
10,000’ Runway / 3,200’ Separation to 18R/36L



Source: L&B, 2020

- Opportunity for “future proofing” for possible additional reductions in triple runway spacing requirements
- 3,200 feet of separation between new midfield runway and Runway 18R/36L
- Arrivals (same as Alt. 1):
  - Runways: 36L, 36C, 36R
  - Simultaneous triple independent approaches permissible in all weather conditions
- Departures (same as Alt. 1):
  - Runways 01 and 36R
  - 10,000-foot long Runway 01/19
- Runway capacity:
  - Simultaneous triple approaches

Alternative 2 – South Flow
10,000’ Runway / 3,200’ Separation to 18R/36L

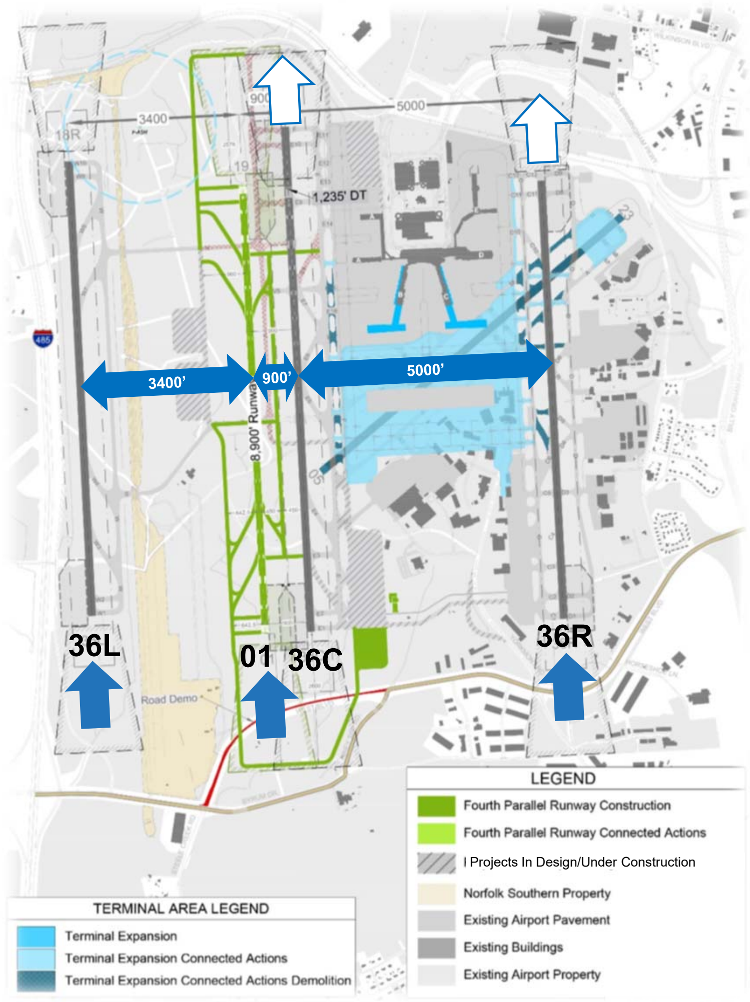


Source: L&B, 2020

Source: L&B, 2020

- Opportunity for “future proofing” for possible additional reductions in triple runway spacing requirements
- 3,200 feet of separation between new midfield runway and Runway 18R/36L
- Arrivals (same as Alt. 1):
  - Runways: 18R, 18C, 18L
  - Simultaneous triple independent approaches permissible to RVR 4500
- Departures (same as Alt. 1):
  - Runways 19 and 18L
  - 10,000-foot long Runway 01/19
- Runway capacity:
  - Simultaneous triple approaches

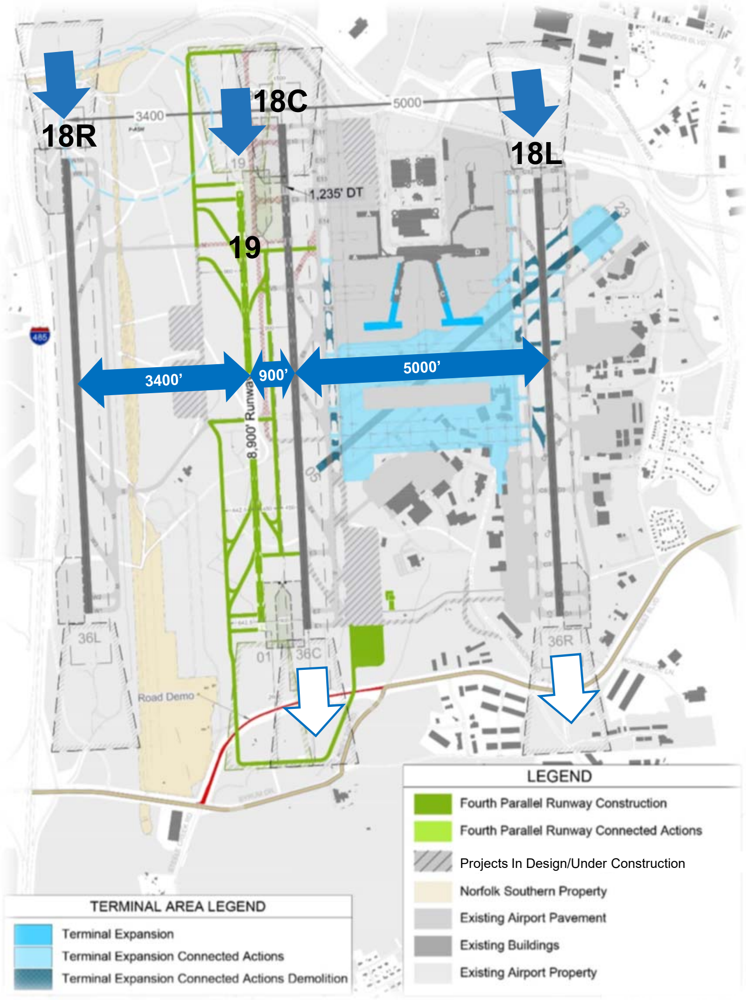
Alternative 3 – North Flow
8,900’ Runway / 3,400’ Separation to 18R/36L



Source: L&B, 2020

- Opportunity to change runway use through the use of proposed runway spacing criteria
- **3,400** feet of separation between new midfield runway and Runway 18R/36L
- Arrivals:
  - Runways 36L, **01**, and 36R
  - **8,900**-foot long Runway 01/19
  - Simultaneous triple independent approaches permissible in all weather conditions (assumes CAT II/III on Rwy 01)
- Departures:
  - Runways **36C** and 36R
- Runway capacity:
  - Simultaneous triple approaches
- Does not allow for a full taxiway between Runway 01/19 and 18C/36C

Alternative 3 – South Flow
8,900’ Runway / 3,400’ Separation to 18R/36L



Source: L&B, 2020

- Opportunity to change runway use through the use of proposed runway spacing criteria
- **3,400** feet of separation between new midfield runway and Runway 18R/36L
- Arrivals:
  - Runways 18R, **19**, and 18L
  - **8,900**-foot long Runway 01/19.
  - Simultaneous triple independent approaches permissible (assumes CAT II/III on Rwy 19) to RVR 4500
- Departures:
  - Runways **18C** and 18L
- Runway capacity:
  - Simultaneous triple approaches
- Does not allow for a full taxiway between Runway 01/19 and 18C/36C

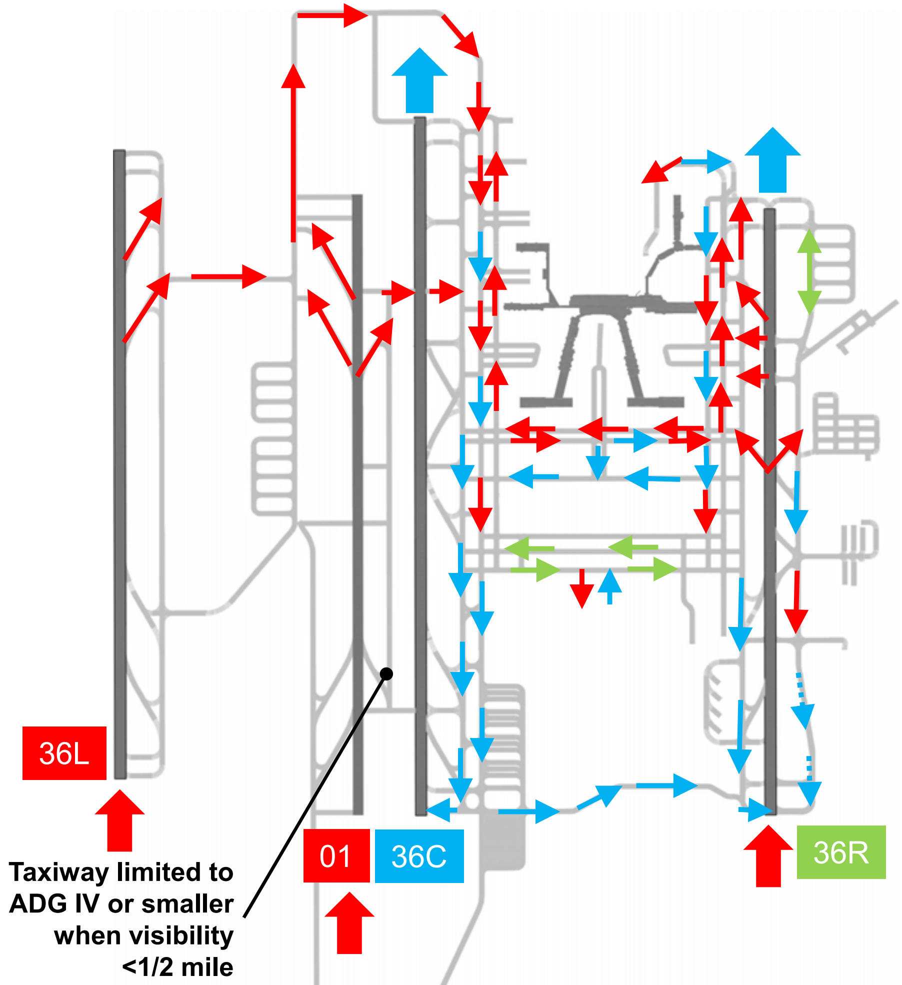
Alternatives Taxi Flow Assumptions

Aircraft Taxi Flows – Alternatives 1 and 2

- Taxi flows for the Proposed Action (Alternative 1) were presented earlier
- Taxi flows for Alternative 2 will be identical to the Proposed Action with one exception
  - Taxiway V cannot be used by ADG V aircraft when visibility is less than a half mile due to the 1,100-foot separation between Runways 01/19 and 18C/36C

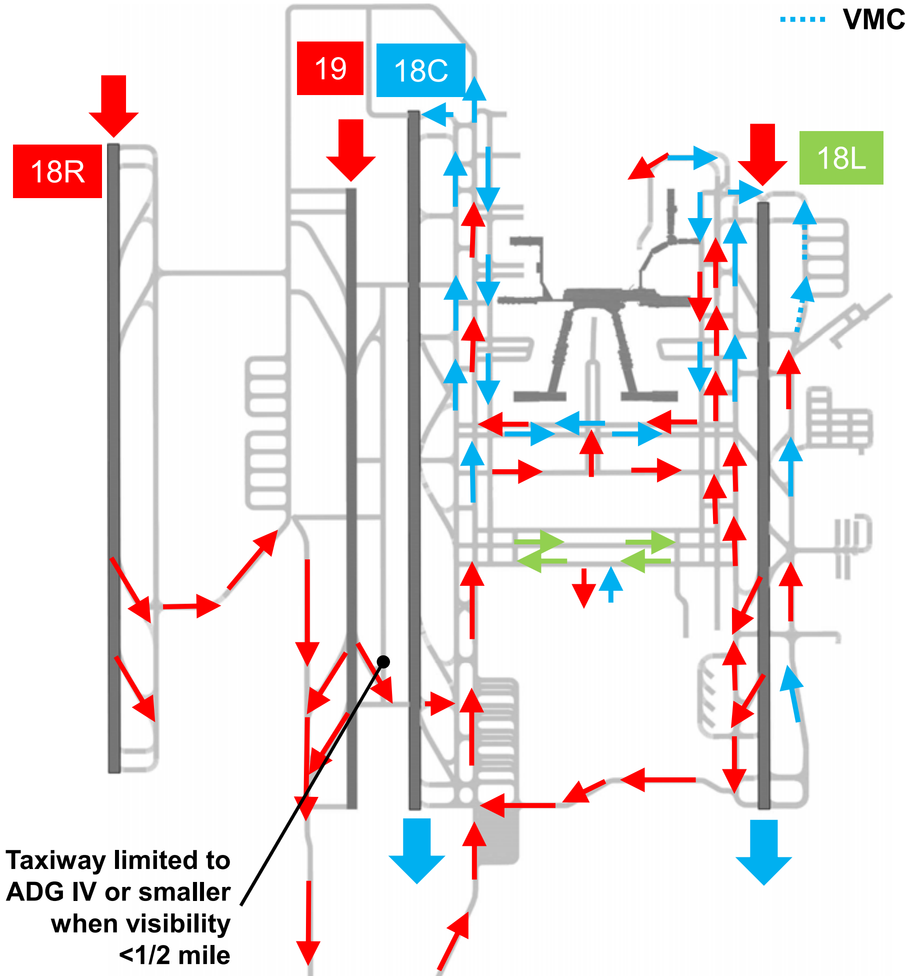
Aircraft Taxi Flows – Alternative 3

▲ Arrivals
▲ Departures
▲ Mixed-Use
⋯⋯ VMC Only



Taxiway limited to ADG IV or smaller when visibility <1/2 mile

North Flow



Taxiway limited to ADG IV or smaller when visibility <1/2 mile

South Flow

Next Steps

Next Steps

- Provide comments to EA Team by November 20, 2020
  - Send comments to spotter@landrum-brown.com
- Incorporate comments from DORA Team
- Conduct alternatives modeling analysis
- DORA Meeting #4
- Continue preparation of the Draft EA

CLT DORA (Direction, Oversight, Review & Agree) Meeting #4

January 27, 2021

Agenda

- Role Call
- Meeting Objectives
- DORA Process
- EA Process Overview
- Present Alternatives Modeling Results
- Next Steps

DORA Process

Charlotte Douglas International Airport EA

DORA Process Overview

Prepared for: CLT EA DORA Meeting #4

By: Kent Duffy

Date: January 27, 2021

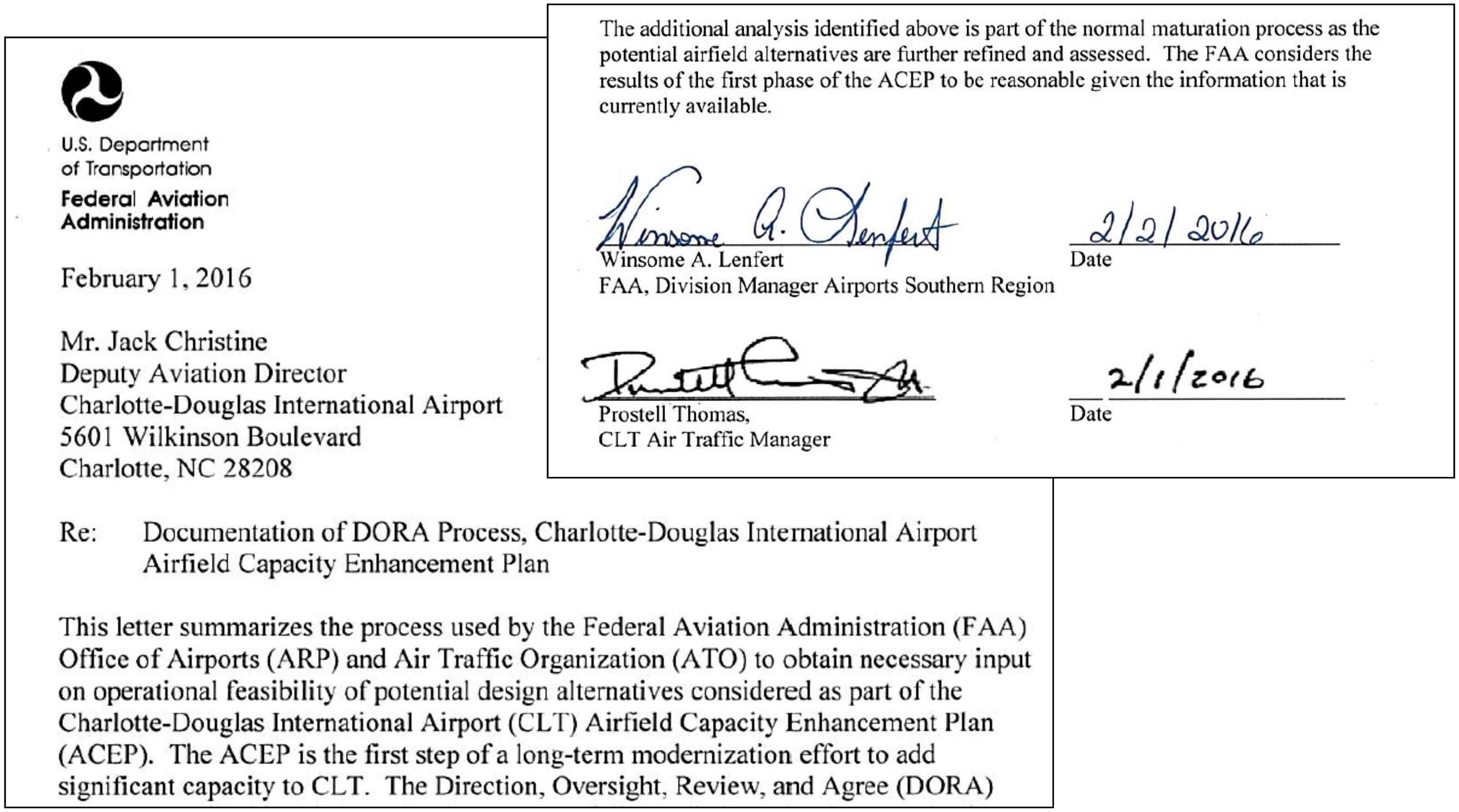
What is DORA?

- **DORA** =
  Direction, **O**versight, **R**eview and **A**gree
- Obtaining and understanding controller input on operational issues and viability of proposed alternatives is a key to airport capacity development
- DORA has been applied successfully to other large-scale airport and airspace modernization efforts (e.g., O’Hare Modernization Program)

Objectives: Why are we here?

- **Ensure collaboration w/ATO on simulation activities as needed to complete EA**
  - Obtain input development of the simulation model
  - Revise and refine simulation model, rather than develop new alternatives
- **Build from successful process used during planning phase**
  - Update with recent changes: forecast trends, CRO, metroplex, heading usage, Atlantic coast routes, etc.
  - Validate operating assumptions used in the simulation model
    - Airspace flows and procedures, Runway usage and balancing, Aircraft separation and buffers, Taxi-flows and ground movement, etc.
  - Review and validate airspace's ability to accommodate new runway throughput
- **Collaboration ensures the simulation results can be used in the EA analyses with confidence**

Planning Phase DORA Letter



U.S. Department
of Transportation
**Federal Aviation
Administration**

February 1, 2016

Mr. Jack Christine
Deputy Aviation Director
Charlotte-Douglas International Airport
5601 Wilkinson Boulevard
Charlotte, NC 28208

Re: Documentation of DORA Process, Charlotte-Douglas International Airport Airfield Capacity Enhancement Plan

This letter summarizes the process used by the Federal Aviation Administration (FAA) Office of Airports (ARP) and Air Traffic Organization (ATO) to obtain necessary input on operational feasibility of potential design alternatives considered as part of the Charlotte-Douglas International Airport (CLT) Airfield Capacity Enhancement Plan (ACEP). The ACEP is the first step of a long-term modernization effort to add significant capacity to CLT. The Direction, Oversight, Review, and Agree (DORA)

The additional analysis identified above is part of the normal maturation process as the potential airfield alternatives are further refined and assessed. The FAA considers the results of the first phase of the ACEP to be reasonable given the information that is currently available.

