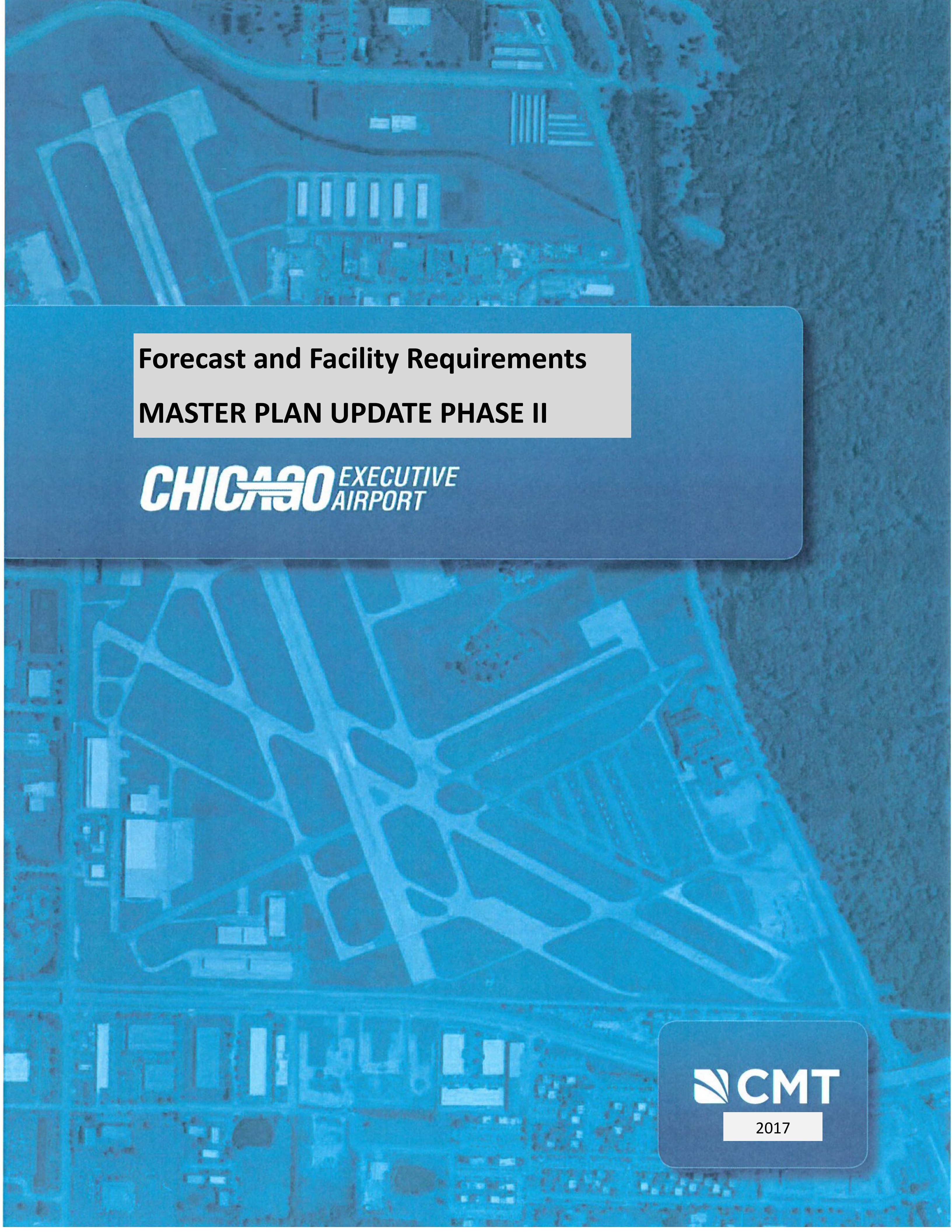


Forecast and Facility Requirements

MASTER PLAN UPDATE PHASE II

CHICAGO EXECUTIVE AIRPORT

CMT

2017

Section 1

Forecast

1.0 Introduction

Developing a comprehensive forecast for activity at an airport over a 20-year planning horizon involves the consideration and analysis of many factors. Due to the complex nature of aeronautical demand at an airport located within a major metropolitan area, the "demand" factors can vary greatly. A comprehensive forecast should include factors that range from complex data-based quantitative measures to anecdotal qualitative observations supported by the users. This assertion is especially true for Chicago Executive Airport (CEA).

1.1 Background

In 2014, a Phase 1 Master Plan was initiated at CEA to determine the future planning needs of the airport. The four guiding principles established as the foundation for future planning activity in this report included:

1) Integrating the Airport within the local communities
2) Fulfilling the Airport's role
3) Enhancing the Airport's safety and compatibility
4) Maintaining the Airport's financial viability

Based on the findings within the Phase 1 Master Plan report, the airport initiated a second phase of the master planning process. The purpose of the second phase is to further define future demand, constraints, and impacts that were identified within first phase.

This forecasting document will serve as a component of the Phase 2 Master Plan. It will help establish the Airport's constraints and potential demand scenarios to better understand the future planning needs of CEA.

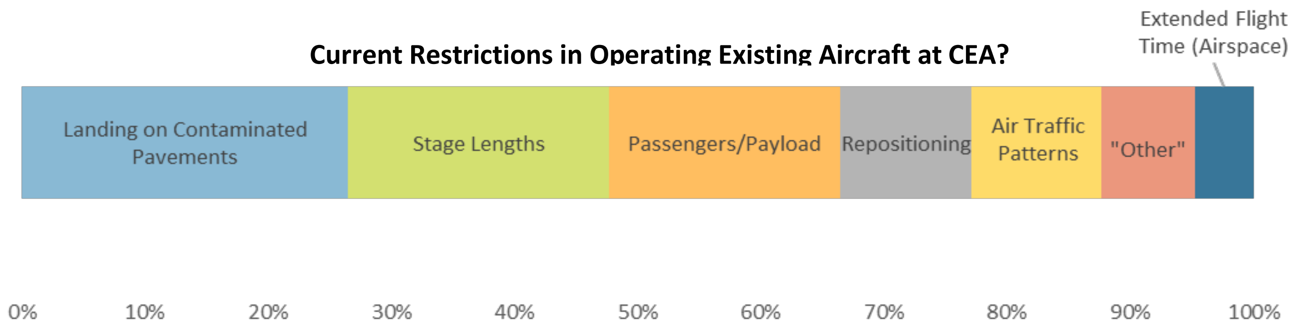
1.2 Constraints

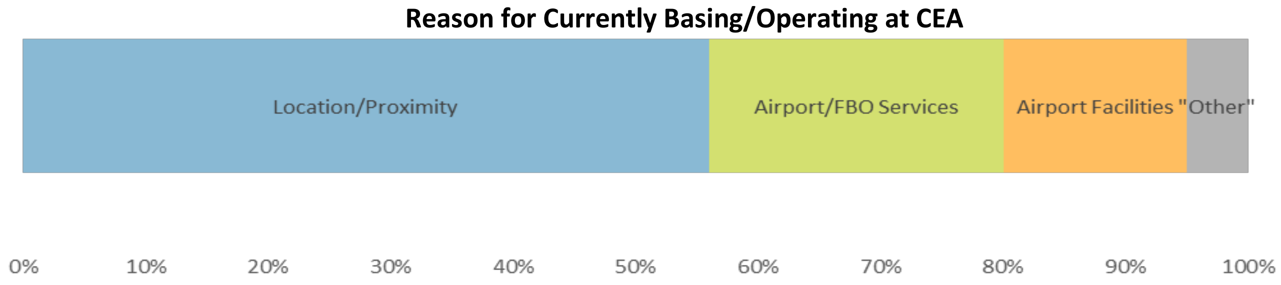
CEA is unique because it serves as the top Chicago metropolitan area reliever in both itinerant and local operations, yet users consider it to be constrained relative to comparable relievers in the nation. These constraints have been generally understood by the airport and users for many years; however, they were further defined in the Phase 1 Master Plan through user surveys. As direct influencers of demand, these constraints are a major factor to consider when forecasting future operations.

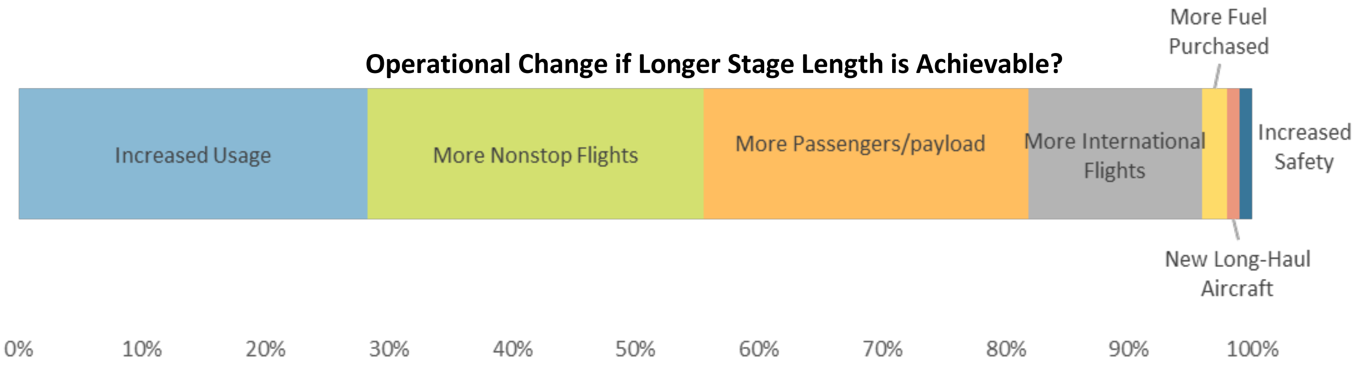
Phase 1 Master Plan Surveys: The surveys within the Phase 1 Master Plan were distributed to both existing users and potential corporate users via two separate versions. The first version was provided electronically and in hardcopy to the users at CEA. The second, more condensed version was provided to pilots at a National Business Aviation Association Conference (NBAA) in October 2014. In total, there were over 300 participants that provided insight on CEA's constraints that impact existing users and prevent potential users from operating at CEA. The following provides a graphical summary of the key questions from the Phase 1 Master Plan survey.

Rank Overall Needs for Improved Facilities at CEA:

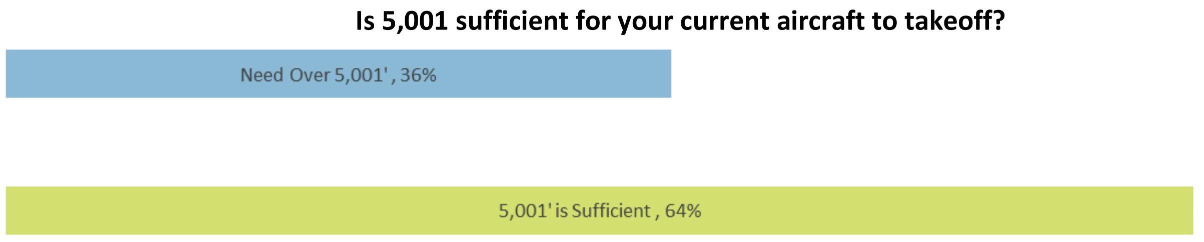
1) Runway Length **2) Runway Instrumentation** **3) Secondary Runway Length**

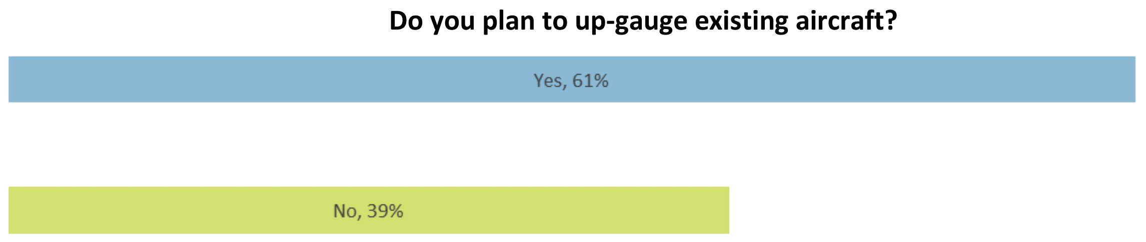

Current Restrictions in Operating Existing Aircraft at CEA?