Winsome A. Lenfert
Winsome A. Lenfert
FAA, Division Manager Airports Southern Region

2/2/2016
Date

Prostell Thomas,
CLT Air Traffic Manager

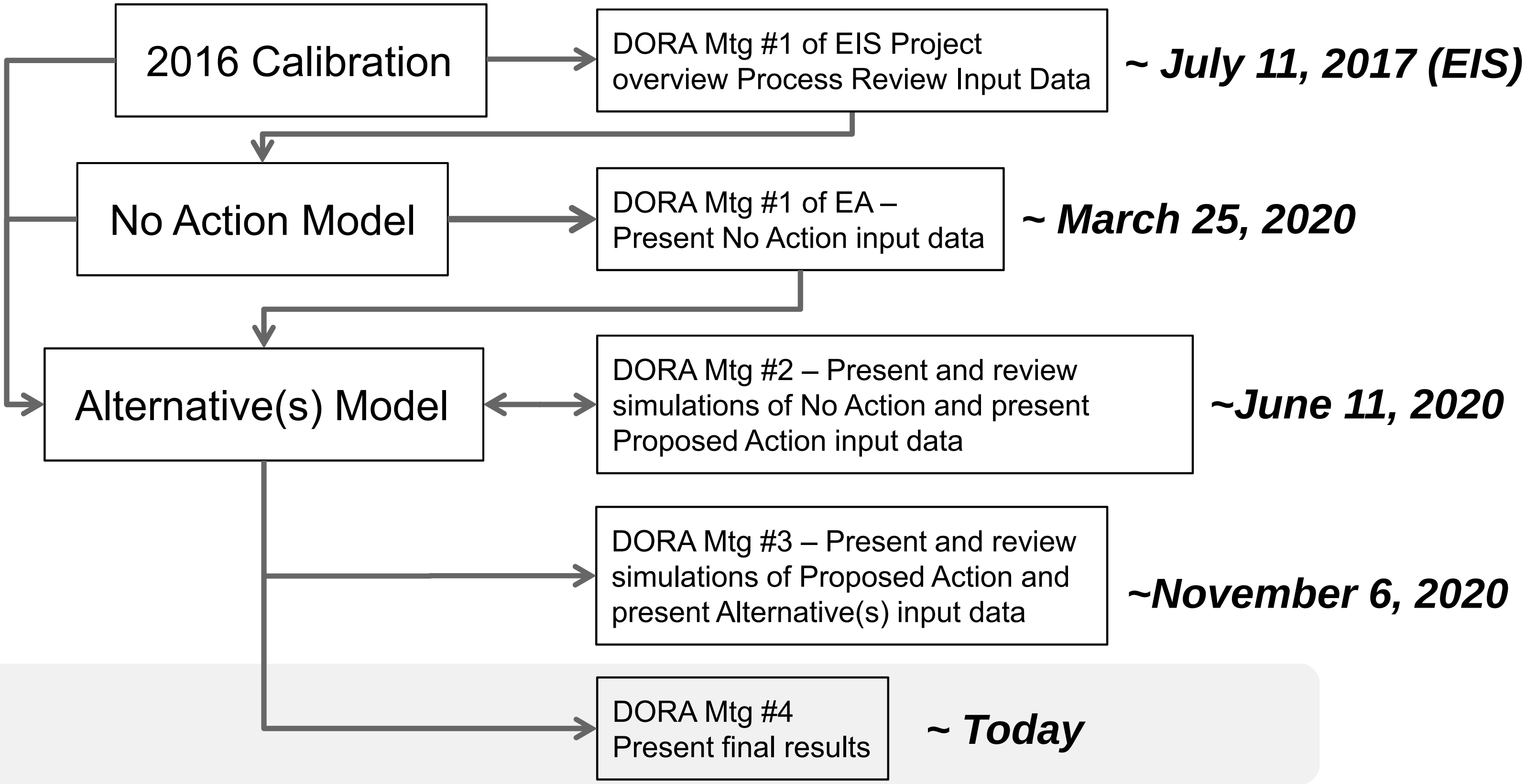
2/1/2016
Date

Desired Result: 2nd DORA Letter

Active ATC participation

- **FAA Letter signed by ATO and ARP**
- **Explains process and summarizes meetings**
- **Identifies further analyses required in subsequent phases (e.g., design/ implementation), as needed**
- **Desired findings:**
  - Modeling approach is reasonable
  - Modeling assumptions accurately reflects operational perspectives
  - Subsequent capacity, throughput and delay results are reasonable representations of the proposed airfield and airspace designs

DORA Process Relationship to Modeling



2016 Calibration

DORA Mtg #1 of EIS Project overview Process Review Input Data

~ July 11, 2017 (EIS)

No Action Model

DORA Mtg #1 of EA – Present No Action input data

~ March 25, 2020

Alternative(s) Model

DORA Mtg #2 – Present and review simulations of No Action and present Proposed Action input data

~June 11, 2020

DORA Mtg #3 – Present and review simulations of Proposed Action and present Alternative(s) input data

~November 6, 2020

DORA Mtg #4
Present final results

~ Today

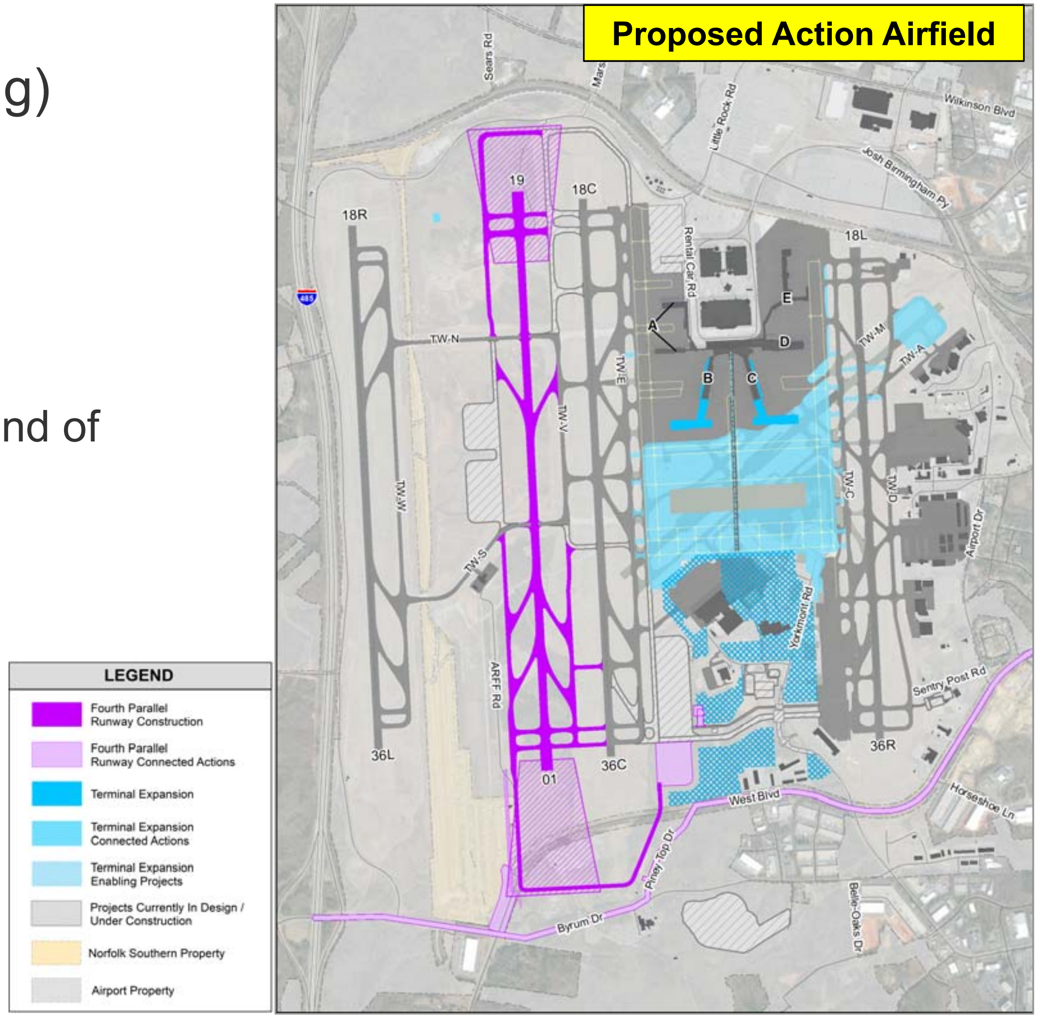
EA Process Overview

EA Process Overview - Background

- The CLT Environmental Impact Statement (EIS) that the Federal Aviation Administration (FAA) began was cancelled on February 27, 2019.
- The FAA cancelled the EIS because a runway length analysis determined only a 10,000 foot runway is required to meet the purpose and need.
- The FAA determined that this was a sufficient change to warrant cancellation of the EIS and conversion to an Environmental Assessment (EA).
- The City of Charlotte (Airport Sponsor) is responsible for preparing the EA.
- FAA is still the lead agency.
- Similar to the EIS, the EA will evaluate the potential direct, indirect, and cumulative environmental impacts that may result from the Proposed Action.

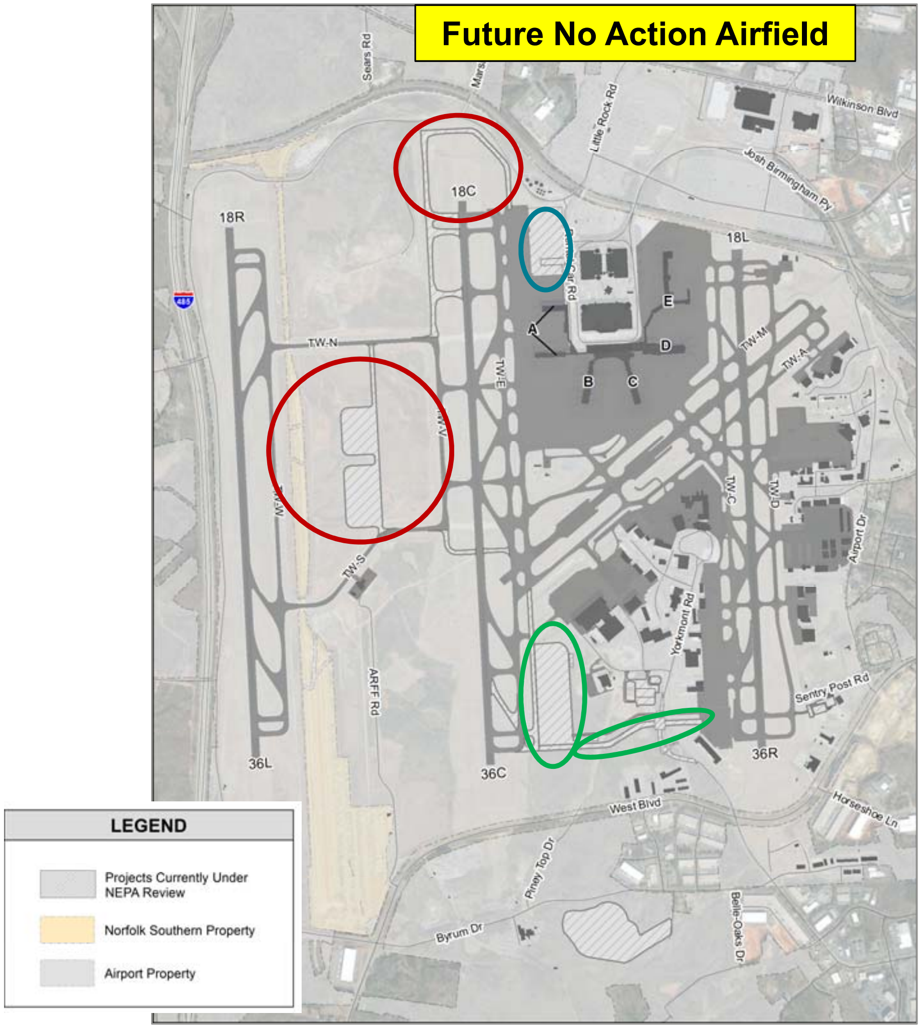
EA Process Overview – Proposed Action

- 4th Parallel Runway (10,000 feet long)
  - North and South End Around Taxiways
- Extensions of Concourse B and C
  - Decommissioning Runway 5/23
- Dual Taxilanes Around Ramp
  - Requires the removal of gates off the end of Concourse D and E
- Crossfield Corridors



EA Process Overview - Simulations

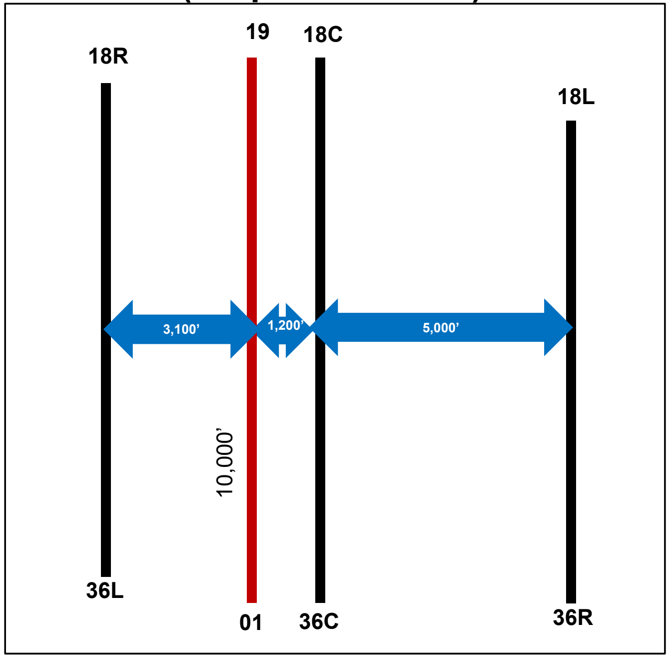
- Simulations will:
  - Be used in developing the Purpose and Need, noise modeling, and air quality modeling.
  - Conducted for the following scenarios:
    - 2016 Calibration - Complete
    - 2019 Baseline - Complete
    - 2028 Future No Action - Complete
    - 2033 Future No Action - Complete
    - 2028 Alternative(s) - Complete
    - 2033 Alternative(s) - Complete
  - Use forecast of operations approved by the FAA.
  - Include 3 independent projects as part of the Future No Action.
    - Deice Pad and crossfield taxiway
    - North End Around Taxiway around Runway 18C/36C, hold pads and threshold displacement (1,235 feet)
    - Concourse A Phase II



Alternatives Simulation Modeling Results

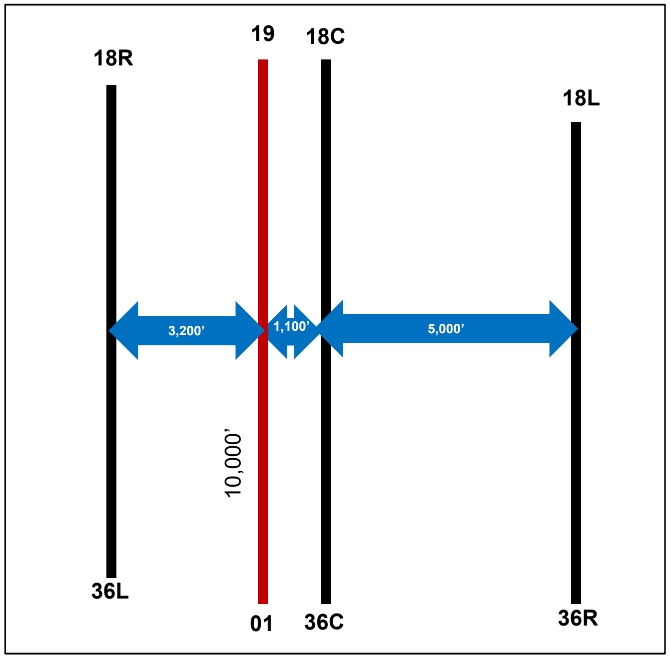
Alternatives Overview

Alternative 1
(Proposed Action)



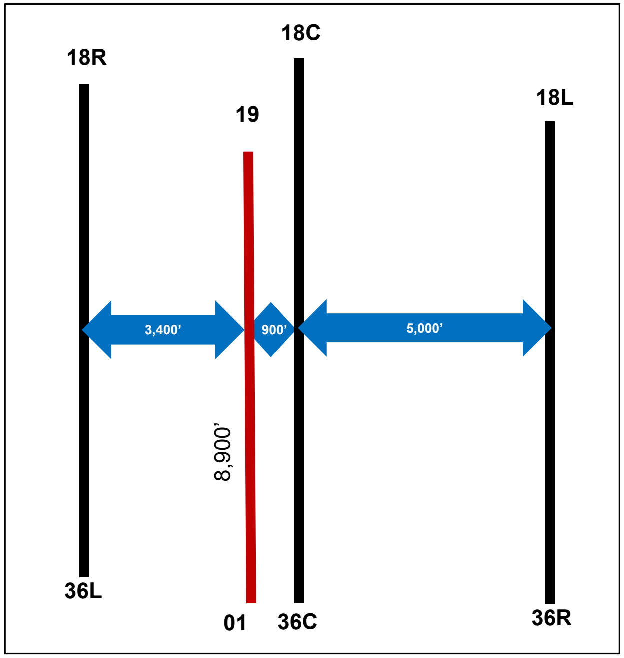
3,100' separation to 18R/36L
10,000' departure runway

Alternative 2



3,200' separation to 18R/36L
10,000' departure runway

Alternative 3

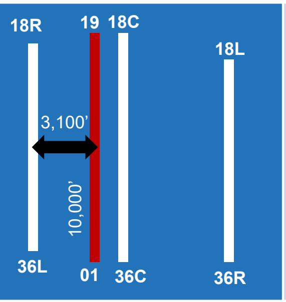
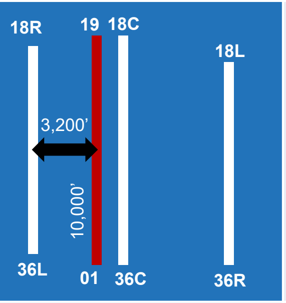
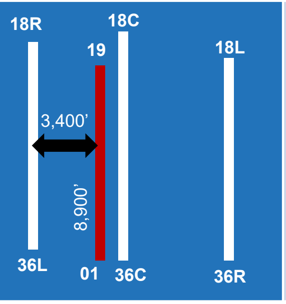


3,400' separation to 18R/36L
8,900' arrival runway

Alternative 2 simulation results are assumed to be same as Alternative 1, with only slight taxi time differences

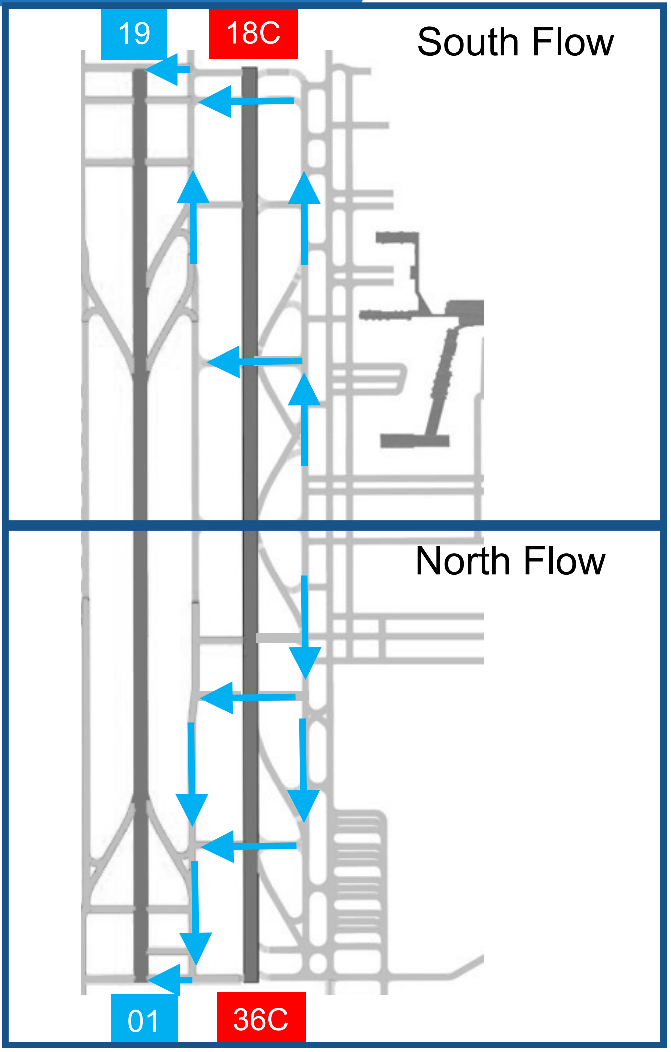
Note: Diagrams are not to scale.

Comparison of Alternatives

Alternative	Future Flexibility	Taxiway V Capability	Navigational Aid Placement	Runway Use	Crossings of Rwy 18C/36C
1 **Proposed Action** 	No	Full length; unrestricted	Standard placement	Arrivals on inboard runway	More than Alternative 3
2 	Potential for Rwy 01/19 to be part of simultaneous triples if rules changed in future	Full length; minor restrictions	Standard placement	Arrivals on inboard runway	More than Alternative 3
3 	n/a	Partial taxiway; minor restrictions	Co-located glideslopes (Rwy 18C/19 and 36C/01)	Arrivals on outboard runway	Fewer than Alternatives 1 & 2

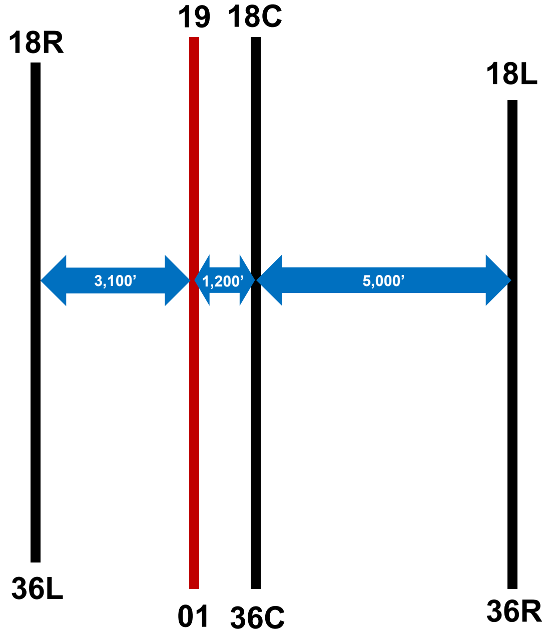
Alternative 1 (Proposed Action) Refinement

- Added runway crossing points to let two departing aircraft cross Runway 18C/36C simultaneously
  - Reduces Runway 01/19 departure delay
  - Allow more arrivals on Runway 18C/36C
- Rebalanced runway usage to optimize delay and throughput
  - Offload arrivals from Runway 18L/36R to Runway 18C/36C
  - Balance departures between Runway 01/19 and Runway 18L/36R



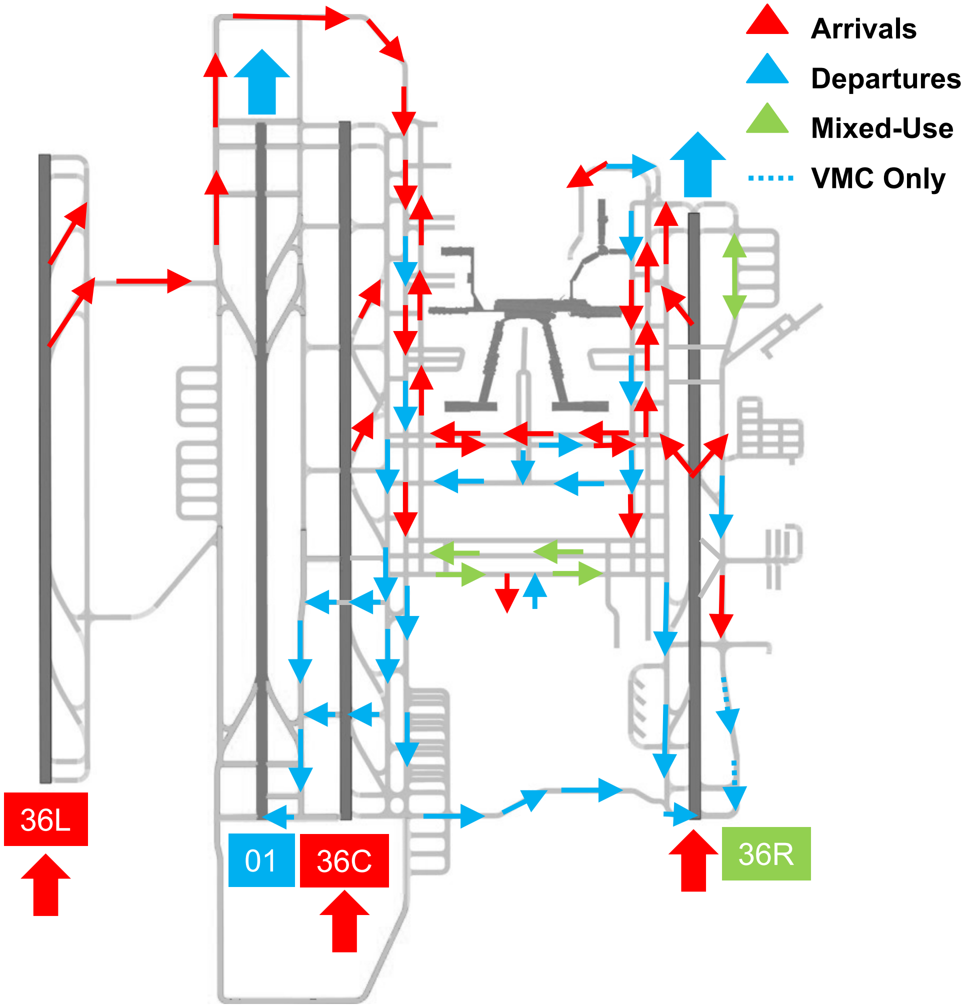
Alternative 1 (Proposed Action)/Alternative 2