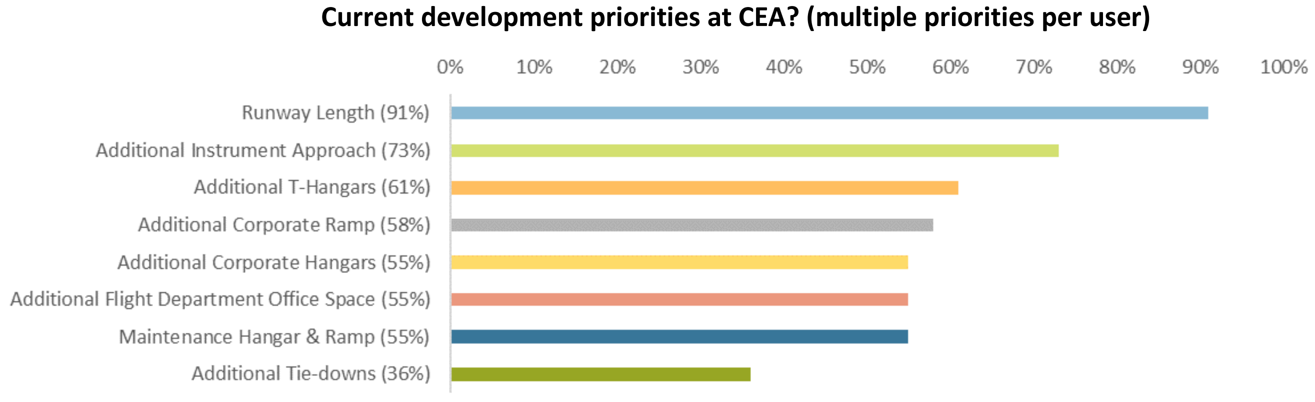

Reason for Currently Basing/Operating at CEA


Operational Change if Longer Stage Length is Achievable?

<u>Phase 2 Master Plan Survey:</u> To better understand the constraints identified in the Phase 1 Master Plan, an additional survey was developed as an element of the Phase 2 Master Plan. The surveys in Phase 2 were distributed to existing tenants and users at CEA. The survey was an electronic form that included the participant's information, type of operation, and questions regarding the constraints identified in the Phase 1 Master Plan. The following are the key questions and responses included within the survey.


Is 5,001 sufficient for your current aircraft to takeoff?


Do you plan to up-gauge existing aircraft?


Current development priorities at CEA? (multiple priorities per user)

Survey Summaries: In both the Phase 1 and Phase 2 surveys, the primary constraint identified is related to the runway length. Phase 1 survey results show that CEA users consider additional runway length as the number one priority for future improvements. Further, the participants acknowledge that their operations would improve in a variety of ways should the runway be extended. In the Phase 2 survey, additional runway length is confirmed as the number one priority for users and over one third of the users indicate their aircraft cannot takeoff with 5,001′ at max takeoff weight. One important response that may increase the magnitude of the runway length constraint is that 61% of the users intend to up-gauge, or increase the size of, their current jet. This would suggest that in the near future, the majority of users that are currently unconstrained, will potentially be constrained.

In addition to the identification of the runway length as the primary constraint, there were several other secondary constraints identified. These constraints include a need for additional instrument approaches with lower minimums, contaminated runway concerns, airspace delays, additional hangar space, additional corporate office space, and additional ramp space. All of these constraints are extremely important to an operator, especially when considering an airport to base an aircraft at. These constraints impact the efficiency and effectiveness of operations, deterring users from basing and/or operating at CEA.

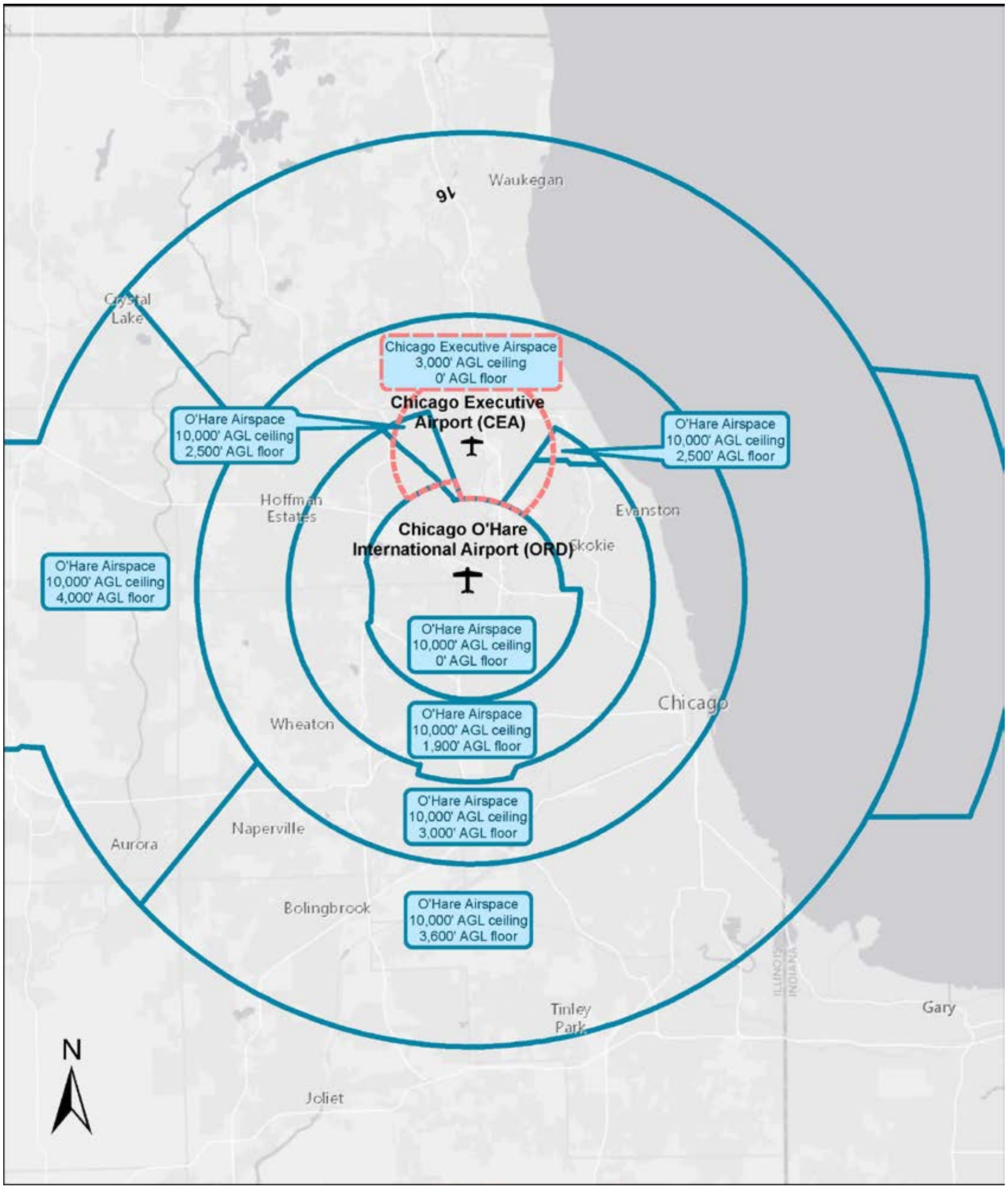
Phase 2 Master Plan Interviews: In addition to the surveys, a number of interviews were conducted with select tenants at CEA, as well as fractional and charter users of the Airport. A fractional operation is defined as multiple parties that own or share a corporate jet. Charter operators are when a fully staffed corporate jet is essentially rented to a customer. Within the Chicago area, over 50% of all corporate jet operations are conducted by fractional or charter operators.

The interviews confirmed many of the constraints that were identified in the surveys, with the primary constraint being the runway length. As a factor of runway length, a highly emphasized concern was landing during contaminated runway conditions by fractional and charter operations. As a fractional or corporate operator with a turbojet, the FAA has established more restrictive landing regulations to abide by compared to most private corporate fleets. These regulations require fractional and charter operators to factor in additional calculations when landing on precipitation-induced contaminated runways. Contaminated runway conditions are when precipitation (rain, snow, ice) has collected on the landing runway surface. These impacts will be discussed further within this report.

Interviews with users at CEA also brought attention to airspace constraints that were originally identified in the Phase 1 study. These airspace constraints result from CEA’s location within the Chicago airspace system. CEA lies under Chicago O’Hare’s (ORD) class B airspace which creates an extended routing scenario for aircraft traveling to CEA, especially from the south.

Extended airspace routing can cause flight delays that impact and deter users from operating at the Airport. Another factor of CEA’s proximity to ORD’s class Bravo airspace is that it only allows for instrument approaches from the north. This severely limits access to the airport during inclement weather, especially when winds are not favoring the northerly Runway 16. Exhibit 1-1 depicts the location of CEA in comparison to ORD’s Class B airspace.

Exhibit 1-1: Chicago O’Hare International Airspace



Source: CMT (2016)

The greatest takeaway from the surveys and interviews was the notion that the constraints are significant enough to discourage many users from either operating or basing their operations at CEA. With this understanding, it can be deduced that an unconstrained CEA would have a significant impact on both operations and based aircraft. This forecast will investigate the impact of these constraints, how they have an effect on existing operation, and the potential effect on operations if CEA was not constrained.

2.0 Economic Outlook

Aviation plays an extremely important role in the economies of the world. It facilitates the fast and efficient transportation of goods and people, allowing for a greater connectivity of markets and businesses.

Under most circumstances, the economy shares a direct relationship with the aviation industry. As the economy grows, the aviation activity within that economy also grows. Similarly, in many instances the development of aviation infrastructure has helped stimulate the local economy. Because of this important mutualistic connection between the economy and aviation industry, it is necessary to understand the economic factors that can influence the forecasting of aviation activity at an airport.

At CEA, there are three primary economies of concern, including: Chicago Metropolitan Statistical Area (MSA), U.S./national, and worldwide economies. These economies are listed in order of magnitude and influence on CEA's aviation demand.

2.1 Chicago Metropolitan Area Economy

The Chicago metropolitan area is a vast and diverse economic system. Chicago ranks number three in the Nation's Gross Domestic Product (GDP), trailing only behind New York and Los Angeles. When considering Chicago on the global scale, Chicago has the 23rd largest GDP out of all of the world economies.[1]

Having such an enormous economy and GDP does not come without pitfalls. Following the recession in the late 2000s, Chicago lost nearly 331,000 jobs, a 7% total decline in the metropolitan job market, since its peak in 2008.[1] Despite the significant drop in the job market during the recession, Chicago fared better than the majority of the other national metropolitan areas, showing considerable resiliency throughout the recession. In Q4 of 2015, Chicago has reached its pre-recession job peak which was in Q1 of 2008.[1]

Beyond the relatively quick recovery from the economic recession, Chicago's economy is showing tremendous growth. This growth has been primarily in the Loop and River North locations, both within Chicago's downtown business district. These locations have been hotspots for both tech start-ups and long established Fortune 500 companies relocating headquarters. This great influx of companies to the Chicago downtown area has helped stimulate significant employment opportunities which further fuels the downtown economy.

> *"The explosion of tech-related hiring on the Near North and West sides and corporate relocation such as Motorola Mobility and United Continental Withholdings from their suburbs suggest that this new economic engine has reached a critical mass, enabling its growth to become self-perpetuating."*
>
> *-Moody's – State of Illinois Economic Forecast*

One of the quickest growing markets in Chicago is the technology and start-up industry. Chicago's tech center has grown more than 30%, placing it at number three in national tech markets in 2013. This tech market not only generates billions of dollars in investments but also thousands of high-income jobs, with an average of $80,000 per year.[2] As a market driven by globally backed venture capitalist funding, it is an industry that promotes frequent national and worldwide travel.