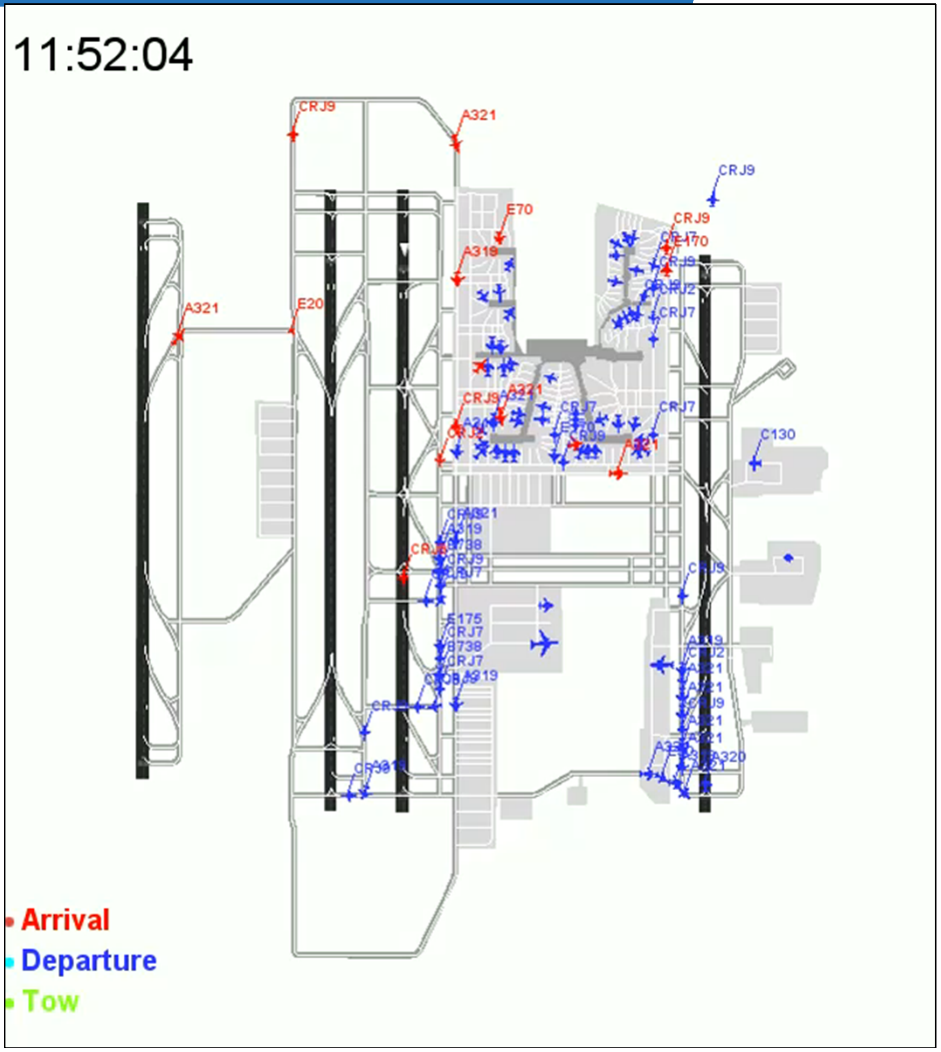
- Alternatives 1 and 2
  - Same runway use and procedures
  - Same performance with the exception of slight differences in taxi times
- Closely spaced parallel runways:
  - Runways are dependent in IMC
  - Arrivals block departures 2 miles out



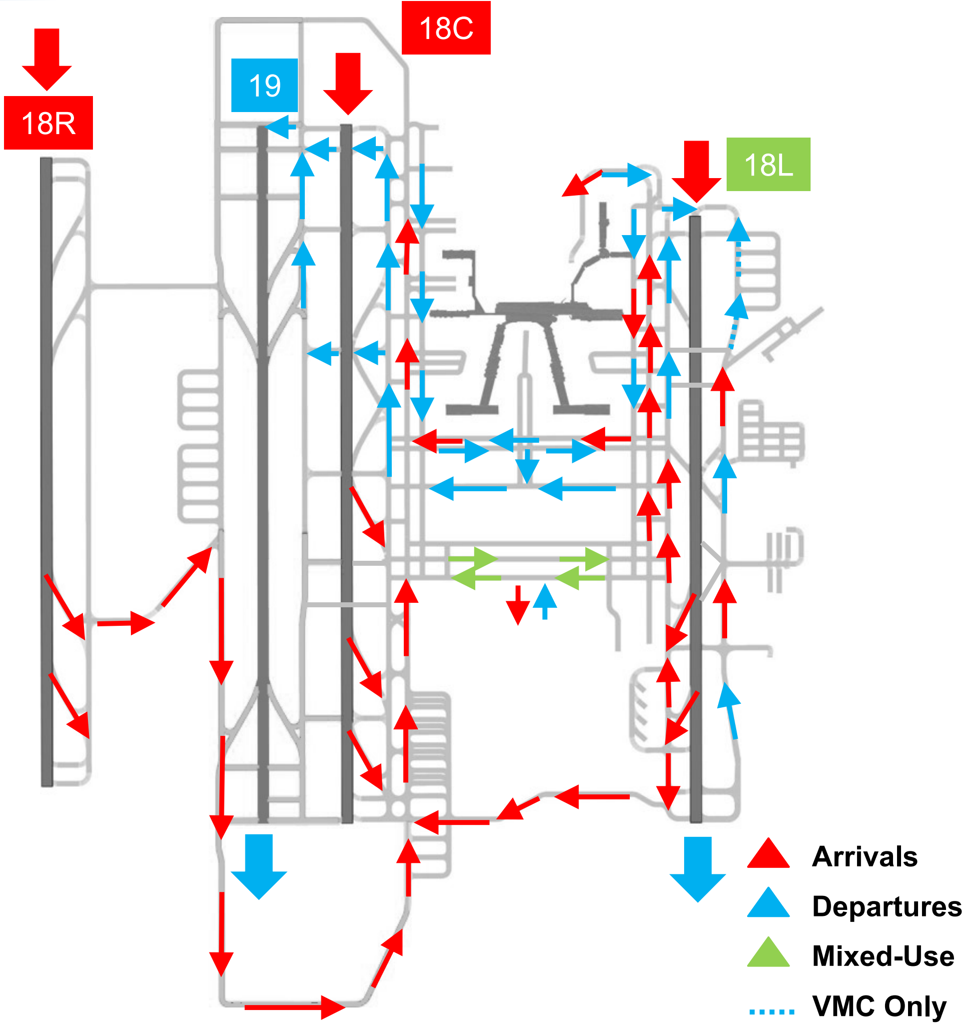
Note: Diagram is not to scale.

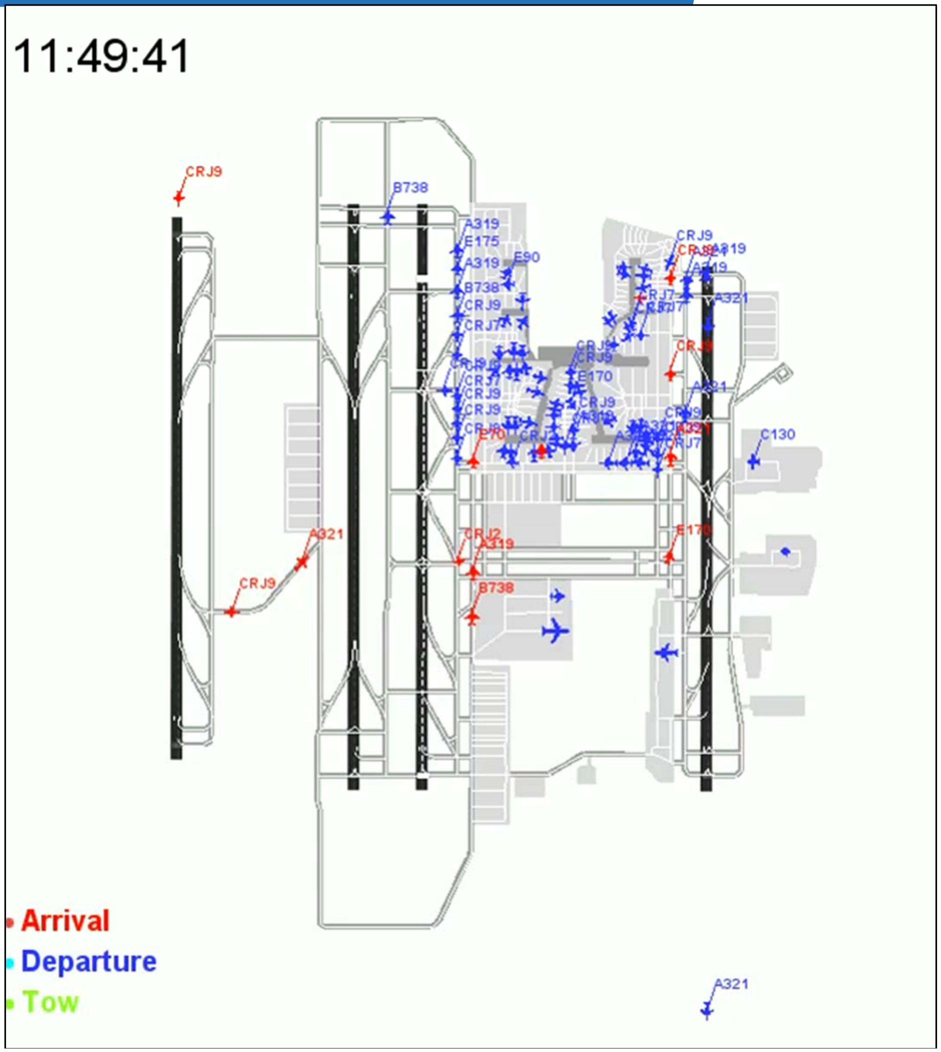
Alternative 1 (Proposed Action) – North Flow





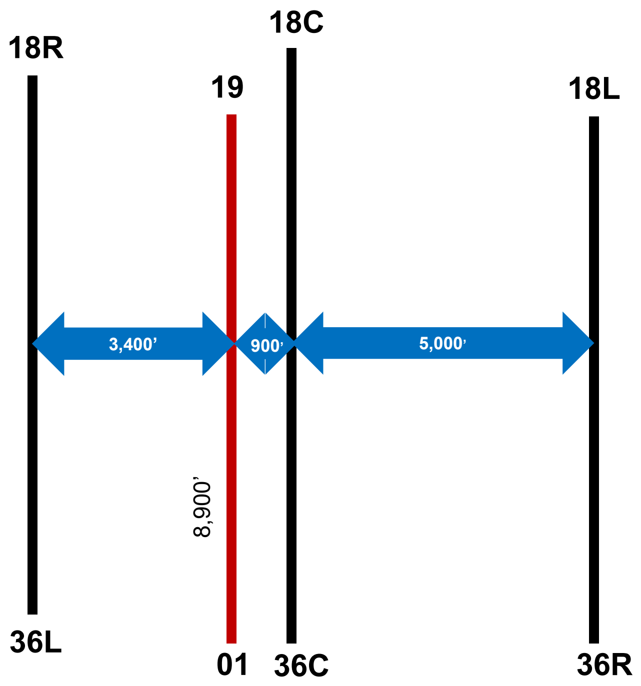
Alternative 1 (Proposed Action) – South Flow





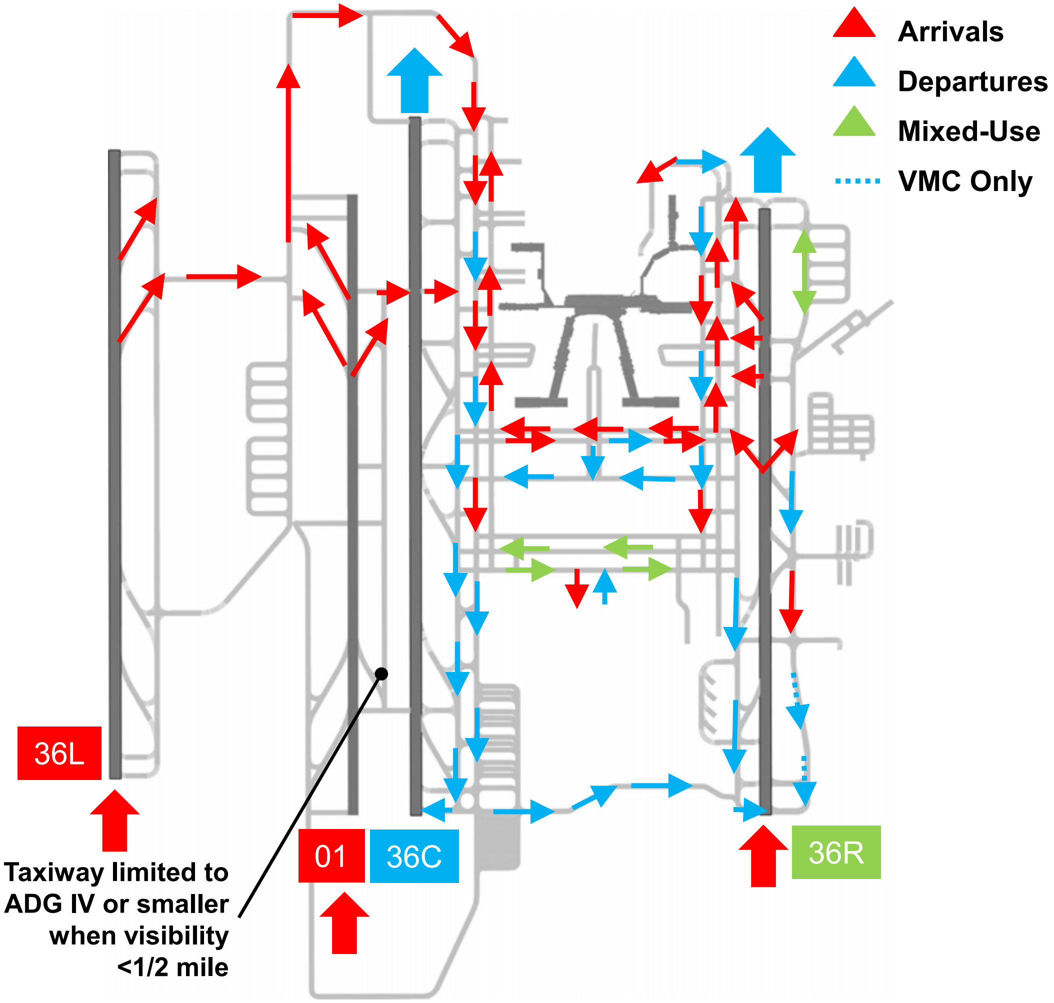
Alternative 3

- Assumes that new FAA rules for parallel runways allow simultaneous triple approaches to new runway
- Alternative 3 will use same the airspace assumptions and procedures as Alternative 1 (Proposed Action)

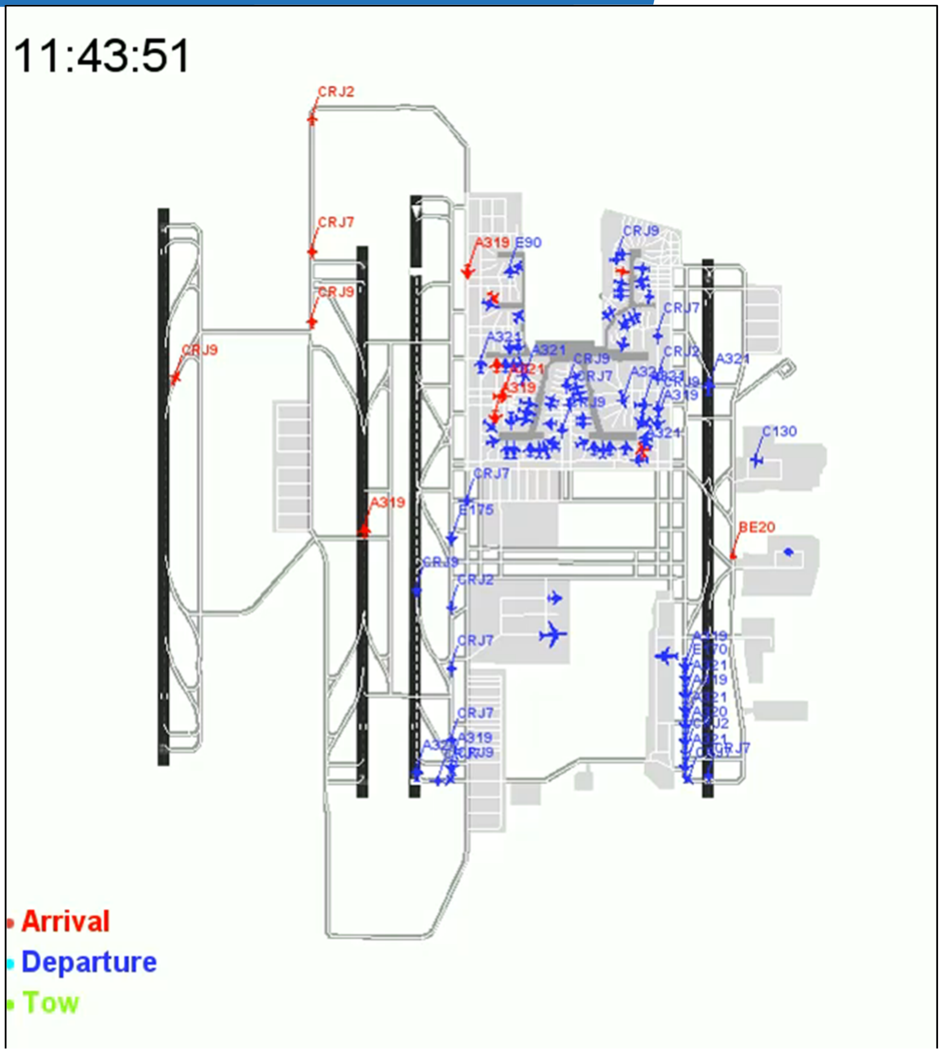


Note: Diagram is not to scale.