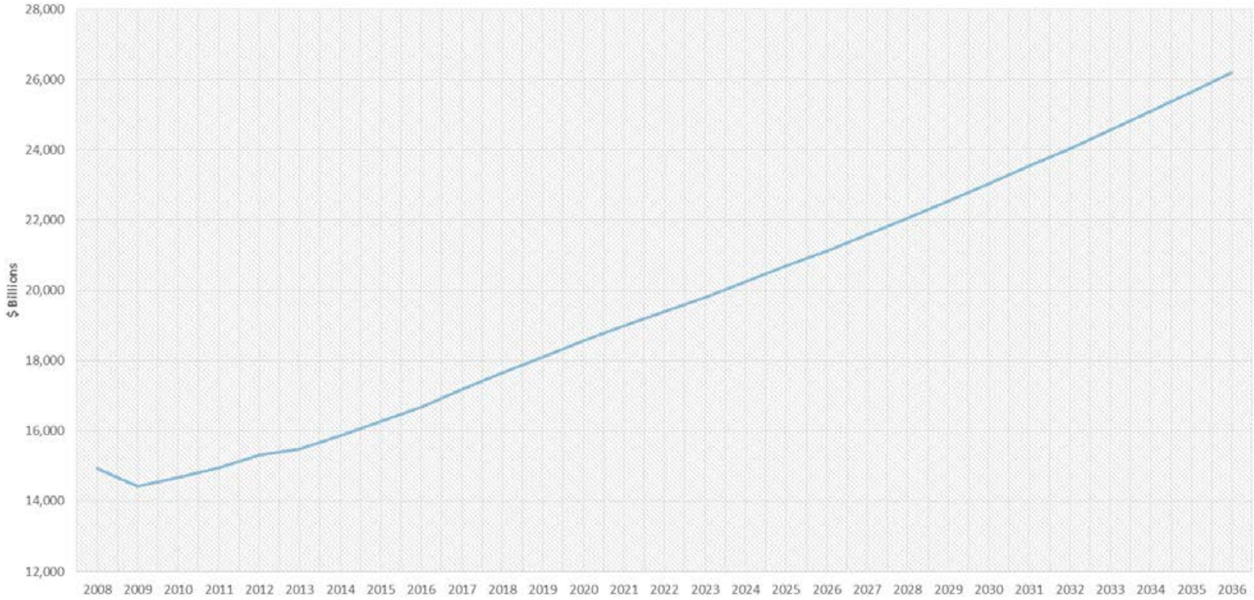
Often these technology start-ups are collocated in tech centers called incubators or accelerators. The largest 15 of these incubators, which house several start-ups in one location, are located in the downtown Loop or River North area.[2]

2.2 National Economy

As mentioned in the Chicago economic outlook, the U.S. national economy suffered a recession in the late 2000s. This recession resulted in millions of job losses and contraction of billions of dollars in GDP.

Despite this downturn from the recession, the national economy as a whole has rebounded and is showing positive signs. After a sharp decline of GDP in 2009, the national economy has grown at a Compound Annual Growth Rate (CAGR) of 2% through 2015. By 2036, the GDP will have grown at a CAGR of 2.3%.[4] Ultimately, this growth represents a stable economic economy, which provides a favorable indicator for the national aviation market.

Figure 2-1: United States Gross Domestic Product



FAA Aerospace Forecast (2016)

2.3 Global Economy

The United States was not the only economy to experience a recession. During the same period of time, Europe experienced a similar recession and the global economy GDP declined for the first time since the 1930s. While some of the European countries are still struggling to recover, the global economy as a whole has improved considerably. Through 2036, the global GDP is forecasted to grow at an average annual growth of 3%.[4]

The greatest growth in the global economy has been found in the emerging economies. In 2015, the two largest emerging economies, India and China, grew 7.5% and 6.8%, respectively.[4] These emerging markets are forecasted to continue growth above the average global rates. This is important because quickly growing emerging economies pose a significant beneficial impact to the aviation industry. Based on an Aviation Economic Benefit report published by the International Air Transportation Association [5], the relationship between economic connectivity and economic productivity is logarithmic, primarily in developing economies. This means that, as connectivity of a developing economy increases, the productivity of that economy grows exponentially in comparison to an already developed economy. When this is considered from the perspective that existing emerging economies are growing at such high rates, especially compared with the rest of the global economy, it would seem to indicate that the aviation connectivity is one of the primary contributors and/or resultants.

As the emerging economies continue to grow, it can be expected that the increase in connectivity and GDP will begin to influence the international aviation industry within the U.S. This will be necessary to facilitate business and trade with quickly growing emerging countries as their exporting capability and importing needs grow. As the top corporate reliever in the nation’s third largest city in the United States, CEA could be well positioned to facilitate the influx of quickly growing international business.

3.0 Trends and Industry Forecasts

In order to accurately forecast demand at an airport, there needs to be a quantifiable basis for generating the proposed growth rates. The basis of this forecast is founded upon two core components: industry trends and industry forecasts.

3.1 Trends

To develop the most representative trends, they should be as specific as possible. Since general aviation (GA) airports and aircraft serve such diverse roles within in the aviation industry, GA aircraft and airports have been further specified by aircraft classification and airport for this trend analysis. The trends found within this section have been established from 2011-2015 using the FAA's Traffic Flow Management System Counts (TFMSC) data.

Aircraft: General Aviation aircraft can range from small experimental aircraft to large corporate jets. To develop trends for aircraft that operate at CEA, the aircraft classifications in Table 3-1 have been established.

Table 3-1: Aircraft Classification

Aircraft Classification					
Propeller Engine	**Weight**	**Passengers**	**Range**	**Typical Model**	**Role**
Piston	< 12,500 lbs.	3	1,000 NM	Cessna 182	Recreational & Training
TurboProp	< 15,000 lbs.	12	1,500 NM	King Air 200	Regional Business
Jet Engine	**Weight**	**Passengers**	**Range**	**Typical Model**	**Role**
Light Jet	< 15,000 lbs.	6	1,500 NM	Embraer Phenom 100	Continental U.S. Business
Small Jet	15,001 - 40,000 lbs.	12	3,000 NM	Citation 680	Transcontinental Business
Medium Jet	40,001 - 70,000 lbs.	16	4,000 NM	Challenger 600	Intercontinental Business
Large Jet	> 70,000 lbs.	20	5,000 NM	Gulfstream 550	Global Business

CMT (2016)

The aircraft in Table 3-1 have been classified for two primary reasons. First, each category of aircraft has comparative operating characteristics such as weight, takeoff/landing requirements, and stage lengths. Second, as a function of the aircraft operating characteristics, each aircraft generally serves different user group needs. To accurately define the trends in such varying demand profiles, this forecast will consider growth rates of each aircraft classification separately.