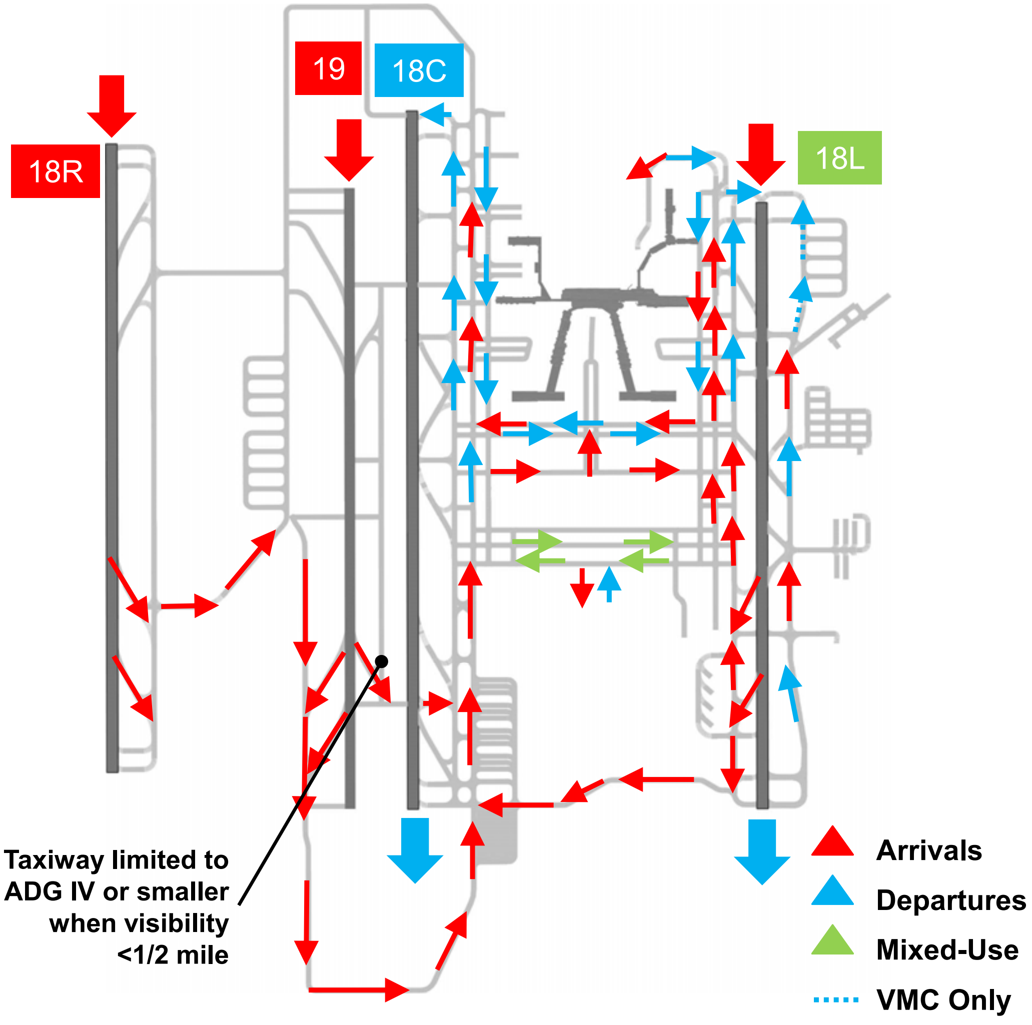
Alternative 3 – North Flow



Taxiway limited to ADG IV or smaller when visibility <1/2 mile

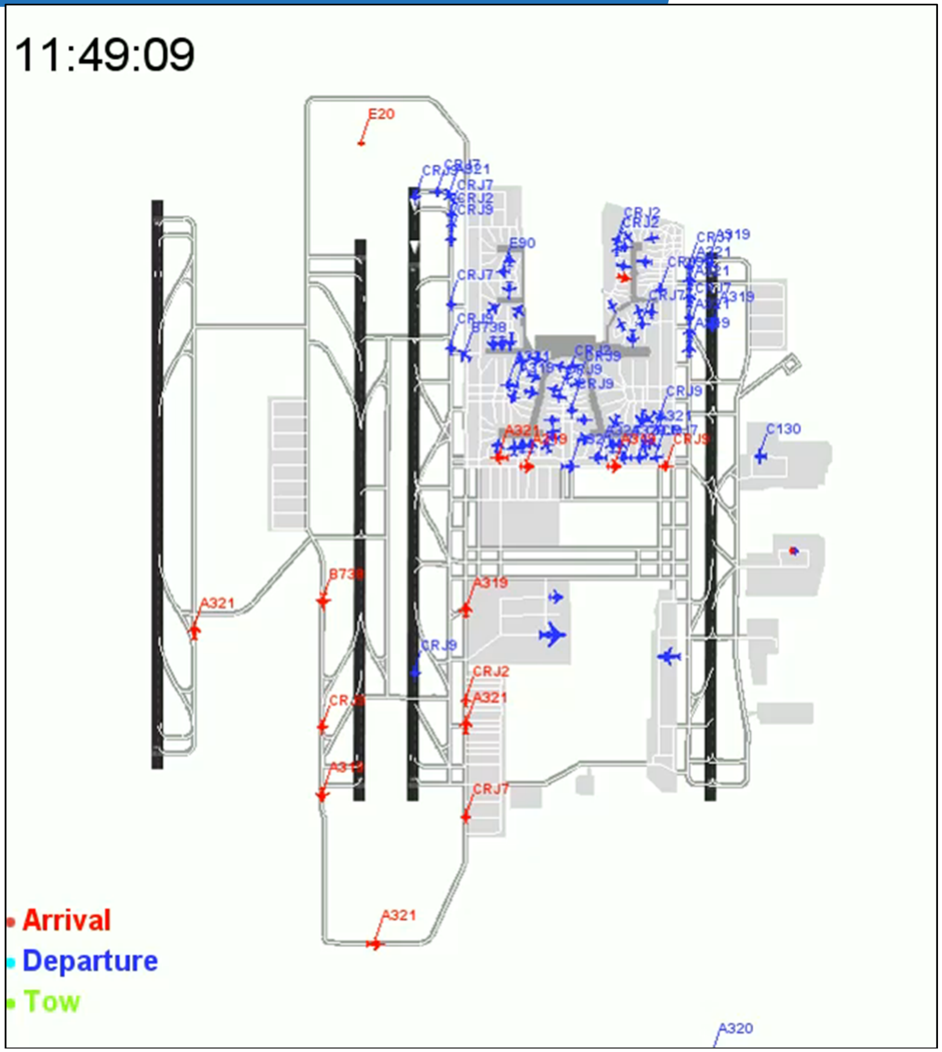


Alternative 3 – South Flow

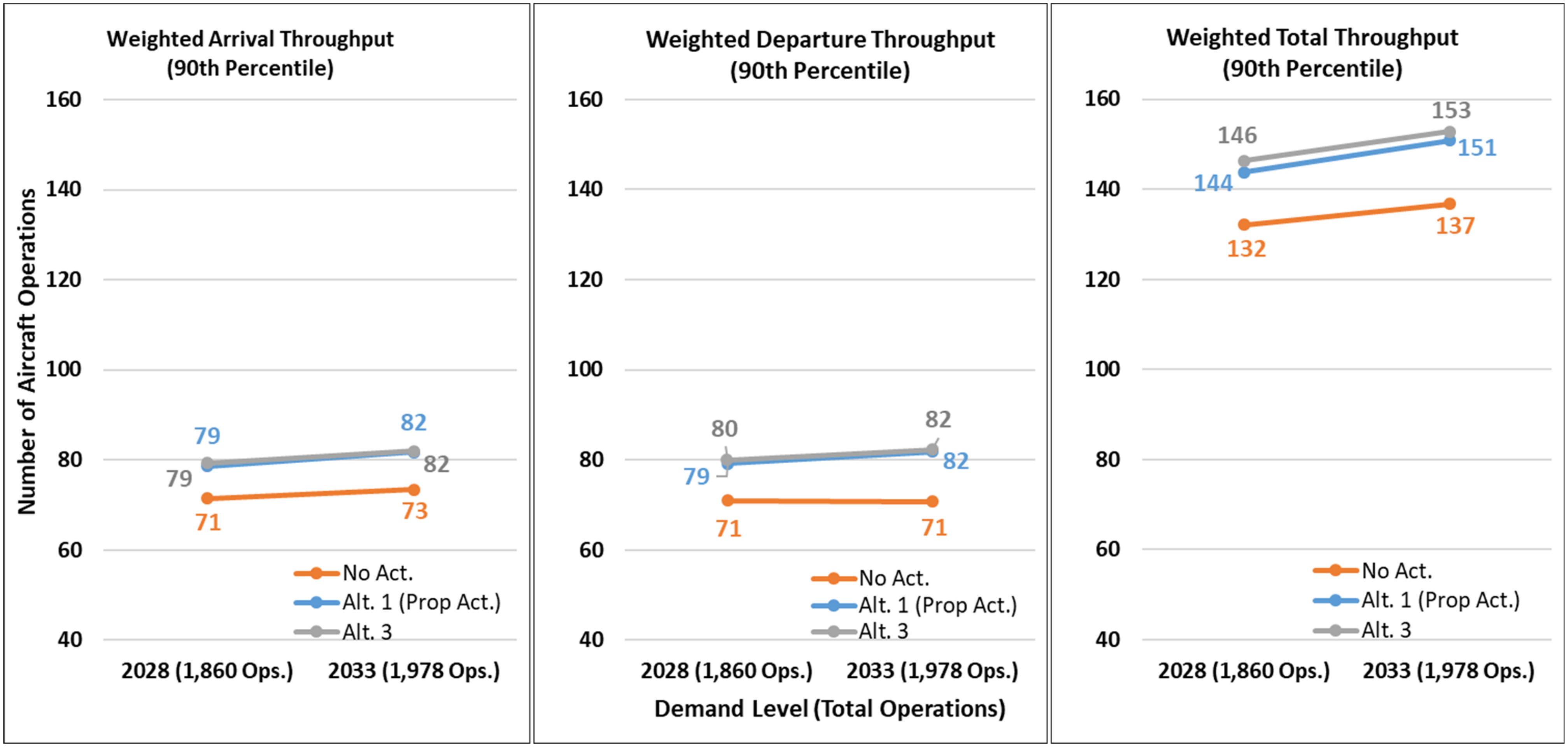


Taxiway limited to ADG IV or smaller when visibility <1/2 mile

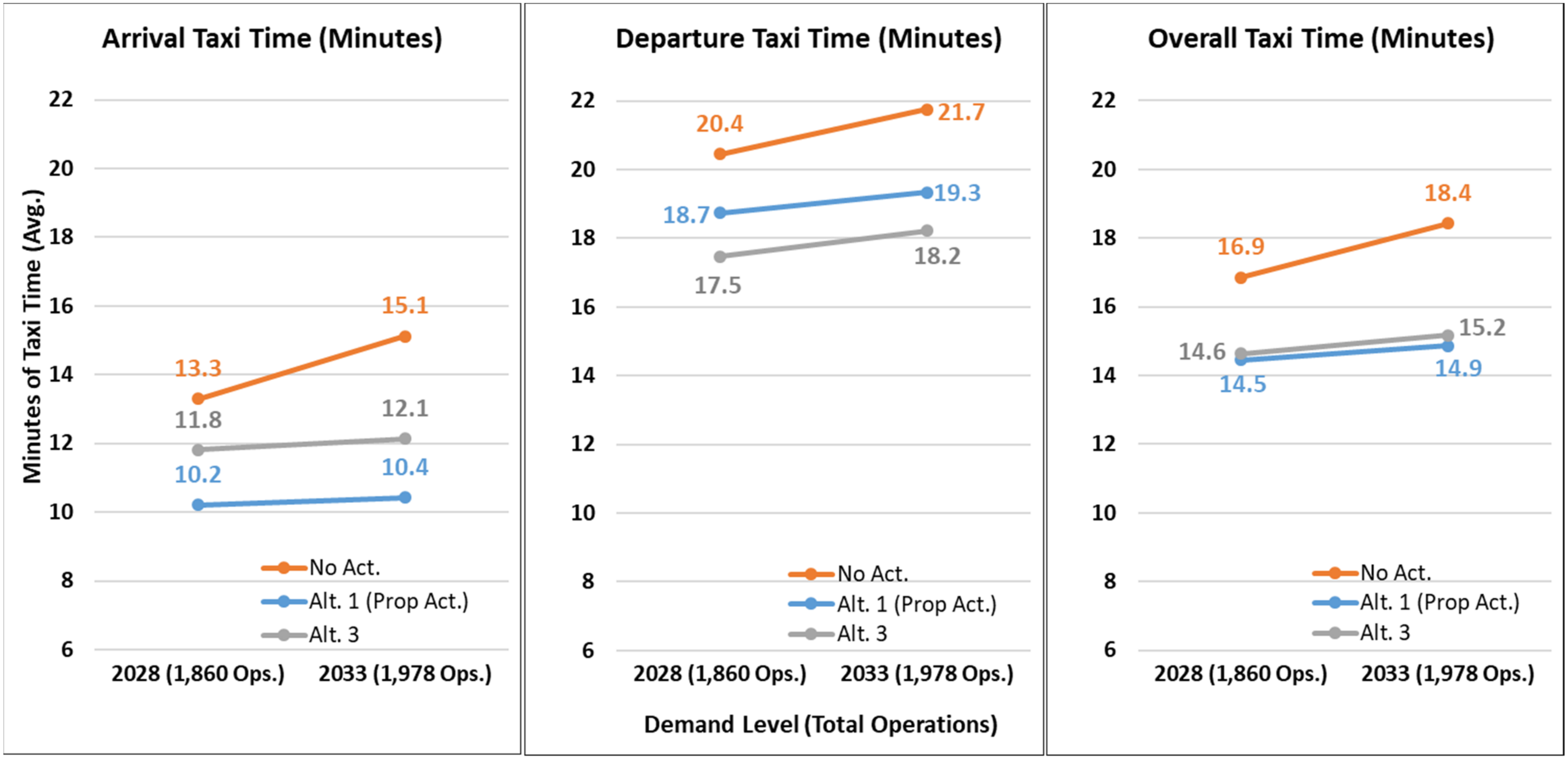
- ▲ **Arrivals**
- ▲ **Departures**
- ▲ **Mixed-Use**
- ┈ **VMC Only**



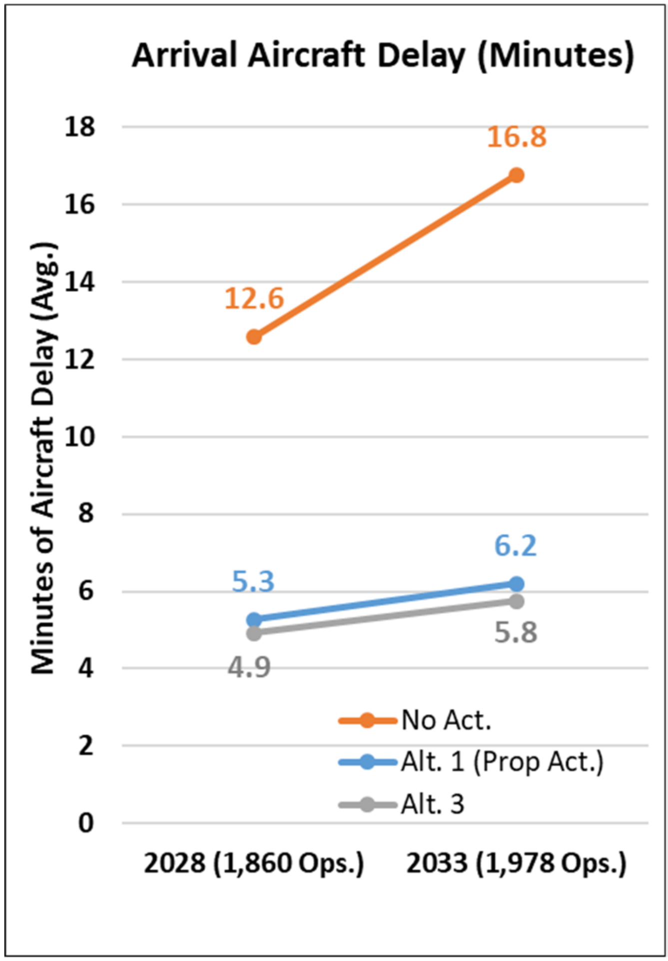
Alternatives Weighted Aircraft Throughput



Alternatives Taxi Time (Including Delay)



Alternatives Average Aircraft Delay



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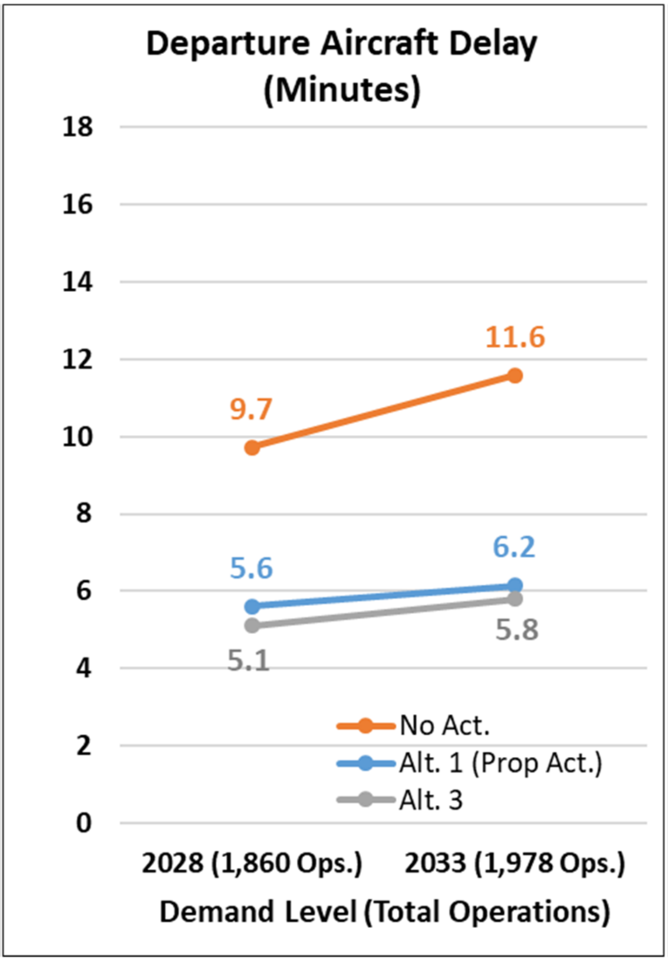

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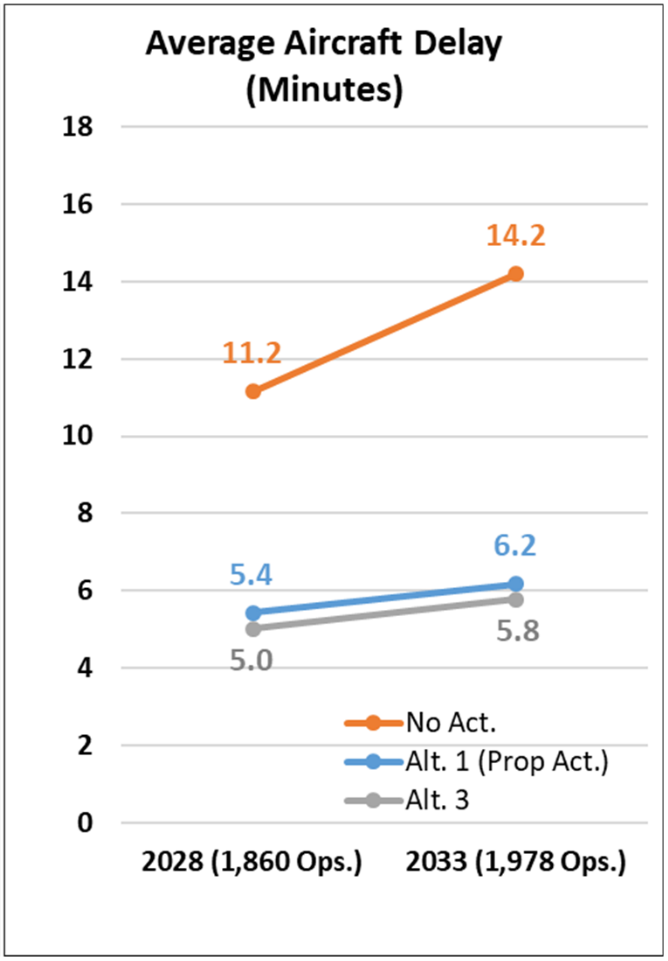
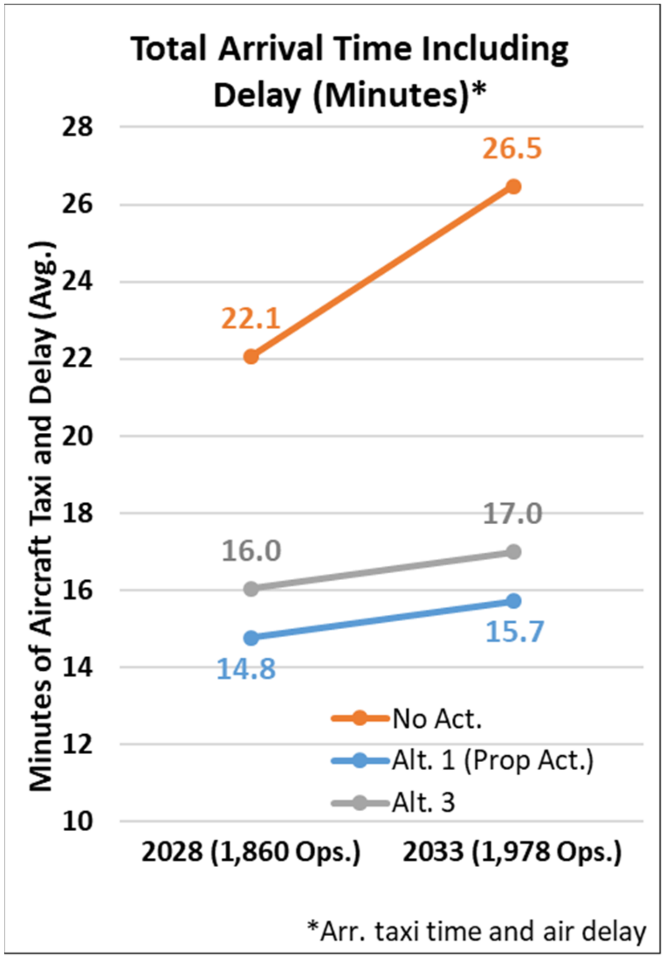
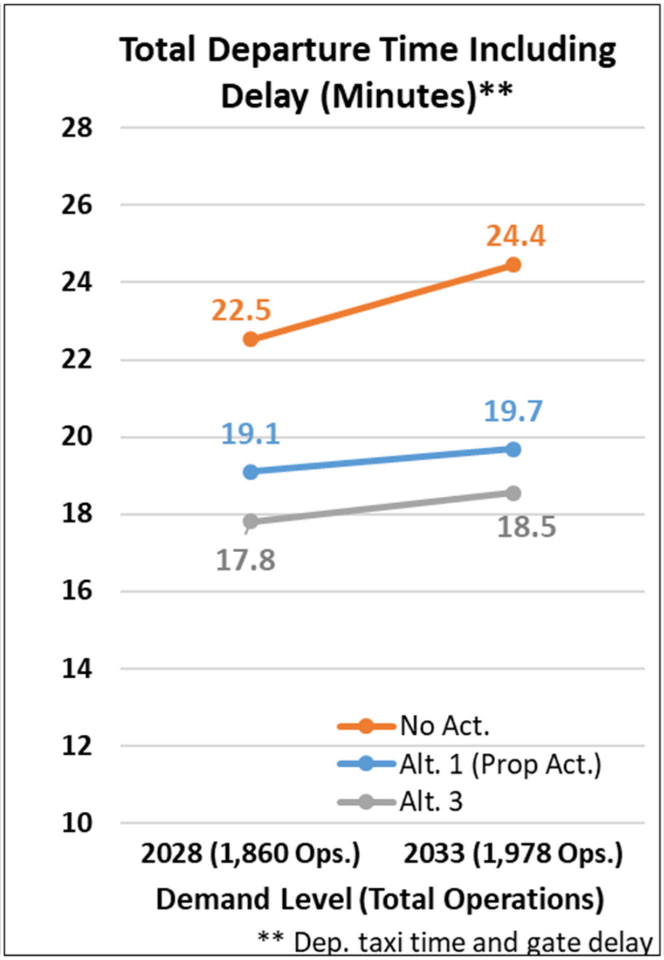
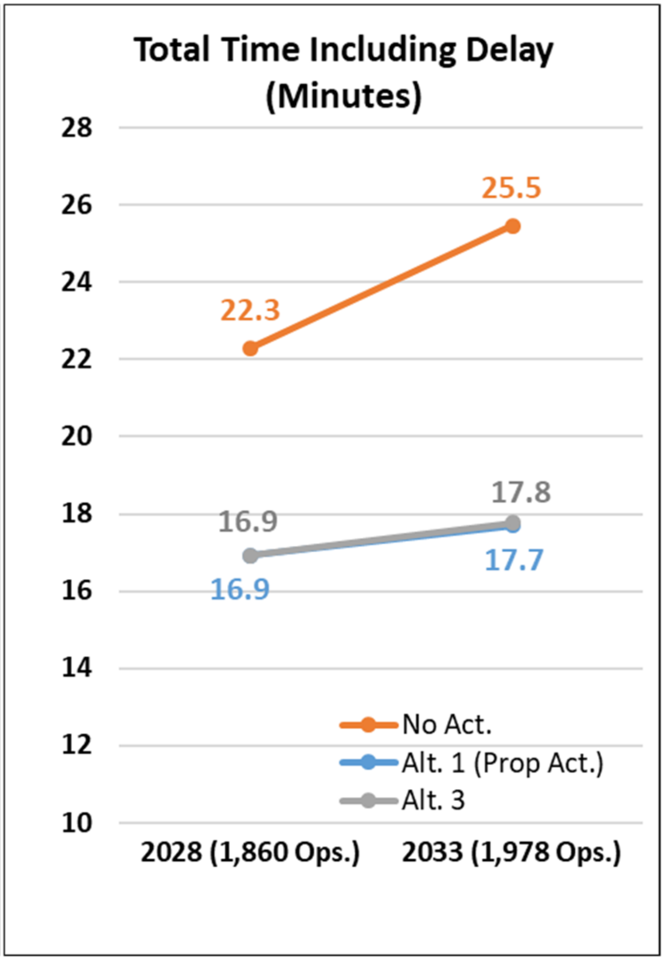


Average Aircraft Delay (Minutes)

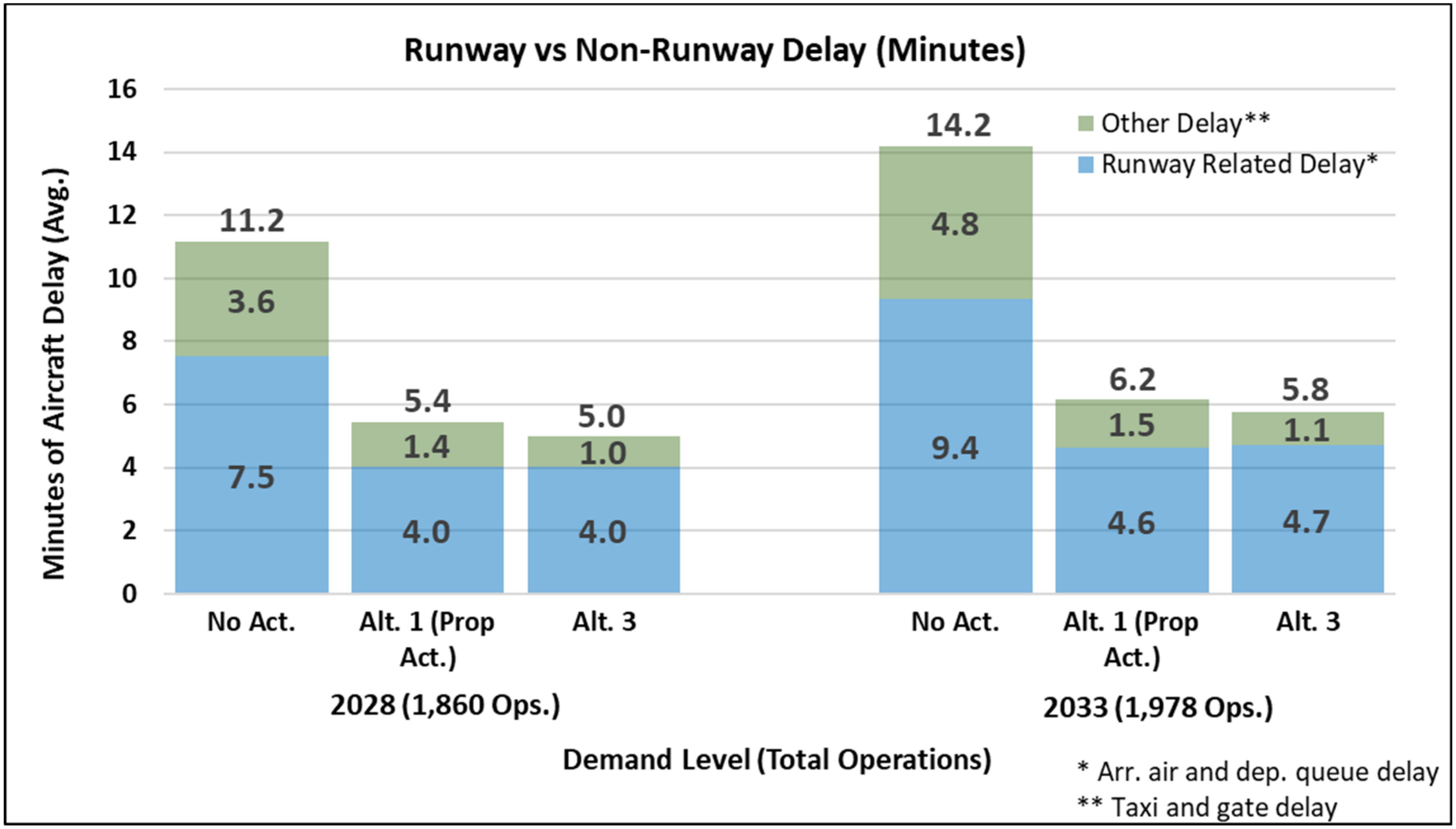
Alternatives Total Time Including Delay







Alternatives Average Aircraft Delay



* Arr. air and dep. queue delay

** Taxi and gate delay

Next Steps

Next Steps

- Send questions to sarah.potter@landrumbrown.com
- Complete DORA compliance letter
- Continue preparation of the Draft EA

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Proposed Capacity Enhancements at Charlotte Douglas International Airport

National Environmental Policy Act Environmental Assessment

Alternatives Analysis

August 2021

PREPARED FOR
Charlotte Douglas International
Airport

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1 Introduction

The Federal Aviation Administration (FAA) notified Charlotte Douglas International Airport (CLT) in April of 2020 of an upcoming modification to the lateral runway separation requirements for dual and triple simultaneous independent approaches that were specified in FAA Order 7110.65Y, *Air Traffic Control*. This rule change had the potential to affect the placement of the new runway under consideration in the Environmental Assessment (EA) for the Capacity Enhancement Projects. As a result, alternatives with different separations from CLT's existing runways were studied. This appendix discusses the development and evaluation of those runway separation alternatives for the CLT EA based on the FAA rule change, which has since become final (FAA issued the revised FAA Order 7110.65Z, *Air Traffic Control*, in June of 2021).

Each of the alternatives includes a new runway which is referred to as Runway 01/19 for purposes of the analysis in this EA. If the new runway is implemented in the future, the proper nomenclature will be determined at that time.

2 Runway Separation

The separation provided between parallel runways is the primary factor that determines the air traffic procedures that must be followed, which in turn determines the capacity of the runways. The FAA runway separation requirements based on FAA Order 7110.65Y, *Air Traffic Control*, that are relevant to the CLT analysis are shown in **Table 2-1**.

TABLE 2-1, LATERAL RUNWAY SEPARATION REQUIREMENTS

Type of Operation	Lateral Runway Separation (in feet)
Simultaneous VFR Operations – Standard	700 feet
Simultaneous VFR Operations – Recommended for ADG V and VI Runways	1,200 feet
Simultaneous IFR Approaches and Departures	2,500 feet[1]
Simultaneous IFR Departures	2,500 feet[1]
Dual Simultaneous Independent IFR Approaches	3,600 feet[2]
Triple Simultaneous Independent IFR Approaches	3,900 feet[2]

[1] When thresholds are not staggered.
[2] Assumes straight-in approaches.
Note: VFR = Visual Flight Rules; IFR = Instrument Flight Rules; ADG = Airplane Design Group
Source: FAA Order 7110.65Y, *Air Traffic Control*

The FAA's updated lateral runway separation requirements for the dual and triple simultaneous independent approaches that were published in June of 2021 (FAA Order 7110.65Z, *Air Traffic Control*) are compared to the previous lateral runway separation requirements in **Table 2-2**.

TABLE 2-2, RUNWAY SEPARATION REQUIREMENTS COMPARISON

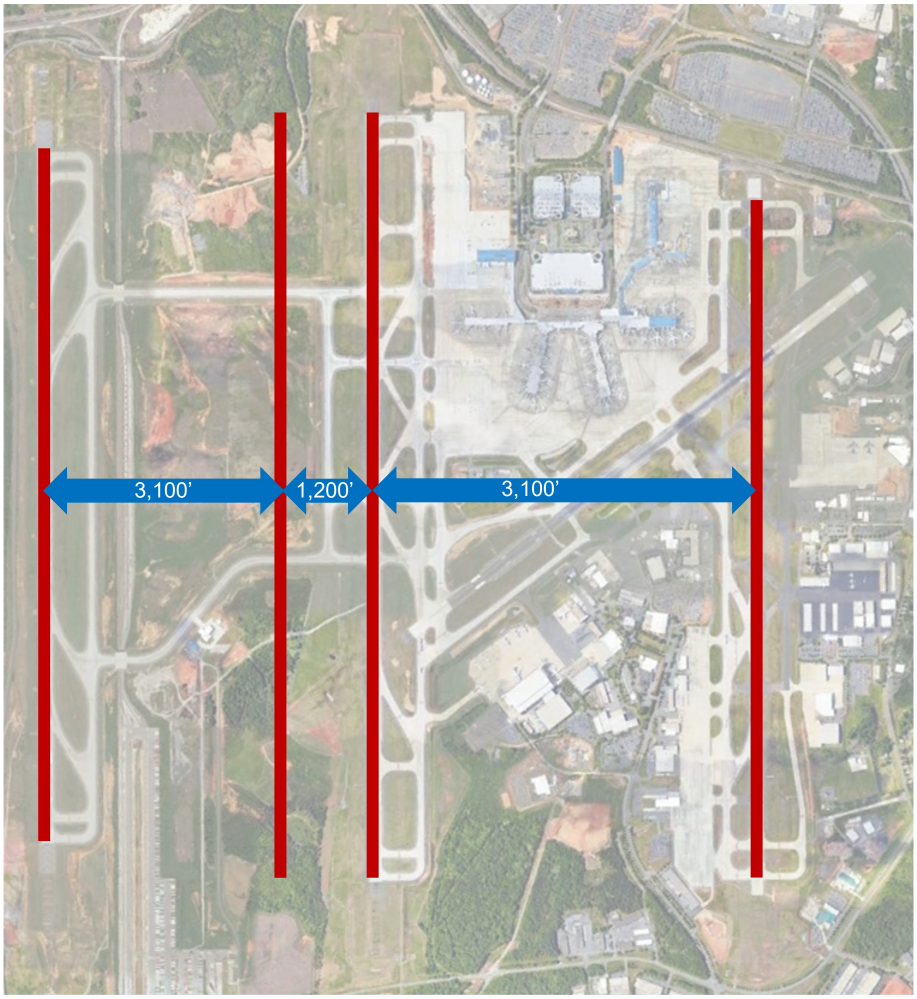
Type of Approach	Order 7110.65Y Runway Separation Requirement	Order 7110.65Z Runway Separation Requirement
Dual Simultaneous Independent	3,600 feet	3,200 feet
Triple Simultaneous Independent	3,900 feet	3,400 feet

Note: Assumes straight-in approaches.
Source: FAA Order 7110.65Z, *Air Traffic Control*; FAA Headquarters office

This rule change is relevant at CLT because the new runway location and intended runway use in the Proposed Action Alternative were chosen based on the runway separation requirements in FAA Order 7110.65Y, *Air Traffic Control*. As shown on **Exhibit 2-1,** the Proposed Action includes a new "midfield" runway located on the west side of the airfield between Runways 18R/36L and 18C/36C, which are separated by 4,300 feet. Based on the current FAA separation requirements, it is not possible to meet the separation requirement for simultaneous Visual Flight Rules (VFR) operations between Runways 01/19 and 18C/36C (700 to 1,200 feet) while also meeting the 3,900-

foot separation requirement for triple approaches between Runway 01/19 and 18R/36L. Therefore, the new runway in the Proposed Action alternative was sited so that it provides 1,200 feet of separation to Runway 18C/36C (the recommended separation for ADG V and VI aircraft), leaving 3,100 feet between it and Runway 18R/36L. Because Runway 01/19 does not have the necessary separation between it and the other runways to allow for triple simultaneous independent straight-in approaches, the new runway in the Proposed Action Alternative is intended primarily for departure use (with limited use for arrivals), with Runway 18C/36C intended primarily for arrival use.[1]

EXHIBIT 2-1, PROPOSED ACTION RUNWAYS



Source: Landrum & Brown, 2020

The reduction in separation requirements for triple simultaneous independent straight-in approaches, results in two possible alternative locations for the new runway in the midfield. The first is placement of Runway 01/19 so that it provides 3,400 of separation to Runway 18R/36L and 900 feet of separation to Runway 18C/36C (see **Exhibit 2-2**). The 3,400-foot separation to Runway 18R/36L would allow triple simultaneous independent straight-in approaches to Runways 18R/36L, 01/19, and 18L/36R. Another possible location for Runway 01/19 is to place

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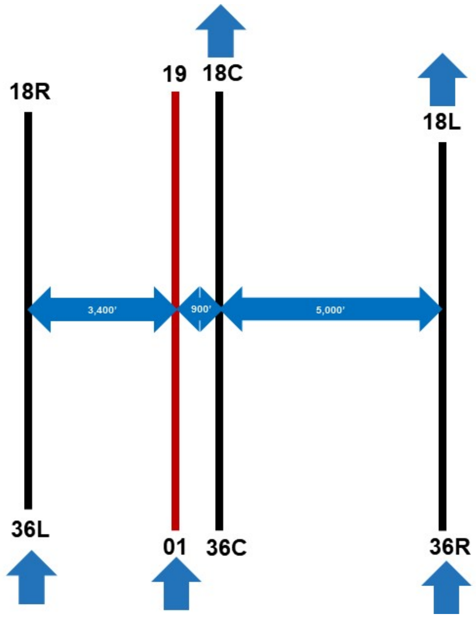
[1] It is important that air traffic controllers have the flexibility to use Runway 01/19 and Runway 18C/36C for both arrivals and departures to maximize capacity and operational flexibility. While Runway 01/19 is primarily assumed to be used by departures and Runway 18C/36C is primarily assumed to be used by arrivals, limited use of Runway 01/19 can be expected for arrivals. For example, during off-peak periods, air traffic controllers may choose to land on Runways 18R/36L and 18L/36R while departing Runways 01/19 and 18C/36C. Air traffic controllers could also choose to land on Runway 01/19 and depart Runway 18C/36C during visual weather conditions.

Runway 01/19 with 3,200 of separation to Runway 18R/36L and 1,100 feet of separation to Runway 18C/36C (see **Exhibit 2-3**). This option would not allow triple simultaneous independent straight-in approaches to Runways 18R/36L, 01/19, and 18L/36R but would provide operational flexibility[2] and position CLT to take advantage of any potential future reductions in runway separation requirements.[3] Both of these runway separation options meet standards for the separation between Runway 01/19 and Runway 18R/36L but do not provide the recommended separation of 1,200 feet between Runway 01/19 and Runway 18C/36C. The 3,200-foot and 3,400-foot runway separations will be evaluated in the alternatives analysis.

EXHIBIT 2-2, POTENTIAL SEPARATION SCENARIO 1



Notes: Diagram is not to scale. The length of the new runway is shown at 10,000 feet but may vary depending on the use of the runway.
Source: Landrum & Brown analysis, 2021

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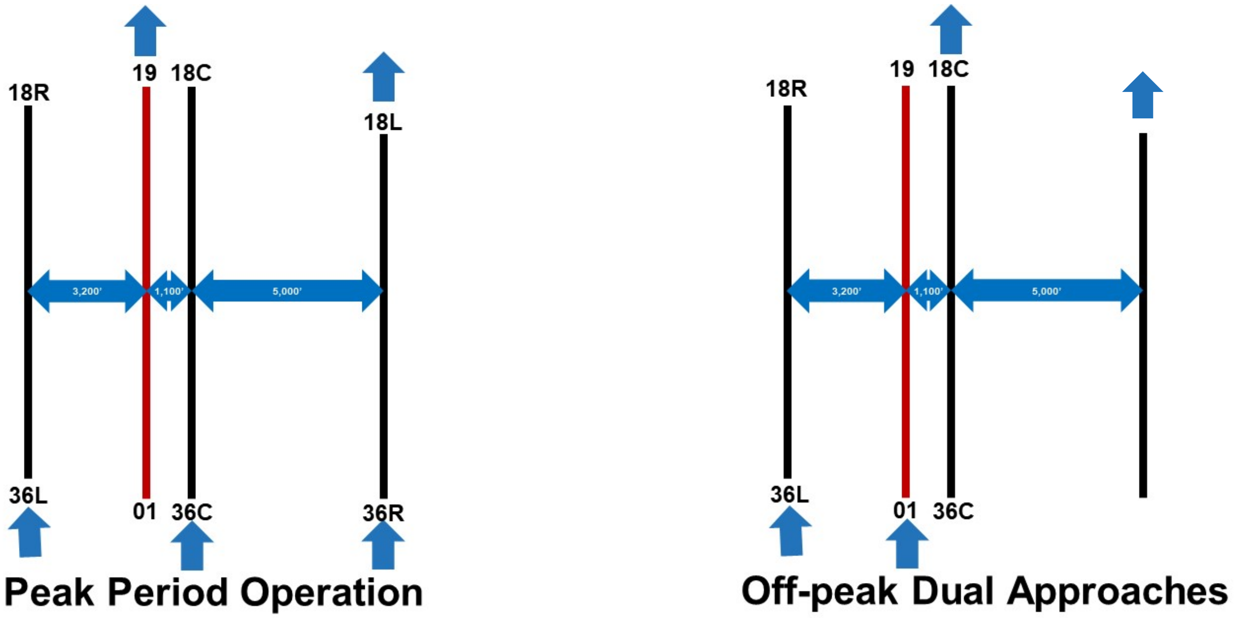
[2] The 3,200-foot separation between the new runway and Runway 18R/36L would allow these runways to be used by arrivals, with departures on the two eastern most runways, during off-peak periods when triple approaches are not required. The operational benefit of this runway use configuration is the segregation of arrival and departure traffic.

[3] Because dual simultaneous independent approaches would be permitted to Runways 18R/36L and Runway 01/19 if the runways were 3,200 feet apart and because the separation between Runway 01/19 and Runway 18L/36R far exceeds the requirement of 3,400 feet for triple simultaneous independent approaches, it may be possible to obtain a waiver from FAA to operate triple simultaneous independent approaches at CLT in the future. Such an operation would require further study and is not assumed for this EA.

EXHIBIT 2-3, POTENTIAL SEPARATION SCENARIO 2



Notes: Diagram is not to scale. The length of the new runway is shown at 10,000 feet but may vary depending on the use of the runway.

Source: Landrum & Brown analysis, 2021

3 Runway Length Requirements

This section describes the takeoff and landing runway length requirements for CLT.

3.1 Runway Length Methodology

Landing and takeoff requirements were calculated following the recommended guidance in FAA Advisory Circular (AC) 150/5325-4B, *Runway Length Requirements for Airport Design*. As such, the aircraft manufacturers' airport planning manuals from Airbus, Boeing, and Gulfstream were utilized in conjunction with the 2033 forecast fleet mix to calculate runway length requirements. Runway length requirements are a function of the following factors:

- Aircraft Fleet
- Density Altitude
- Runway Contamination (landings only)
- Flap Settings (landings only)

3.1.1 Aircraft Fleet

The CLT 2033 fleet mix was reviewed to determine the most critical aircraft for runway length requirements. Thirteen aircraft were selected for the analysis. All of the analyzed aircraft meet the critical aircraft threshold of maintaining at least 500 operations annually in the 2033 forecast. Landing runway length requirements for these aircraft were assessed at maximum landing weight (MLW). Takeoff requirements were calculated for the furthest destination for each aircraft, assuming 100 percent payload. Each aircraft used in this analysis is depicted in **Table 3-1**.

3.1.2 Density Altitude

Density altitude is pressure altitude corrected for non-standard temperature. It affects an aircraft's performance including how fast it can accelerate, how quickly it can obtain lift, and how fast it can climb. As an airport's elevation and/or temperature increase, air density decreases, which results in decreased aircraft performance and longer runway length requirements.[4]

Airfield elevation is the first component to density altitude. It is used as an input factor on the landing and takeoff charts in the aircraft manufacturers' airport planning manuals to determine accurate takeoff and landing requirements. The elevation at CLT is 747.9 feet above Mean Sea Level (MSL).[5]

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[4] https://www.aopa.org/training-and-safety/active-pilots/safety-and-technique/weather/density-altitude#WIDA

[5] FAA Airport Data and Information Portal (ADIP) 2020

TABLE 3-1, 2033 AIRCRAFT FLEET FOR RUNWAY LENGTH ANALYSIS

Aircraft	Operator	Critical Destination (distance in NM from CLT)	2033 Annual Operations
Airbus A300-600F	FedEx, UPS	MEM (444)	4092
Airbus A321	American	SFO (1,995)	96,503
Airbus A321NEO	American	KEF (2,711)	21,142
Airbus A330-200	American	GRU (4,018)	3,410
Boeing B717-200	Delta	MSP (808)	4,092
Boeing B737-800	Delta, Southwest	PDX (1,983)	6,138
Boeing B737MAX8	American, Southwest	PDX (1,983)	37,169
Boeing B737MAX9	United	SFO (1,995)	2,046
Boeing B787-900	American	FCO (4,182)	3,069
Bombardier CRJ900	American, Delta	n/a[1]	133,672
Embraer 145	American	n/a[1]	1,364
Gulfstream G500/600	General Aviation	n/a[1]	682
McDonnel Douglas DC10	FedEx	MEM (444)	1,364

[1] Aircraft not assessed for takeoffs.
Source: 2033 design day flight schedule

The second component to density altitude is temperature. The effect of temperature on density altitude is greater with takeoffs than landings. As a result, the FAA requires temperature adjustments for takeoffs, but not landings, according to FAA AC 150/5325-4B, *Runway Length Requirements for Airport Design*. The aircraft manufacturers' manuals contain charts to calculate takeoff runway length requirements based on temperature. Takeoff length requirements may be calculated based on a "standard day" (defined as 59 degrees Fahrenheit) or a "hot day." The hot day charts in the aircraft manufacturers' manuals vary the conditions of the hot day depending on the aircraft type. The determination of which temperature chart to use depends upon the average or typical weather conditions for a particular region or airport. FAA guidance prescribes the use of an airport's mean-max temperature for use in runway length calculations. The mean-max temperature is defined as the average daily maximum temperature of the hottest month. The mean daily maximum temperature at CLT is approximately 87 degrees Fahrenheit,[6] making the hot day charts most appropriate for use in the CLT takeoff analysis.