Airports: Airports can also vary greatly within the General Aviation system. For this trend analysis, the Chicago Area corporate airports and top 25 relievers in the nation by Instrument Flight Rules (IFR) operations have been selected. These groups have been chosen because they are most representative of CEA's operational profile for the regional and national trends, respectively.

Table 3-2: Trend Analysis Airport Groups

Trend Analysis Airports		
Trend Group 1	**Trend Group 2**	**Trend Group 3**
Chicago Executive Airport	**Chicago Area Airports**	**Top 25 IFR Relievers**
CEA - Chicago	CEA - Chicago	CEA - Chicago
		TEB - Teterboro
		VNY - Van Nuys
		APA - Denver
		PDK - Atlanta
	MDW - Chicago	SDL - Scottsdale
		OPF - Miami
		FXE - Fort Lauderdale
		SUS - St Louis
		MMU - Morristown
	DPA - Chicago	ADS - Dallas
		MKC - Kansas City
		FTW - Fort Worth
		LUK - Cincinnati
		SMO - Santa Monica
	UGN - Chicago	SGR - Houston
		AGC - Pittsburgh
		DPA - Chicago
		ORL - Orlando
		YIP - Detroit
	GYY - Chicago	TMB - Miami
		ISM - Orlando
		HIO - Portland
		AFW - Fort Worth
		MYF - San Diego

TFMSC; CMT (2016)

Chicago Executive Trends (Trend Group 1)

Over the last 5 years, CEA has experienced a very moderate increase in total airport operations at a CAGR of .3% (TFMSC). This low growth in operations can be attributed to the sharp decline in piston aircraft operations with a CAGR of -3.6%.

Despite the downward trend in piston operations, CEA has seen a positive CAGR in turboprop (2.4%) and corporate jet aircraft (2%). The greatest growth in an individual classification has been in the large corporate jets at a CAGR of 5.2%.

These trends would indicate an increasing shift towards increased corporate presence at CEA through steady growth in both turboprop and jet aircraft. The decrease in piston operations would suggest a significant decrease in training and recreational activities.

Chicago Area Trends (Trend Group 2)

The Chicago area airports used for this analysis include Chicago Executive Airport (CEA), DuPage Airport (DPA), Waukegan Regional Airport (UGN), Gary International Airport (GYY), and Chicago Midway International Airport (MDW). These airports were identified because they represent the most comparable airport profile to CEA in regards to fleet mix and services offered within the Chicago area. It is important to note that while MDW is a commercial service airport and much larger than the other airports within this group, MDW is a frequent destination for general aviation traffic. To establish a more parallel comparison between MDW and the other corporate airports within this group, only General Aviation traffic was analyzed and all commercial service traffic was excluded from the study.

The operational trend of the Chicago area relievers shows a slightly negative CAGR of approximately -.4%. Similar to the trends at CEA, the aircraft classification with the greatest negative trend was the piston driven aircraft at -3.3%. Following the piston aircraft were the turboprop aircraft at -3.2%.

The Chicago area airport trend indicates similar growth rates in the light, small, and medium jet classification but showed a significantly higher growth in large jets compared to CEA. The large jet operations have grown 8.2% over the last 5 years in the Chicago area.

Top 25 IFR Reliever Trends (Trend Group 3)

Like the Chicago area airports, the top 25 IFR relievers were also selected for similarities to CEA in fleet mix and services provided. There are two important distinctions that make these airports ideal comparisons to CEA, including “IFR” ranking and “Reliever” status.

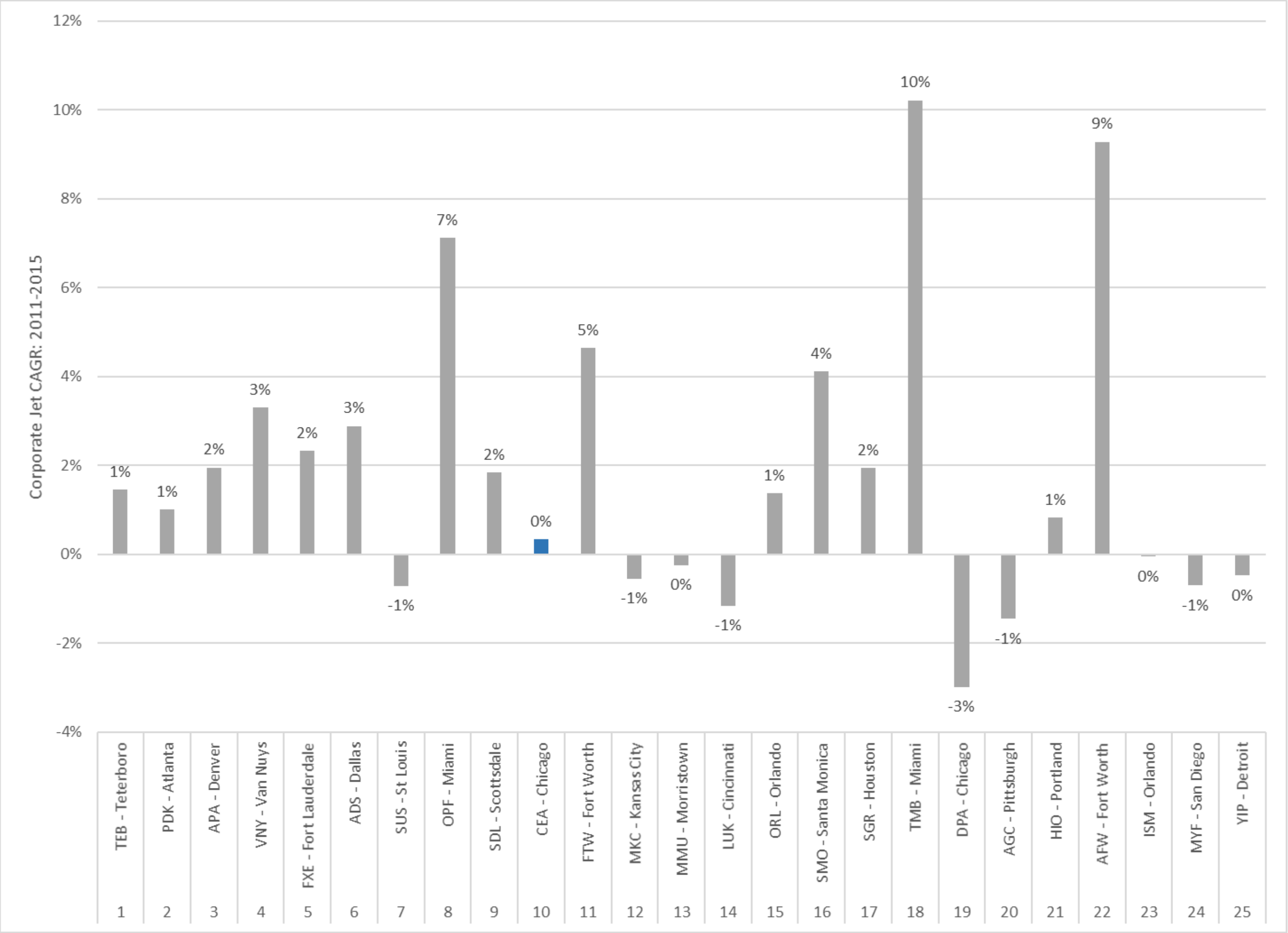
The IFR distinction is used because the majority of business and corporate-related traffic use IFR flight plans. With the majority of CEA’s traffic being comprised of corporate traffic, comparing CEA to other airports with high corporate-related traffic is most fitting.