3.1.3 Runway Contamination

Landing length requirements should be calculated for wet (contaminated) runways when following FAA AC 150/5325-4B, *Runway Length Requirements for Airport Design*. Contaminated runway conditions require longer runways for landing than dry conditions, due to the additional distance needed to decelerate on wet pavement. For those aircraft where the aircraft performance manuals do not specifically show a wet landing length curve, the dry landing length was increased by 15% as specified in the runway length AC. Takeoff runway length requirements do not factor in runway contamination per FAA guidance.

3.1.4 Flap Settings

Flaps are used on landings to produce a slower stall speed (so the pilot can land slower) and more drag (which allows the pilot to fly at a steeper descent angle to the runway). Maximum flap settings allow a pilot to maximize the lift and drag that the aircraft wings produce. All landing analysis was conducted using the highest landing flap settings available. Flap settings are not used in determining takeoff requirements.

3.2 Takeoff Runway Length Requirements

The *Runway Length Analysis: Proposed Runway 1-19 Technical Memorandum*, April 15, 2019, found that 10,000 feet of runway length is required at CLT to serve departures by the critical aircraft. This analysis was based on

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[6] National Centers for Environmental Information, *1981-2010 Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days*.

performance engineering data from the airlines, which found that the Boeing 787-9 is the critical aircraft for runway length. This aircraft would require 10,000 feet of runway when departing in north flow.

As a result of critical aircraft runway length requirement, at least one departure runway at CLT should be 10,000 feet long. Runway 18C/36C is 10,000 feet long and currently serves as the primary departure runway. If this runway will continue to be used as a departure runway it meets the 10,000-foot need. For alternatives where Runway 18C/36C is intended primarily for arrival use and the new runway will become the primary departure runway, the new runway should be 10,000 feet long.

Not every departure runway at CLT needs to be 10,000 feet long. Runway 18L/36R is the secondary departure runway and is 8,676 feet long. The ability of this runway to serve the forecast fleet was assessed using a payload/range analysis (see **Table 3-2**) to determine if it needs to be extended. This analysis assumed 100% payload to the furthest destination for 10 aircraft in the 2033 fleet. The analysis determined that 3 of the 10 aircraft analyzed are unable to takeoff with maximum (100%) payload from Runway 18L/36R:

- A330-300 international passenger aircraft to GRU (4,018 nautical miles)
- B787-900 international passenger aircraft to FCO (4,182 nautical miles)
- B737-900 domestic passenger aircraft to SEA (1,980 nautical miles)

All of the other analyzed aircraft were found to be able to depart Runway 18L/36R with maximum payloads to the furthest destination identified for each aircraft type. The aircraft that require more than 8,676 feet for takeoff at 100% payload are noted in the table.

TABLE 3-2, 2033 RUNWAY 18L/36R PAYLOAD-RANGE ANALYSIS

Aircraft	Critical Destination	CLT to Critical Destination (NM)	Payload to Critical Destination (lbs.)	% Payload to Critical Destination
A330-200*	Brazil (GRU)	4,018	90,000	90%
MD-DC10	Memphis (MEM)	444	152,964	100%
B787-900*	Rome (FCO)	4,182	148,000	95%
B737MAX8	Portland (PDX)	1,983	52,040	100%
A321	San Francisco (SFO)	1,995	56,000	100%
A300-600F	Memphis (MEM)	444	102,852	100%
B737-800	Portland (PDX)	1,983	47,000	100%
A321NEO	Keflavik (KEF)	2,711	56,200	100%
B717-200	Minneapolis-St Paul (MSP)	808	32,000	100%
B737MAX9	San Francisco (SFO)	1,995	156,500	100%
B737-900*	Seattle (SEA)	1,980	43,720	96%

Note: * = Aircraft that require more than 8,676 feet of runway for takeoff at 100% payload.
Source: Aircraft manufacturer’s airport planning manuals; Landrum & Brown analysis, 2020

If any of the three aircraft have full payloads, they must use Runway 18C/36C to depart instead of Runway 18L/36R. If the aircraft are headed eastbound, the departure from Runway 18C/36C results in an airspace crossing, which means aircraft waiting to depart on Runway 18L/36R must hold until the eastbound departure from Runway 18C/36C is clear. This negatively affects the capability of the runways. As a result, the 2033 design day schedule was reviewed to determine how many takeoffs per hour would require use of Runway 18C/36C (see **Table 3-3**). This analysis found that there would be at most two aircraft in any hour that cannot depart from Runway 18L/36R. This level of activity is not sufficient to justify an extension to Runway 18L/36R in any of the alternatives. As a result, none of the CLT EA alternatives will include an extension to Runway 18L/36R.

TABLE 3-3, 2033 DEPARTURES THAT CANNOT TAKEOFF FROM RUNWAY 18L/36R AT FULL PAYLOAD

Aircraft	Destination	Daily Departures	Hours of Operation
A330-200	Frankfurt (FRA)	1	16:00
	Paris (CDG)	1	18:00
	Brazil (GRU)	1	20:00
	Barcelona (BCN)	1	20:00
B787-900	Rome (FCO)	1	18:00
B737-900	Seattle (SEA)	1	17:00

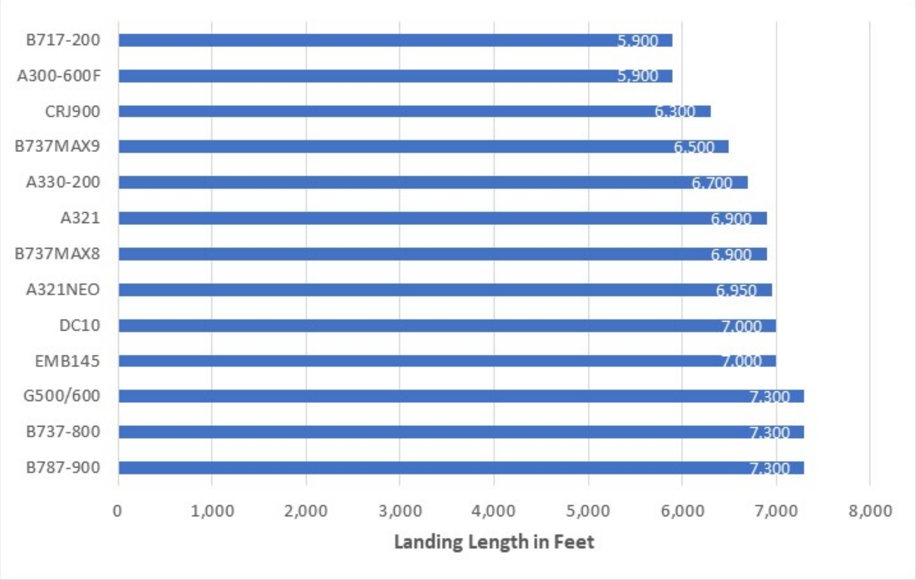
Source: 2033 design day flight schedule; Landrum & Brown analysis, 2020

3.3 Arrival Runway Length Requirements

Given the FAA's rule change for runway separations, it may be possible for CLT's new runway to be a primary arrival runway in some of the EA alternatives. As a result, arrival runway length requirements were determined using the procedures outlined in FAA Advisory Circular (AC) 150/5325-4B, *Runway Length Requirements for Airport Design*. The results of these calculations can differ from the more detailed performance engineering analysis that aircraft operators and airlines are capable of performing. As a result, the airlines at CLT were consulted to validate the runway length conclusions.

The landing length requirements are depicted on **Exhibit 3-1**. The requirements shown for most of the aircraft reflect the results of the aircraft manufacturers' charts. American Airlines provided requirements for the B878-900, B737-800, A321, and B737MAX8; the requirements provided by American are shown instead of the chart results for these aircraft. The B787-900, B737-800, and Gulfstream 500/600 require the most landing length at 7,300 feet. These aircraft combined are forecast to make up 9,889 annual operations in 2033. Therefore, any alternative that considers arrival use for the new runway will include a 7,300-foot long runway, unless there are operational reasons that require a longer length.

EXHIBIT 3-1, 2033 LANDING RUNWAY LENGTH REQUIREMENTS



Notes: Landing lengths based on wet (contaminated) runway conditions at MLW.
Source: Aircraft manufacturer's airport planning manuals; Landrum & Brown analysis, 2020

4 Taxiway Geometry

Taxiway geometry requirements at an airport are dictated by the critical aircraft as specified in FAA AC 150/5000-17, *Critical Aircraft and Regular Use Determination*. CLT's critical aircraft is the Airbus 350-900.[7] It is the largest aircraft that is forecast to have at least 500 annual operations at CLT in 2033. The A350-900 is classified by FAA as an ADG V and Taxiway Design Group (TDG) 5 aircraft. All of the alternatives should be designed to meet ADG V and TDG 5 standards.

The taxiway geometry should be designed to protect for Category (CAT) II/III approaches in the event CLT decides to provide CAT II/III instrumentation on the new runway. In addition, it is preferable that a full-length parallel taxiway be provided on both sides of Runway 01/19 (between Runways 01/19 and 18R/36L and between Runways 01/19 and 18C/36C) in order to maximize operational flexibility and operational performance.

The key taxiway dimension for the CLT alternatives is the lateral spacing between the new runway and its parallel taxiways. The required spacing can vary based on a number of factors. **Table 4-1** provides the various lateral spacing requirements that apply for Runway 01/19. In order to meet TDG 5 and ADG V standards while protecting for CAT II/III approaches, the minimum separation between the new runway and its parallel taxiways should be 500 feet. Another consideration for runway-taxiway separation is the location of the glideslope antenna and the glideslope critical area. In order to be able to taxi past a glideslope antenna, 560 feet of lateral separation must be provided between the runway and the parallel taxiway. In order to be able to taxi unrestricted around a glideslope critical area, 642.5 feet of lateral separation must be provided between the runway and the parallel taxiway. These spacing requirements will be applied in the alternatives.

TABLE 4-1, RUNWAY TO TAXIWAY LATERAL SEPARATION REQUIREMENTS

Criteria	Runway-Taxiway Lateral Separation Requirement (in feet)
ADG V with Visibility >= ½ mile	400
TDG 5 (Minimum)[1]	427
TDG 5 (Recommended)[1]	450
ADG V with Visibility < ½ mile	500
Allow Taxi Past Glideslope Antenna	560
Protect for Glideslope Critical Area	642.5

[1] Separation requirement for reverse turns from a high-speed exit.
Source: FAA AC 150/5300-13A, *Airport Design*

5 Runway Exit Geometry

The type of runway exits and the location and number of exits on a runway depend on many factors including the separation distance between the runway and its associated parallel taxiways, the length of the runway, any displacement of the arrival threshold, and the types of aircraft using the runway. The time it takes an aircraft to decelerate to a slow enough speed to exit the runway varies depending on the size and performance characteristics of the aircraft and condition of the runway. If exits are not placed at the point(s) where the majority of aircraft using the runway reach their exit speed, the aircraft must continue down the runway at a relatively low rate of speed until it reaches the next available exit taxiway.

Runways with adequate and properly spaced runway exits allow capacity to be optimized by minimizing the runway occupancy times (ROT) of arriving aircraft and reducing the spacing required between sequential landing aircraft. The ROT is the length of time required for an arriving aircraft to proceed from over the runway threshold

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[7] The A350-900 is the critical aircraft based on its wingspan and approach speed. The critical aircraft for runway length is the B787-9 based on its landing and takeoff performance characteristics. Per FAA Advisory Circular 150/5000-17, *Critical Aircraft and Regular Use Determination*, Section 3.1, airports can have "multiple critical aircraft determinations."

to a point clear of the runway. An average ROT of 50 seconds or less is considered high efficiency.[8] The number, type, and location of runway exits influences the ROT for each runway.

A runway exit analysis was conducted for CLT to identify the best placement of runway exits on Runway 01/19 in the alternatives. The analysis was completed for the 2028 and 2033 fleet mixes. The new Version 3 release of the FAA's Runway Exit Design Interactive Model (REDIM) was used in this analysis. This new version of REDIM uses real aircraft landing data from 30 major U.S. airports to determine typical landing patterns by aircraft type based on runway length. As a result, the ROT results from REDIM V3 are influenced by factors outside of aircraft performance such as the availability of properly placed exits and terminal/parking locations at the analyzed airports. Because this model is new, additional study will be needed to determine the most appropriate number and location of runway exits for the new runway prior to its construction.

5.1 Assumptions

REDIM uses a mix of airport specific fixed and variable inputs to perform its analysis. The main inputs include the following:

- Fleet Mix
- Airport Temperature
- Airport Elevation
- Surface Conditions

Table 5-1 summarizes the 2028 and 2033 forecast fleet mix for CLT.

TABLE 5-1, REDIM AIRCRAFT FLEET MIX

Fleet Mix	2028 % of Fleet	2033 % of Fleet
319 (A319)	14.6%	14.0%
320 (A320)	2.1%	1.7%
321 (A321)	15.2%	14.3%
32N (A320neo)	0.0%	0.3%
332 (A330-200)	0.5%	0.5%
333 (A330-300)	0.0%	0.0%
359 (A350-900)	0.1%	0.1%
A321 Neo	2.9%	3.1%
717 (B717-200)	0.6%	0.6%
733 (B737-300)	0.0%	0.0%
738 (B737-800 Passenger)	0.9%	1.0%
739 (B737-900 Passenger)	0.0%	0.3%
73G (B737-700 Passenger)	0.6%	0.7%
752 (B757-200 Passenger)	0.0%	0.0%
Boeing 787-8	0.0%	0.1%
Boeing 787-9	0.5%	0.5%
7M7 (B737-Max 7 Passenger)	0.1%	0.1%
7M8 (B737-Max 8 Passenger)	3.6%	5.5%
7M9 (B737-Max 9 Passenger)	0.2%	0.3%
A300	0.6%	0.6%
Beech 350 Super King	0.1%	0.1%
Beech 200 Super King	0.4%	0.4%
Beechcraft Baron	0.1%	0.1%
Beech 90 King Air	0.1%	0.1%
Lockheed C-130	0.1%	0.1%
Cessna 525A	0.1%	0.1%

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[8] An average 50-second ROT on a runway allows air traffic controllers to authorize 2.5-nautical mile separation between aircraft on final approach within 10 nautical miles of the landing runway. FAA Order 7110.65Z, *Air Traffic Control*.

Fleet Mix	2028 % of Fleet	2033 % of Fleet
Cessna 525B	0.1%	0.1%
Cessna T303 Crussader	0.1%	0.1%
Cessna 550	0.2%	0.2%
Cessna Citation V	0.3%	0.3%
Cessna Citation Excel	0.4%	0.4%
Cessna Citation X	0.2%	0.2%
Bombardier Challenger 300	0.2%	0.2%
Bombardier Challenger 350	0.1%	0.1%
Bombardier Challenger 600	0.1%	0.1%
CR2 (CRJ-200)	4.6%	3.7%
CR7 (CRJ-700)	17.9%	17.3%
CR9 (CRJ-900)	21.7%	19.8%
CR7 (CRJ-700)	0.2%	0.3%
CRJ (CRJ)	0.0%	0.0%
Airbus 220-100	0.0%	1.0%
McDonnell Douglas DC-10	0.1%	0.2%
DH3 (DHC-8-300)	0.0%	0.0%
DH8 (DHC-8)	0.0%	0.0%
Embraer Phenom 300	0.4%	0.4%
E70 (E-170)	0.5%	0.5%
E75 (E-175)	5.5%	7.0%
E7W (E-175 Enhanced Winglets)	0.9%	0.9%
E90 (E-190)	0.8%	0.9%
EM2 (EMB-120 Brasilia)	0.2%	0.2%
ER4 (ERJ-145)	0.2%	0.2%
Dassault Falcon 2000	0.4%	0.4%
Dassault Falcon 900	0.1%	0.1%
DASSAULT Falcon 50	0.1%	0.1%
FRJ (328Jet)	0.1%	0.1%
Gulfstream G100	0.1%	0.1%
Gulfstream G280	0.1%	0.1%
Gulfstream G200	0.1%	0.1%
Bombardier Global Express	0.2%	0.2%
Gulfstream 5	0.1%	0.1%
Gulfstream 6	0.1%	0.1%
Hawker 800	0.1%	0.1%
Learjet 45	0.2%	0.2%
Learjet 60	0.1%	0.1%
M88 (MD-88)	0.0%	0.0%
M90 (MD-90)	0.2%	0.0%
Cirrus SR22	0.1%	0.1%
Socata TBM-800	0.1%	0.1%
Socata TBM-900	0.1%	0.1%

Source: 2028 and 2033 design day flight schedules.

Table 5-2 presents the airport specific assumptions that affect the REDIM output. Higher airport elevation results in higher ground speeds, leading to longer landing distances. Similarly, higher airport temperature leads to lower air density and decreased aircraft performance, resulting in increased ROT. Surface conditions affect the landing performance of aircraft. A wet runway results in increased rolling distances and higher ROT times than dry runway conditions.

TABLE 5-2, AIRPORT SPECIFIC INPUTS

Input	CLT
Airport Elevation	747.9 feet above sea level[1]
Airport Temperature	87°F[2]
Surface Conditions	90% Dry, 10% Wet[3]

[1] FAA Airport Data and Information Portal (ADIP) 2020

[2] National Centers for Environmental Information, *1981-2010 Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days*

[3] National Centers for Environmental Information, precipitation data from 1/1/2009 to 12/31/2019

5.2 Runway Exit Analysis Results

REDIM was used to determine the optimal location and number of exits for three runway lengths:

- **10,000 feet**: Based on the runway length analysis presented in Section 1.2, *Runway Length Analysis*, 10,000 feet is the most appropriate length for a departure runway.
- **8,900 feet**: The new 10,000-foot long runway in Alternative 1 includes a 1,100-foot long displaced threshold on the Runway 19 end, resulting in 8,900 feet of available landing length. It was assumed that any alternative with a 10,000-foot long runway would have a similar displaced threshold.
- **7,300 feet**: Based on the runway length analysis presented in Section 1.2, *Runway Length Analysis*, 7,300 feet is the most appropriate length for an arrival runway.

Table 5-3 and **Table 5-4** present the results of the REDIM analysis at each of the demand levels for a 10,000-foot runway, with four versus five exits. The ROT for both scenarios is greater than the desired 50 seconds. The higher ROT occurs because the aircraft will use the end-around taxiways (EATs) and so have no incentive to exit the runway quickly.

TABLE 5-3, REDIM RESULTS FOR 10,000-FOOT LONG RUNWAY WITH FOUR EXITS

Exit	Exit Distance from Threshold	Exit Angle	Exit Usage	
			2028	2033
1	5,800	30°	40%	39%
2	6,600	30°	35%	35%
3	7,600	90°	21%	21%
4	10,000	90°	4%	5%
Average ROT			54 seconds	54 seconds

Note: Percentages may not sum to 100% due to rounding.
Source: REDIM V3 analysis

TABLE 5-4, REDIM RESULTS FOR 10,000-FOOT LONG RUNWAY WITH FIVE EXITS

Exit	Exit Distance from Threshold	Exit Angle	Exit Usage	
			2028	2033
1	5,500	30°	25%	25%
2	6,200	30°	34%	33%
3	7,000	30°	26%	26%
4	7,900	90°	13%	13%
5	10,000	90°	3%	3%
Average ROT			53 seconds	53 seconds

Note: Percentages may not sum to 100% due to rounding.
Source: REDIM V3 analysis

Table 5-5 presents the results of the REDIM analysis at each of the demand levels for an 8,900-foot long runway. This 8,900-foot length represents the 1,100-foot long displaced threshold on 10,000-foot long Runway 19, which would be used in south flow. As with the 10,000-foot length, the ROT is higher than 50 seconds. This higher ROT occurs because aircraft in south flow are traveling away from the terminal area when they land so pilots have no incentive to exit the runway early.

TABLE 5-5, REDIM RESULTS FOR 8,900-FOOT LONG RUNWAY

Exit	Exit Distance from Threshold	Exit Angle	Exit Usage	
			2028	2033
1	5,700	30°	37%	37%
2	6,500	30°	38%	37%
3	7,200	90°	20%	22%
4	8,900	90°	5%	4%
Average ROT			52 seconds	52 seconds

Note: Percentages may not sum to 100% due to rounding.
Source: REDIM V3 analysis

Table 5-6 presents the REDIM results for a 7,300-foot long runway. ROT is below 50 seconds due to the shorter length of the runway.

TABLE 5-6, REDIM RESULTS FOR 7,300-FOOT LONG RUNWAY

Exit	Exit Distance from Threshold	Exit Angle	Exit Usage	
			2028	2033
1	4,900	30°	51%	50%
2	5,700	30°	37%	38%
3	7,300	90°	12%	12%
Average ROT			47 seconds	48 seconds

Source: REDIM V3 analysis

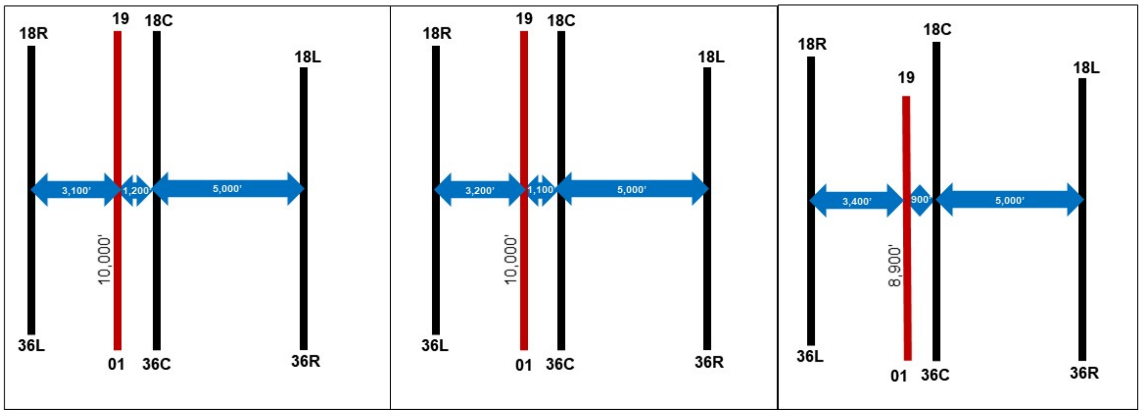
This exit location information for the various runway lengths will be used to determine the appropriate placement of exits in the alternatives. The actual locations of the exits may differ slightly due to the location of thresholds, existing exits, and glideslopes.

6 Development of Alternatives

Based on the changes in FAA runway separation requirements and the runway length analysis, three alternatives with new runways in the midfield were developed. The alternatives are summarized in **Exhibit 6-1**. The three alternatives are shown in more detail on **Exhibit 6-2** through **Exhibit 6-4**. This section discusses typical or primary runway use when discussing the alternatives. It is important to note that no new restrictions on runway use are proposed or assumed. The proposed new runway will be usable by arrivals and departures.

EXHIBIT 6-1, MIDFIELD RUNWAY ALTERNATIVES SUMMARY

ALTERNATIVE 1 ALTERNATIVE 2 ALTERNATIVE 3



Alternative	Separation to West Rwy (in feet)	Separation to East Rwy (in feet)	Primary Use of New Runway	Length (in feet)
1	3,100	1,200	Departure	10,000
2	3,200	1,100	Departure	10,000
3	3,400	900	Arrival	8,900

Source: Landrum & Brown analysis, 2020

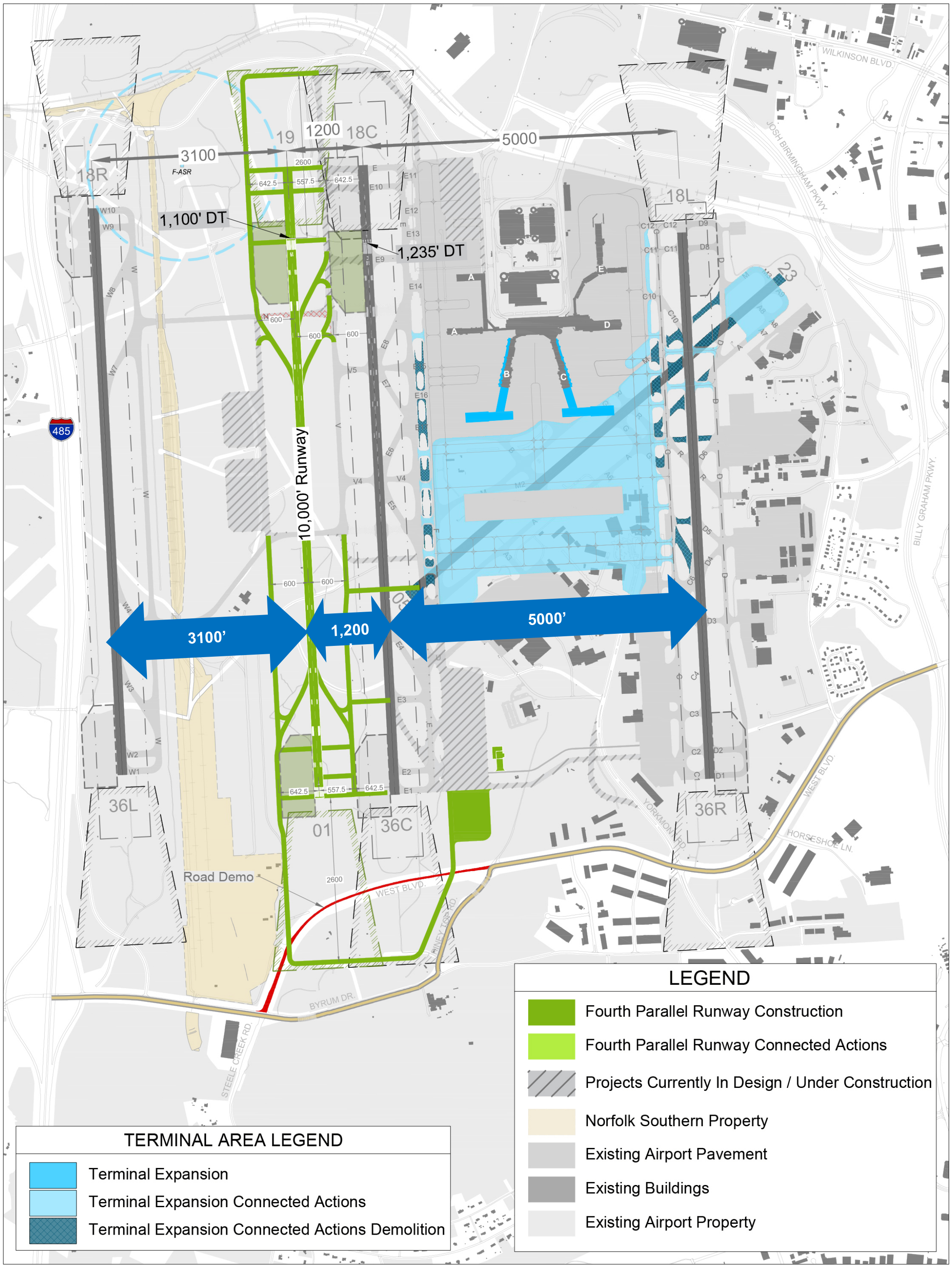
6.1 Alternative 1

Alternative 1 includes a 10,000-foot long midfield runway with 3,100 feet of separation to Runway 18R/36L and 1,200 feet of separation to Runway 18C/36C. The new runway does not have sufficient spacing between it and either of its two adjacent runways to allow for triple simultaneous independent straight-in approaches, so it is intended to be used primarily by departures (with limited use for arrivals). As a result of this intended use, the new runway is 10,000 feet long in this alternative. Runways 18R/36L, 18C/36C, and 18L/36R are anticipated to be used for arrivals, providing triple simultaneous independent approach capability. Runways 01/19 and 18L/36R would be used for departures.

Runway 01/19 is intended for departure use so it is not necessary to optimize ROT in this alternative. As a result, two high-speed exits are provided in north flow and one is provided in south flow. The locations of the exits differ from that shown in Section 5, *Runway Exit Geometry*, due to the location of other taxiways and navigational aids.

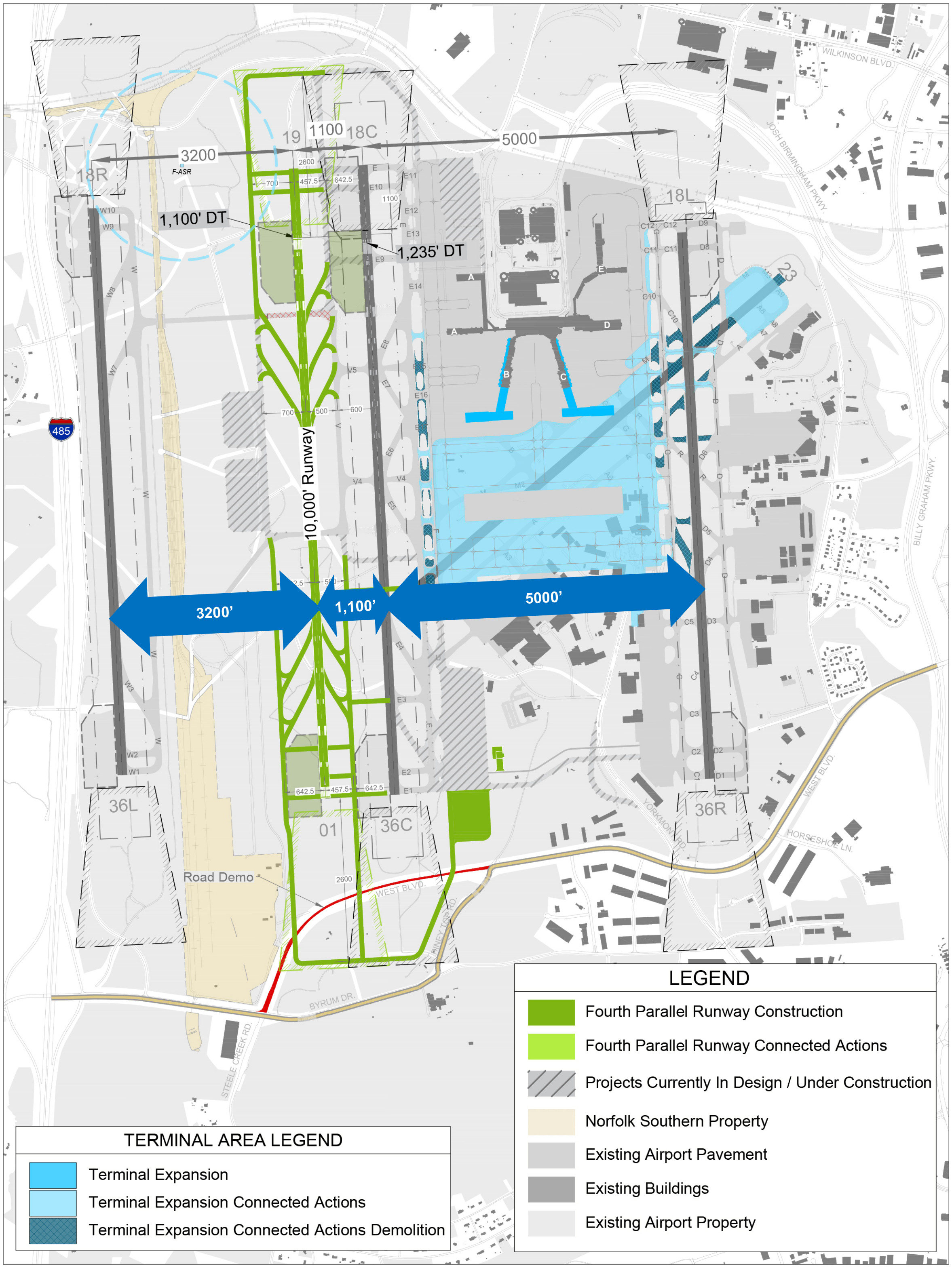
Alternative 1 includes the construction of a partial north EAT (NEAT), and a full south EAT (SEAT). The alternative also includes the construction of a west parallel taxiway and the extension of Taxiway V (the taxiway between the new runway and Runway 18C/36C) to the Runway 01 threshold. There is 1,200 feet of separation between Runways 01/19 and 18C/36C, so Taxiway V has sufficient spacing to both runways to allow unrestricted taxiing during all weather conditions.

EXHIBIT 6-2, ALTERNATIVE 1



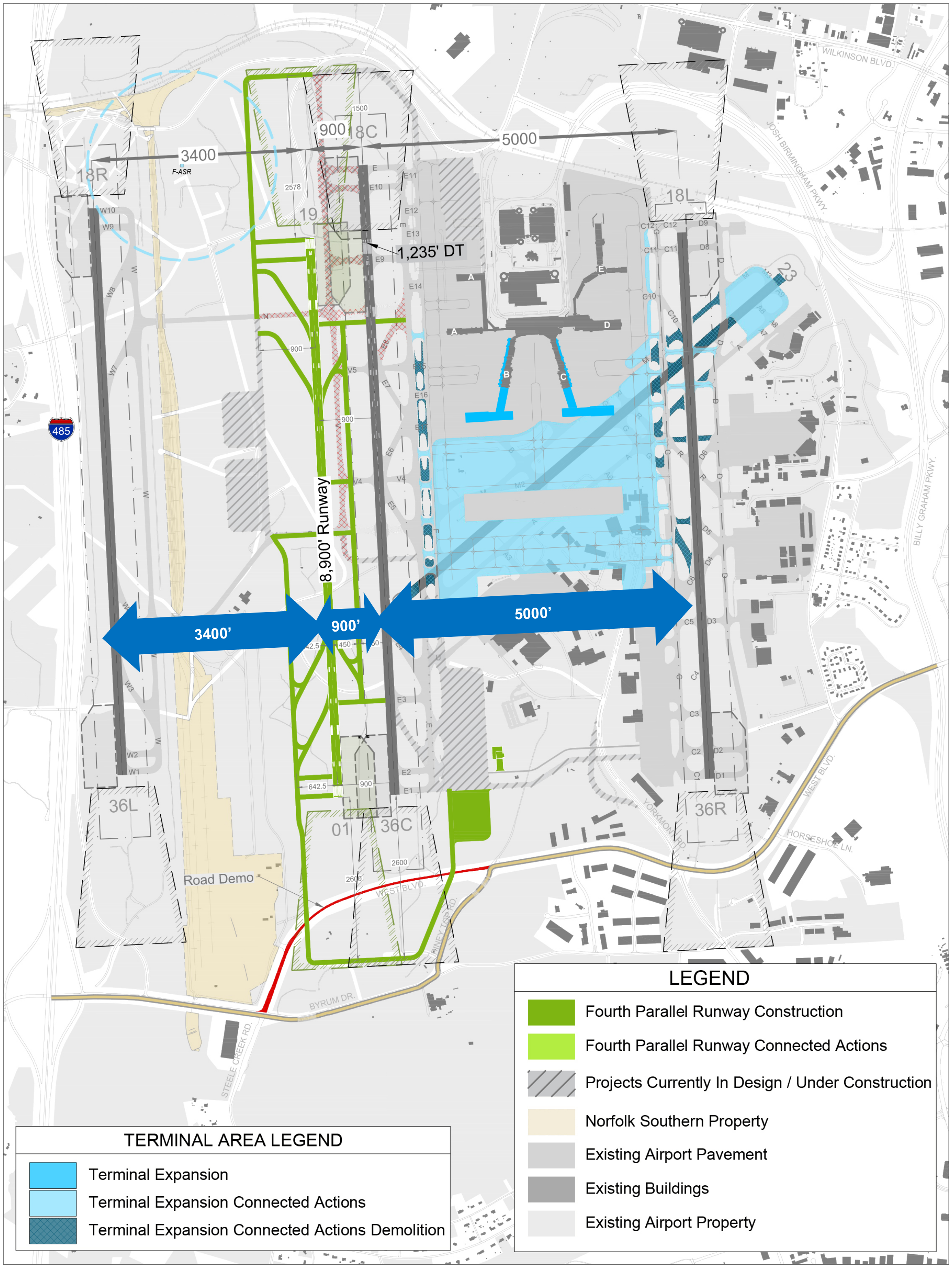
Source: Landrum & Brown, 2020

EXHIBIT 6-3, ALTERNATIVE 2



Source: Landrum & Brown, 2020

EXHIBIT 6-4, ALTERNATIVE 3



Source: Landrum & Brown, 2020

6.2 Alternative 2

As in Alternative 1, Alternative 2 includes a 10,000-foot long midfield runway. The runway is shifted 100 feet to the east in this alternative to provide 3,200 feet of separation to Runway 18R/36L and 1,100 feet of separation to Runway 18C/36C. The new runway does not have sufficient spacing between it and either of its two adjacent runways to allow for triple simultaneous independent straight-in approaches so is intended to be used primarily by departures (with limited use for arrivals). As a result of this intended use, the new runway is 10,000 feet long in this alternative. Runways 18R/36L, 18C/36C, and 18L/36R are anticipated to be used primarily for arrivals, providing triple simultaneous independent approach capability. Runways 01/19 and 18L/36R would be used for departures. This runway use is the same as in Alternative 1.

As discussed in Section 2, *Runway Separation*, the 3,200-foot separation between the new runway and Runway 18R/36L would provide operational flexibility to air traffic controllers because dual simultaneous independent approaches would be permitted to Runways 18R/36L and 01/19. The controllers could opt to run arrivals to these two runways while using Runways 18C/36C and 18L/36R for departures in non-peak arrival periods. This would segregate arriving and departing traffic, possibly providing operational benefits. The 3,200-foot separation would also position CLT to take advantage of any potential future reductions in runway separation requirements.[9]

Runway 01/19 is intended for departure use, however, due to its potential use as an arrival runway during off-peak times, it is important to optimize ROT to the extent possible in this alternative. As a result, three high-speed exits are provided in north flow and two are provided in south flow. The locations of the exits differ from that shown in Section 5, *Runway Exit Geometry*, due to the location of other taxiways and navigational aids.

Alternative 2 includes the construction of a partial NEAT and a full SEAT. The alternative also includes the construction of a west parallel taxiway and the extension of Taxiway V (the taxiway between the new runway and Runway 18C/36C) to the SEAT in order to allow arrivals on Runway 01/19 to access the SEAT. There is 1,100 feet of separation between Runways 01/19 and 18C/36C, which falls short of the recommended separation between closely spaced parallel runways for ADG V aircraft. As a result of having 1,100 feet of separation between the runways and the location of the Runway 36C glideslope, ADG V aircraft cannot taxi on Taxiway V when visibility is less than a half mile.[10]

6.3 Alternative 3

Alternative 3 includes a new midfield runway with 3,400 feet of separation to Runway 18R/36L and 900 feet of separation to Runway 18C/36C. The new runway has sufficient spacing between it and Runways 18R/36L and 18L/36R to allow for triple simultaneous independent straight-in approaches. As a result, it is intended to be used primarily by arrivals along with Runways 18R/36L and 18L/36R. Runways 18C/36C and 18L/36R would be used for departures.

Alternative 3 includes the construction of a partial NEAT, and a full SEAT. The 900-foot separation between the proposed runway and Runway 18C/36C allows for a center taxiway with 450 feet separation to both runways, which results in restricted use. ADG V aircraft cannot use this taxiway when visibility is less than a ½ mile. The 900-foot spacing also results in another restriction. The location of the Runway 18C and 36C glideslopes and associated critical areas combined with the 900-foot spacing means Taxiway V cannot extend the full length of Runway 01/19 and cannot connect to the EATs (a minimum of 560 feet of spacing is required between the runways to allow aircraft to taxi past the Runway 18C and 36C glideslope antennas).

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[9] Because dual simultaneous independent approaches would be permitted to Runways 18R/36L and Runway 01/19 if the runways were 3,200 feet apart and because the separation between Runway 01/19 and Runway 18L/36R far exceeds the requirement of 3,400 feet for triple simultaneous independent approaches, it may be possible to obtain a waiver from FAA to operate triple simultaneous independent approaches at CLT in the future. This would require further study and consultation with FAA.

[10] A separation of 642.5 feet is required between Runway 36C and Taxiway V on the southern portion of Taxiway V to allow unrestricted taxing past the Runway 36C glideslope critical area. With 1,100 feet of separation between Runways 18C/36C and 01/19, that leaves 457.5 feet of separation between Taxiway V and Runway 01/19, which is not sufficient to allow ADG V aircraft to taxi when visibility is less than a half mile.

It is important that aircraft have the ability to exit Runway 01/19 to both the east and the west. Aircraft exiting to the west can use the EATs to reach the terminal area, avoiding runway crossings. In addition, ADG V aircraft, which cannot use Taxiway V when visibility is less than a half mile, need to be able to exit to the west. According to the runway exit analysis, two high-speed exits are required in order to achieve runway occupancy times of less than 50 seconds. If the two glideslopes for Runway 01/19 were placed on the west side of Runway 01/19 (most typical location), their critical areas would conflict with the optimal location of the runway exits. Because the parallel taxiway to the east of Runway 01/19 has restricted use due to the separation between the proposed runway and Runway 18C/36C, the glideslopes were placed on the east side of Runway 01/19. This placement of the glideslopes allows two high-speed exits to be placed on the west side of the runway in both directions.

The ability to exit to the east Runway 01/19 is needed because it provides a shorter path to the terminal. If the new runway were 7,300 feet long, Taxiway V could only extend from Taxiway E3 to Taxiway V4 due to the location of the Runways 18C, 19, 01, and 36 glideslopes as well as the location of Runway 36C high-speed exits. This distance is 3,500 feet which is not sufficient to allow most aircraft in the CLT fleet to exit to the east. In order for the center taxiway to be long enough to provide the capability for all arrivals to exit east, the runway needs to be longer. A length of 8,900 feet provides 7,303 feet of usable runway length for south flow arrivals exiting east and 7,418 feet of usable runway length for north flow arrivals exiting east. Thus, Runway 01/19 is 8,900 feet long in Alternative 3. It has one high-speed exit in both directions to the east of Runway 01/19.

The location of the runway and exit taxiways requires that a portion of Taxiway N, a portion of the newly constructed Taxiway V, and Taxiway E8 (a high-speed exit for Runway 36C) be removed. The removal of a Runway 36C high-speed taxiway is not expected to cause an increase in ROT for Runway 36C.

7 Alternatives Comparison

There are several key differentiators between the three alternatives: (1) EAT holding requirements, (2) runway use and runway crossings, (3) Taxiway V capability, (4) navigational aid placement, and (5) the ability to provide future flexibility. The alternatives were screened with regards to these factors to identify any fatal flaws.

The alternatives will all result in differing costs, implementation time frames, and operational performance. These factors will be assessed as part of the EA alternatives analysis to determine which ones should be carried forward for detailed environmental analysis.

7.1 End Around Taxiway (EAT) Holding

An EAT is a taxiway that crosses the extended centerline of a runway, on which aircraft do not require clearance from air traffic control (ATC) to cross. EATs can improve efficiency and reduce runway crossings. All three alternatives have full EATs around Runways 19 and 18C on the north end and around Runways 01 and 36C on the south end. These EATs were designed based on the following guidance in FAA AC 150/5300-13A, *Airport Design*:

- The centerline of an EAT must be at least 1,500 feet from the stop end of the runway for a minimum of 500 feet on each side of the extended runway centerline.
- The minimum dimensions are typically increased in order to prevent aircraft tails from being a penetration to the 40:1 departure surface or any other relevant surfaces.
- EATs can be placed at a lower elevation than the stop end of the runway to reduce the distance between the runway end and the EAT that is perpendicular to the extended runway centerline.
- It is not currently possible for aircraft to taxi unrestricted on the EAT in the approach surface of an incoming arrival.

7.1.1 South EAT Holding Requirements

The perpendicular portion of the SEAT is located 2,600 feet from the stop end of Runways 01 and 36C in all three alternatives. This distance allows unrestricted flow on the EATs under departing aircraft because all tail heights for the CLT fleet can clear the 40:1 departure surface.

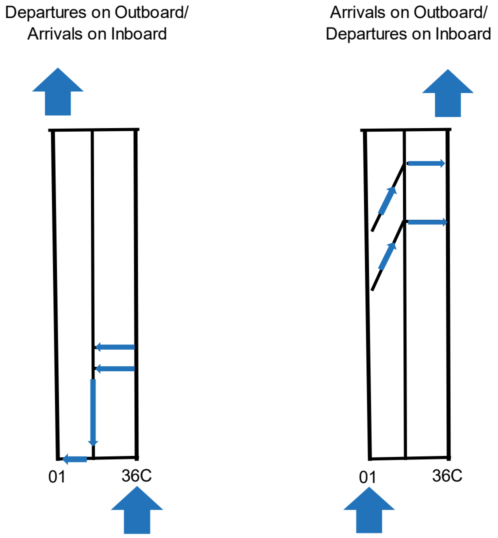
7.1.2 North EAT Holding Requirements

On the north end of Alternatives 1 and 2, the perpendicular portion of the NEAT is located 1,500 feet from the stop end of Runway 19 and 18C. The 1,500-foot distance is the maximum distance that can be achieved without relocating the railroad to the north of the runways. This distance requires that ADG IV and V aircraft hold for ATC clearance before taxiing around the NEAT because the ADG IV and V aircraft tail heights cannot clear the 40:1 departure surface. This restriction is not expected to be significant because there are no commercial ADG IV aircraft forecast for 2028 and 2033 and less than two percent of operations are expected to be ADG V. Air traffic controllers have indicated that they would most likely land ADG V aircraft on one of the other runways to avoid the issue of holding on the NEAT.[11] For Alternative 3, the perpendicular portion of the NEAT is located 2,578 feet from the stop end of Runways 19 and 18C. This distance does not require any holding on the EAT under departing aircraft.