The “Reliever” status distinction is based upon the National Plan of Integrated Airport Systems (NPIAS) classification of Reliever airports. According to NPIAS, relievers are “high-capacity general aviation airports in major metropolitan areas.” To gain the Reliever classification, an airport must have 100 or more based aircraft or 25,000 annual itinerant operations. CEA is considered a Reliever within the NPIAS system.

The top 25 relievers had an overall operation CAGR of 1.8%, showing a strong national growth relative to the Chicago area. When individual aircraft classifications are analyzed, each showed a positive growth.

Piston aircraft operations had higher growth rates than Chicago airports with a CAGR of 2% but a more comparable 1% for turboprops, and 4% for light jets. The large jet classification still maintains the highest growth at 7% among the top 25 IFR airports. Figure 3-1 shows the overall operational CAGRs between each of the top 25 IFR airports from 2011-2015, ranked by total operations.

Figure 3-1: Top 25 IFR Reliever Airports Ranking by CAGR



Source: TFMSC (2016)

Summary

The trend analysis between CEA, Chicago airports, and the national top 25 IFR airports provide an important insight into the operational trends from different levels of perspective. This insight allows for several observations to be made regarding why certain CEA trends may not be consistent with regional and/or national trends. Differences in trend groups are important assessments to better understand the individual influences that impact growth trends. The three main takeaways from this comparison include:

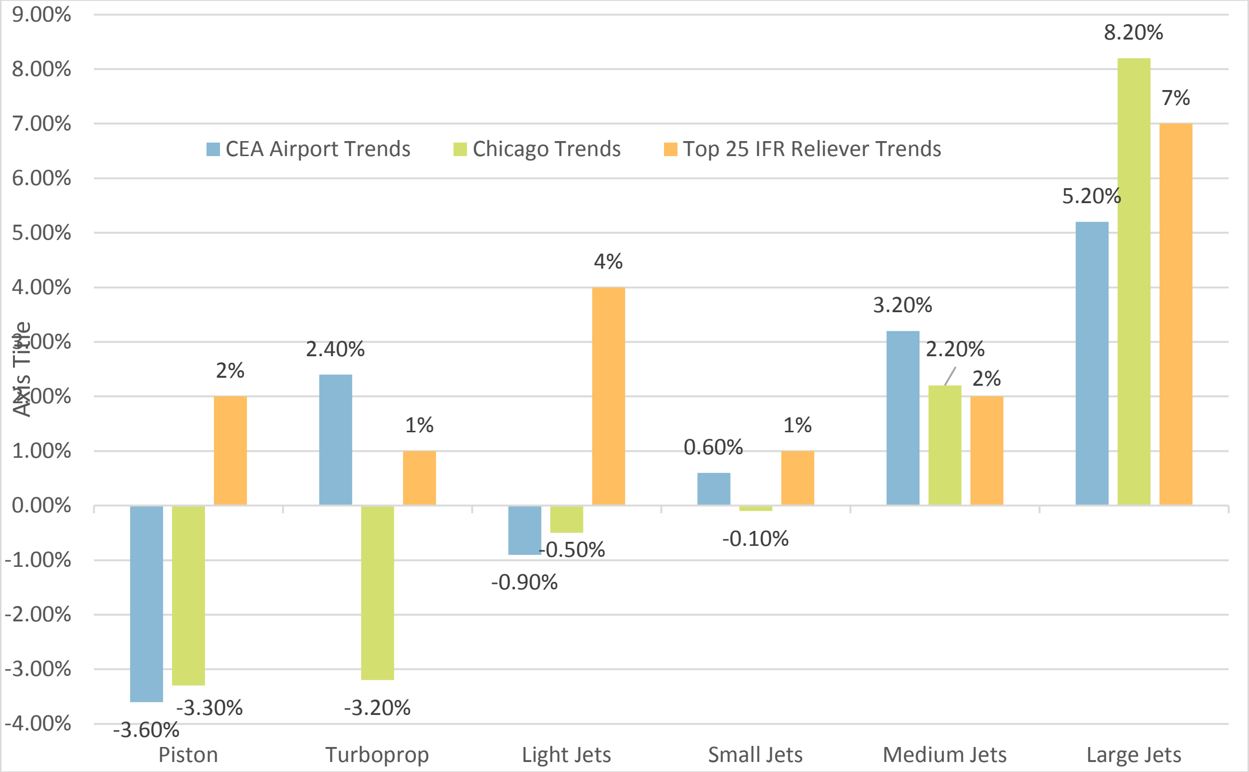
Piston Aircraft: For both CEA and the Chicago area airports, the trend in piston aircraft growth is approximately -3% compared to the top 25 IFR relievers at +2%. This would seem to indicate that regionally, piston aircraft operations are declining. While there are likely many causes of this, it may be due to the operational characteristics of piston aircraft as short stage-length, highly climate-influenced aircraft. With many of the top 25 IFR airports being located in moderate climates, it provides a much more accommodating environment for the smaller piston driven aircraft.