7.2 Runway Use and Runway Crossings

When operating on closely spaced runways such as proposed Runway 01/19 and existing Runway 18C/36C, departures typically occur on the "inboard" runway (runway closest to the terminal) and arrivals occur on the outboard runway (runway furthest from the terminal). Alternative 3 would be able to be operated this way but Alternatives 1 and 2 would not. In the case of Alternatives 1 and 2, there is insufficient separation between Runway 01/19 (the outboard runway) and Runway 18R/36L to allow triple simultaneous IFR approaches on Runways 01/19, 18R/36L, and 18L/36R. As a result, in these alternatives, arrivals would typically use the inboard runway (Runway 18C/36C) and departures would typically use the outboard runway (Runway 01/19).[12] An example of both runway use situations is shown on **Exhibit 6-5**.

EXHIBIT 6-5, RUNWAY USE EXAMPLES



Source: Landrum & Brown analysis, 2020

These differences in runway use would result in different EAT usage and runway crossings assumptions, as described in the subsections that follow.

7.2.1 Alternatives 1 and 2

Primary taxi flows for Alternative 1 are shown on **Exhibit 6-6**. The taxi flows for Alternative 2 would be the same as Alternative 1 so they are not shown on an exhibit. In Alternatives 1 and 2, all North Flow arrivals on Runway 36L and 01 would exit to the east and use the NEAT to reach the terminal. Similarly, in South Flow, arrivals on

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[11] Direction, Oversight, Review, and Agree (DORA) Meeting #4, January 27, 2021

[12] No restrictions on runway use are proposed or assumed for the new runway. Additionally, no runway use restrictions are proposed for the existing runways.

18R and 19 would exit to the east and use the SEAT to access the terminal. No arrivals would be required to cross a runway to reach the terminal area in these alternatives.

Departing aircraft bound for Runway 01 in North Flow or Runway 19 in South Flow would cross Runway 18C/36C at two locations to reach the departure queue. These departing aircraft were assumed to cross Runway 18C/36C instead of using the EATs for several reasons:

- FAA air traffic officials indicated they would rather cross Runway 18C/36C than taxi on the EATs due to the amount of time it would take for aircraft to taxi through the approach surface.[13]
- Participants at the Safety Assessment Workshop (October 16, 2020) identified a hazard with a high potential risk related to holding on the EATs for the approach surface of Runway 18C/36C.
- Large gaps in the arrival stream (eight to nine nautical miles) would be required in order to allow aircraft on the EATs to taxi through the approach surfaces of Runway 18C/36C. These gaps would result in reduced capacity on Runway 18/36C. If the gaps are not provided, taxiing aircraft would have long ground delays while waiting for a natural gap in the arrival sequence. Crossing the runway was found to take less time and result in a more efficient operation than taxiing on the EATs.

Based on these factors, crossing the runway was identified as preferable over taxiing through the approach surfaces on the EATs.

There would be more runway crossings with Alternatives 1 and 2 versus Alternative 3 because all Runway 01/19 departures would be required to cross a runway to reach their departure queue in Alternatives 1 and 2. Runway 01/19 departures would have to cross an arrival runway (Runway 18C/36C) to access the Runway 01/19 departure queue. This type of operation creates a more complex situation for air traffic controllers to manage than when arrivals are on the outboard runway and departures are on the inboard runway. In general, it is more complicated to cross an arrival runway than a departure runway for two reasons:

- Arrivals restrict the runway from use by crossing aircraft for a longer period of time than departures. Arrivals that are less than two miles out “own” the runway until they land and pass the runway crossing point, whereas departures only “own” the runway from the point of takeoff clearance until they pass the runway crossing point.
- Crossing an arrival runway provides less flexibility to manage the flow of aircraft on the ground. Arrivals cannot be told to hold in the air for a runway crossing. If separation cannot be assured between arrivals due to a slow runway crossing or other reason, the controller must send the arriving aircraft around for a missed approach to avoid an operational error. On the other hand, departures on the ground can be told to hold for runway crossings, providing flexibility to reduce taxiway congestion.

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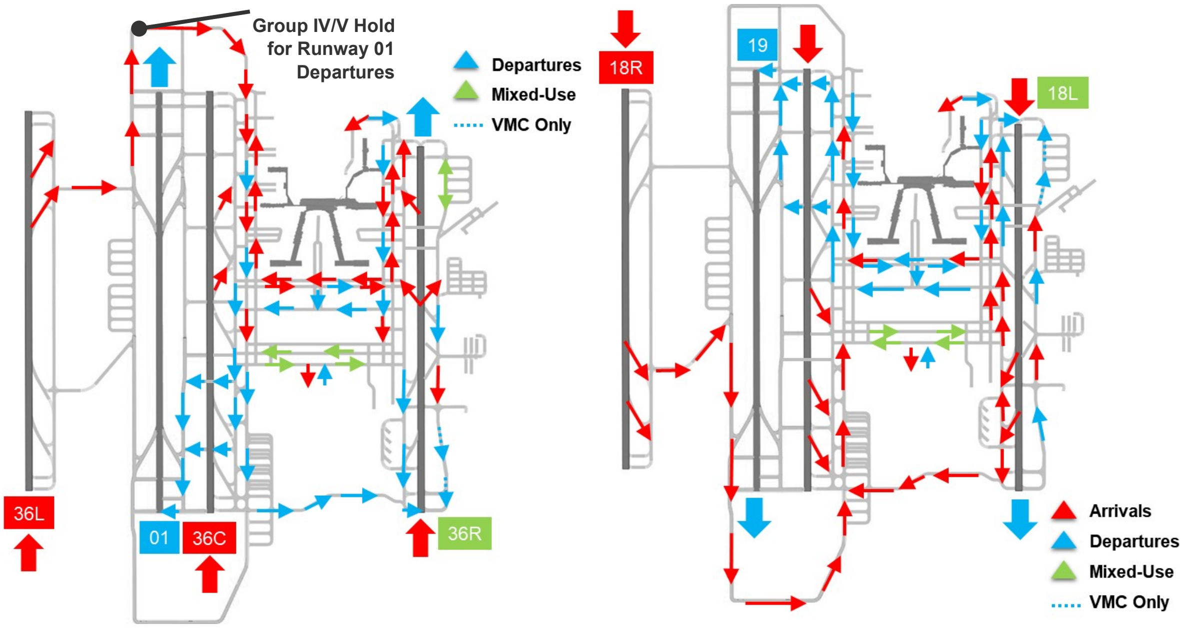
[13] Feedback received at DORA Meeting #2 (June 11, 2020).

EXHIBIT 6-6, ALTERNATIVE 1 PRIMARY TAXI FLOWS – NORTH FLOW/SOUTH FLOW



Note: Alternative 2 would have identical taxi flows to Alternative 1.
Source: Landrum & Brown, 2020

7.2.2 Alternative 3

Primary taxi flows for Alternative 3 are shown on **Exhibit 6-7**. All arrivals on Runways 36L would use the NEAT and all Runway 18R arrivals would use the SEAT. Runway 01/19 arrivals could exit to the east or west. Runway 01 arrivals exiting to the west would use the NEAT and Runway 19 arrivals that exit west would use the SEAT. Runway 01/19 arrivals that exit east would have to cross Runway 18C/36C to reach the terminal area. It was assumed that the Runway 01/19 arrivals would use the EATs during peak periods of activity to reduce the capacity impacts of runway crossings. Exiting to the east (with the associated runway crossing) was assumed to occur in off-peak periods, resulting in fewer runway crossings than Alternatives 1 and 2. Runway 18C/36C would be primarily used by departing aircraft so the Runway 01/19 arrivals that do cross Runway 18C/36C would be crossing a departure runway. Crossing a departure runway is less complex for air traffic controllers to manage than crossings an arrival runway.

7.3 Taxiway V Capability

When constructing a new runway, the supporting taxiway structure is critical. The ability to provide sufficient taxiway capacity and meet all applicable FAA standards to the extent possible is imperative to ensuring that runway capacity can be maximized and in enabling aircraft to transition to/from the terminal area with minimal delay and restrictions. Providing a taxiway between two parallel runways is one key factor in providing sufficient taxiway geometry to support a new runway. A parallel taxiway between two runways provides an alternative location for aircraft to queue for departure that is outside of the terminal area and allows aircraft a place to hold while waiting to cross a runway. FAA recommends 1,200 feet of separation between two parallel runways to allow for proper taxiway geometry.[14]

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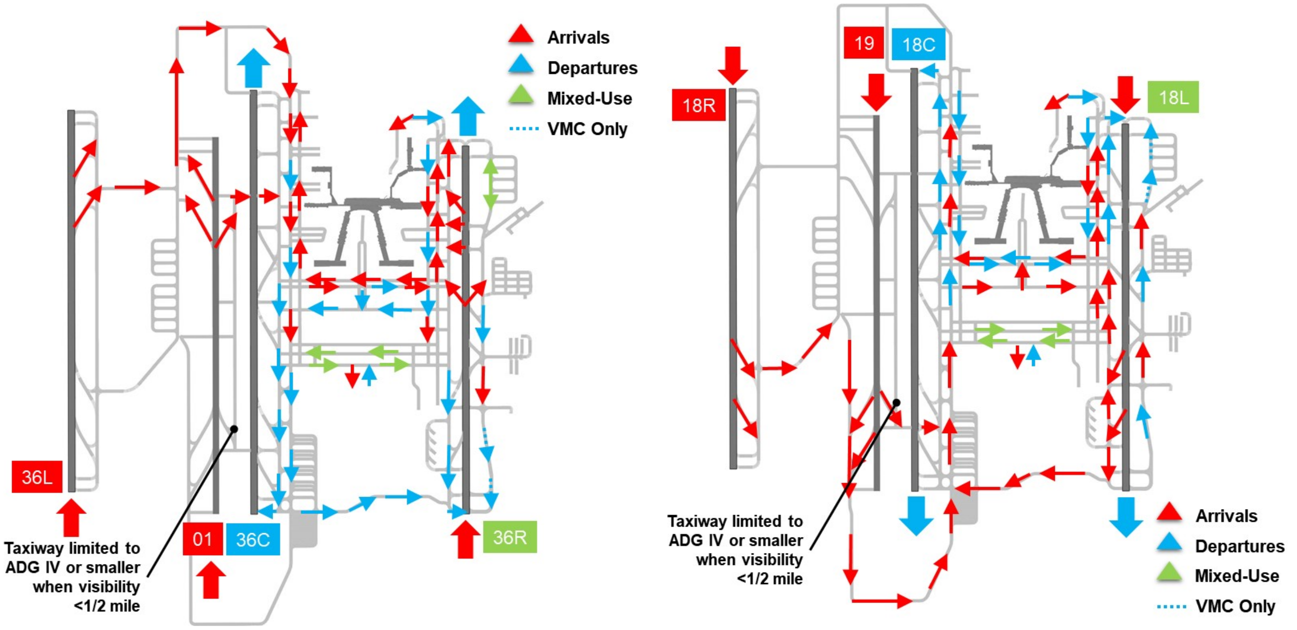
[14] FAA AC 150/5300-13A, *Airport Design*

All of the CLT alternatives meet all applicable FAA requirements for taxiway design and provide a full parallel taxiway to the west of Runway 01/19. They differ in the capability of the taxiway between Runways 01/19 and 18C/36C. Alternative 1 is the only alternative that provides a full parallel taxiway between the runways, meets FAA recommendations, and is capable of accommodating ADG V aircraft in all weather conditions.

Alternative 2 provides a full parallel taxiway between the runways but ADG V aircraft cannot taxi on it when visibility is less than a half mile because the separation between Runways 18C/36C and 01/19 is 1,100 feet. ADG V aircraft would have to exit Runway 01/19 to the west during these low visibility conditions, resulting in a longer taxi times and less flexibility for air traffic controllers. This restriction is not expected to be significant because less than two percent of operations are expected to be ADG V and the referenced low visibility conditions occur less than one percent of the time.

Alternative 3 has 900 feet of separation between Runways 01/19 and 18C/36C. Similar to Alternative 2, this separation does not allow ADG V aircraft to taxi on Taxiway V when visibility is less than a half mile. ADG V aircraft would have to exit Runway 01/19 to the west during these low visibility conditions, resulting in a longer taxi times and less flexibility for air traffic controllers. As with Alternative 2, this restriction is not expected to be significant. In addition, a full taxiway cannot be provided between Runways 01/19 and 18C/36C due to the location of the Runway 18C/36C glideslopes. The lack of a full length taxiway means that the EAT would not be accessible to aircraft that exit Runway 01/19 to the east. It also means there would be less flexibility for controllers because there would be less space for aircraft to queue for departure and fewer places for aircraft to hold while waiting to cross Runway 18C/36C.

EXHIBIT 6-7, ALTERNATIVE 3 PRIMARY TAXI FLOWS – NORTH FLOW/SOUTH FLOW



Source: Landrum & Brown, 2020

7.4 Navigational Aid Placement

Glideslopes are located on the sides of runways near the runway ends. They have critical areas that need to be kept free of aircraft when the glideslope is in use. As a result, glideslope placement must be carefully considered so that there are no implications to taxiing aircraft.

For Alternatives 1 and 2, the Runway 01/19 glideslopes were placed on the west side of the runway. There is sufficient separation between the runway and the west parallel taxiway to allow aircraft to taxi unrestricted adjacent to the glideslope critical area. The glideslope and its critical area do not cause restrictions on taxiing aircraft.

Alternative 3 would require that the Runway 01/19 glideslopes be placed between Runways 01/19 and 18C/36C in order to allow for high-speed exits on the west side of the runway. This placement results in the Runway 01 glideslope being co-located with the Runway 36C glideslope. While it is possible to co-locate the glideslopes, there may be issues with the glideslopes and the terminal instrument procedures (TERPS) surfaces – this requires further study. If this glideslope siting is ultimately not possible, the glideslope would have to be placed on the west side of the runway. If the Runway 01 glideslope is located on the west side of the runway, the second high-speed exits in both directions would be in the glideslope critical area which may not be permitted due to signal reflectivity issues. Not having the second high-speed exit in both directions could increase runway occupancy times and ultimately reduce the capacity of the runway.

7.5 Future Flexibility

Alternative 2 provides 3,200 feet of separation between Runways 01/19 and 18C/36C, which meets the minimum requirement for dual simultaneous independent approaches under the FAA's rule change. The separation between Runways 01/19 and 18L/36R in this alternative is 6,100 feet, which is far in excess of the 3,400 feet of separation that will be needed for triple simultaneous independent approaches under the new FAA requirements. The capability to run duals to Runways 18R/36L and 01/19 combined with the excess separation between Runways 01/19 and 18L/36R may make it possible to get approval to run triples to Runway 01/19 in the future. If so, Alternative 2 would be operated with arrivals on Runways 18R/36L, 01/19, and 18L/36R. With regards to the set of closely spaced parallel runways (01/19 and 18C/36C), arrivals would occur on the outboard runway, with departures on the inboard runway. This is a more typical runway use which would result in fewer runway crossings and reduce crossings of an arrival runway. As a result, Alternative 2 could provide future flexibility that may not be available with Alternative 1. It is important to note that this runway use has not been approved and is not assumed as part of this EA. The ability to run triples with 3,200 feet of separation would require future study and consultation with the FAA.

The future flexibility concept is not necessary with Alternative 3 because its 3,400-foot separation takes advantage of the FAA rule change for triple approaches. No additional flexibility would be needed.

7.6 Conclusions

The results of the alternatives screening are summarized in **Table 7-1**. Alternative 1 would have a fully capable taxiway system with no aircraft size restrictions and the glideslope siting is standard. However, this alternative would have more runway crossings than Alternative 3, would require crossings of an arrival runway, would require holding by ADG IV and V aircraft on the NEAT, and would not provide future flexibility with regards to triple approaches to the new runway.

TABLE 7-1, ALTERNATIVES SCREENING SUMMARY

Alternative	Pro/Con	EAT Holding	Runway Crossings	Taxiway V Capability	Navigational Aid Placement	Future Flexibility
1	Con	ADG IV and V aircraft required to hold on NEAT;	Rwy 01/19 departures cross inboard arrival runway	n/a	n/a	No
	Pro	no holding on SEAT	n/a	Full length, unrestricted Taxiway V	Standard placement	n/a
2	Con	ADG IV and V aircraft required to hold on NEAT;	Rwy 01/19 departures cross inboard arrival runway	ADG V cannot use Taxiway V when visibility is less than a half mile	n/a	Yes
	Pro	no holding on SEAT		Full length Taxiway V	Standard placement	n/a
3	Con	n/a	n/a	Partial Taxiway V; ADG V cannot use Taxiway V when visibility is less than a half mile	Requires 18C/19 and 36C/01 glideslopes to be co-located which may have TERPS issues	n/a
	Pro	No holding on NEAT or SEAT	some Rwy 01/19 arrivals cross inboard departure runway	n/a	n/a	n/a

Source: Landrum & Brown analysis, 2021

Alternative 2 would provide a full length Taxiway V, the glideslope siting is standard, and it would provide future flexibility with regards to triple approaches to the new runway. However, this alternative would have an aircraft size restriction on Taxiway V, more runway crossings than Alternative 3, require crossings of an arrival runway, and require holding by ADG IV and V aircraft on the NEAT.

Alternative 3 would not require holding for arriving aircraft on the EATs, would have the least complex runway use, and would have fewer runway crossings than Alternatives 1 and 2. However, it would have the least amount of capability on Taxiway V and would require co-location of glideslopes.

Each of these alternatives has its pros and cons but no fatal flaws. It is therefore recommended that all three alternatives be carried forward into the EA for airfield simulation analysis to determine the best performing alternative from an operational perspective.

U.S. Department
of Transportation
**Federal Aviation
Administration**

July 23, 2021

Mr. Jack Christine
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Re: Documentation of DORA Process, Charlotte-Douglas International Airport Airfield Capacity Enhancement Plan

This letter summarizes the process used by the Federal Aviation Administration (FAA) Office of Airports (ARP) and Air Traffic Organization (ATO) to obtain necessary input on operational feasibility of potential design alternatives considered as part of the Charlotte-Douglas International Airport (CLT) Environmental Assessment (EA) for the Capacity Enhancement Projects. The Direction, Oversight, Review, and Agree (DORA) process described in this letter has been successfully applied to other large-scale airport and airspace modernization efforts.

The target years of analysis for the capacity enhance projects are through 2033. This letter documents the second stage of a multi-year planning, design, and analysis process, which builds on the prior analysis conducted for the Airfield Capacity Enhancement Plan (ACEP) as is documented in a February 2016 letter. The purpose of the DORA process during the conduct of the EA is to provide current operational input on the feasibility and reasonability of the No-Action and other potential alternatives. The operational input is a crucial component to validate the modeling conducted using AirTOP. AirTOP is a modern airspace and airport simulation model that is used to test and analyze the performance of various airport development scenarios.

The DORA work group was comprised of representatives from the FAA, CLT, airlines serving the airport including American Airlines, and the Landrum & Brown team (consultant to CLT). FAA membership included both ARP and ATO participants, including:

- Air Traffic Management, Traffic Flow Management, and National Air Traffic Controller Association (NATCA) representatives from Charlotte Air Traffic Control Tower and Terminal Radar Approach Control (TRACON).
- ARP representatives from the Memphis Airport Districts Office (ADO) and the Office of Airport Planning and Programming (APP).

The CLT DORA process consisted of a simple present>feedback>incorporate cycle, which proceeded as follows: Airfield alternatives and airspace utilization were presented by Landrum & Brown. Operational input and feedback on use of the alternative designs was then solicited from ATO and airline subject matter experts. Prior to the next DORA meeting, Landrum & Brown incorporated the collected information into the modeling.

A total of five DORA meetings were held starting in 2017 and concluding in 2021. These meetings are summarized below:

- July 2017: CLT ACEP project overview, introduction to DORA process and protocols, review collected No Action input data.
- March 2020: Present and review revised No Action input data.
- June 2020: Present and review simulation results for No Action, present and review input data for Proposed Action.
- November 2020: Present and review simulation results for Proposed Action, present and review input data for Alternatives.
- January 2021: Present and review simulation results for Alternatives, synthesize overall simulation results, and close-out of the DORA process.

The DORA process ensured that the appropriate operational expertise and experience, from both airlines and controllers, informed and influenced the design, analysis, and decision-making for the CLT capacity enhancement effort. In particular, ATC's operational input was vital to the DORA process. As applicable and relevant to the simulation tool, the operational input was incorporated into the AirTOP simulation model. For this second phase of analysis, ARP and ATO are satisfied that the modeling approach was reasonable, that the modeling assumptions accurately reflected operational perspectives, and the capacity, throughput, and delay results derived from the DORA process are reasonable representations of the performance expected with the potential airfield designs.

Going forward, subsequent analysis will be needed during implementation phases to:

- Define dependent procedures between aircraft departing from a new runway while an aircraft is landing on Runway 18C/36C, and vice versa, in order to ensure aircraft separation in the event of a missed approach per FAA Order 7110.65 paragraph 5-8-5. It is expected that the tower simulator available at the CLT ATCT/TRACON will be effective in developing the specific procedures needed for incorporation into the facility's Standard Operating Procedures.
- Evaluate possible TCAS interactions and mitigations through coordination with the Flight Technologies and Procedures Division, Flight Operations Group, AFS-410. The TCAS analysis is recommended in order to evaluate if the planned parallel final approach courses to a new runway, using either Established on RNP

(EoR) RNAV transitions or traditional 1000-feet vertical separations, could result in recurring TCAS alerts between aircraft on simultaneous approach courses.

- A future Part 150 study is expected to investigate the efficiency benefits, operational viability, and community acceptance of divergent departure headings from CLTs runways (as well as other recommendations advocated by the Airport Community Roundtable).

The additional analysis identified above is part of the normal maturation process for large-scale airport capacity initiatives. The FAA considers the results of the simulation evaluation conducted for the EA to be reasonable given the information that is currently available.

FOR

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