Turboprop Aircraft: In each trend profile, the turbo prop varies significantly. CEA shows a moderate growth of 2.4%, the Chicago area shows a considerable decline of -3.2%, and the national relievers show a slight growth of 1%. The disparity between CEA and the Chicago area airports indicates that CEA is capturing an increasing amount of the Turboprop growth. This is most likely due to two factors. First, CEA is in an ideal location for business related traffic of which turboprops are most commonly used for. The second factor is a combination of the location and the fleet mix. The only other airport that accommodates corporate operations within the same distance from downtown Chicago is Midway International Airport. Since the majority of MDW's traffic consists of large commercial service and corporate traffic, CEA is a much less demanding airport to operate out of for a small to midsize turboprop aircraft.

Large/Medium Jets: On both a regional and national level, large corporate jet aircraft are showing high operational GAGRs. CEA's large corporate jet CAGR is 5.3%, Chicago's is 8.3% and the top 25 IFR reliever's is 7%. This shows a consistent indication that large corporate jets operations are growing quickly on a large scale. Another consistent trend on a national level is the steady growth in medium jets. Each trend group shows a CAGR of 2-3% in medium corporate jet growth.

Despite the overall healthy growth in large corporate jets, CEA's large jet CAGR is 3% less than its peers in the Chicago area. With this difference in mind, it would be expected that the Top IFR reliever in Chicago would have a comparable large corporate jet growth to the average of the metropolitan area. Figure 3-2 presents the trend rate of each aircraft classification for each trend group.

Figure 3-2: Aircraft Operational Trends



TFMSC and TAF (2016)

3.2 Industry Forecasts

Aviation industry projections are helpful with identifying influences in the aviation industry by using industry metrics such as aircraft units shipped and hours flown. These metrics can provide general guidance regarding the future growth or decline of pertinent sections of the aviation market, including general aviation.

Industry forecasts chosen for reference in this forecast include the 2016 Federal Aviation Administration (FAA) Aerospace Forecast, the 2015 General Aviation Manufacturers Association (GAMA) Forecast[6], and the 2015 Bombardier Market Forecast[7]. Each of these forecasts provide some level of insight on the forecast of the general aviation industry and overall economy.

Another forecast that will be referenced throughout this document is the FAA's Terminal Area Forecast (TAF). This forecast is established by the FAA and it is used as the official forecast for determining future aviation demand at specific airports. The TAF will be used as a baseline establishment of existing aircraft operations and based aircraft within this forecast, as well as a benchmark for forecasted operations and based aircraft.

2016 Federal Aviation Administration (FAA) Forecast

The FAA releases an annual aerospace forecast that provides historical, existing, and future air traffic activity. This forecast is established from 2016 through 2036 and is based on the FAA's General Aviation and Part 135 Survey, as well as industry interviews. While the FAA forecast does provide general categories for the aircraft classification, it does not specify the jet size classifications used within this forecast. As such, the growth rate of the "Jet" category is applied evenly among each jet size for the purposes of consistent forecasting.

<u>Fleet Growth</u>: The FAA forecasts the overall fleet to grow at an average annual growth (AAG) of 2%. This growth is attributed to steady growth in turboprop aircraft at an average of 1.3% per year, and a strong growth rate in jet aircraft at an average of 2.5% per year. The Piston aircraft fleet is shown to decrease in size by an average of -.7% per year.

<u>Hours Flown</u>: The total hours flown are projected to grow at an average of 2.5% per year. Similar to the fleet forecast, this growth is primarily attributed to the turboprop and jet aircraft. The Turboprop hours flown are projected to grow at an average of 1.6% and the Jet hours flown will grow 3.1%. The FAA states that the increase in jet hours flown results from the increase in size, efficiency, and utilization of corporate jet aircraft.

General Aviation Manufacturers Association (GAMA) - 2015 General Aviation Statistical Databook and 2016 Industry Outlook

Every year, the GAMA develops a report that includes the historical shipments and billings of general aviation aircraft, as well as a forecast. The primary factors within this forecast are the same as the FAA forecast: fleet growth and hours flown. Also like the FAA forecast, all general aviation jets are grouped into one category, requiring the jet growth to be evenly applied to each jet classification in this forecast.

<u>Fleet Growth:</u> The GAMA forecast indicates that jets are projected to have the largest average annual growth among each category at approximately 2.8%. Following jets, turboprops are projected to have an AAG of 1.5% and piston aircraft will decline at -0.6%. The overall general aviation fleet are projected to have an AAG of 0.4% through 2035.

<u>Hours Flown:</u> The overall hours flown by 2035 are projected to increase by an AAG of 1.4%. Jets maintain the highest growth in hours flown at 3.6% AAG and turboprops as the second highest at 1.7% AAG. The piston aircraft are projected to continue to negatively trend at -.5% AAG.

2015 Bombardier Business Aircraft Market Forecast

The Bombardier forecast focuses on business jet growth through the year 2025. This forecast categorizes the business jets into three groups: small, medium, and large. Based on the types of aircraft noted within each group, the Bombardier small category aligns best with this forecast's "light" and "small" classifications. The medium and large groups in the bombardier group are similar to those identified in this forecast.

Fleet Growth: The light jets in the Bombardier forecast are projected to grow at an average annual rate of 2.4% and the medium jets have an average annual growth of 3.8%. The Large Jet category has the highest AAG at 9.6%. This forecast further states that the industry is transitioning to larger, longer stage length corporate aircraft which is the cause for the robust growth in forecasted large corporate jet fleet.

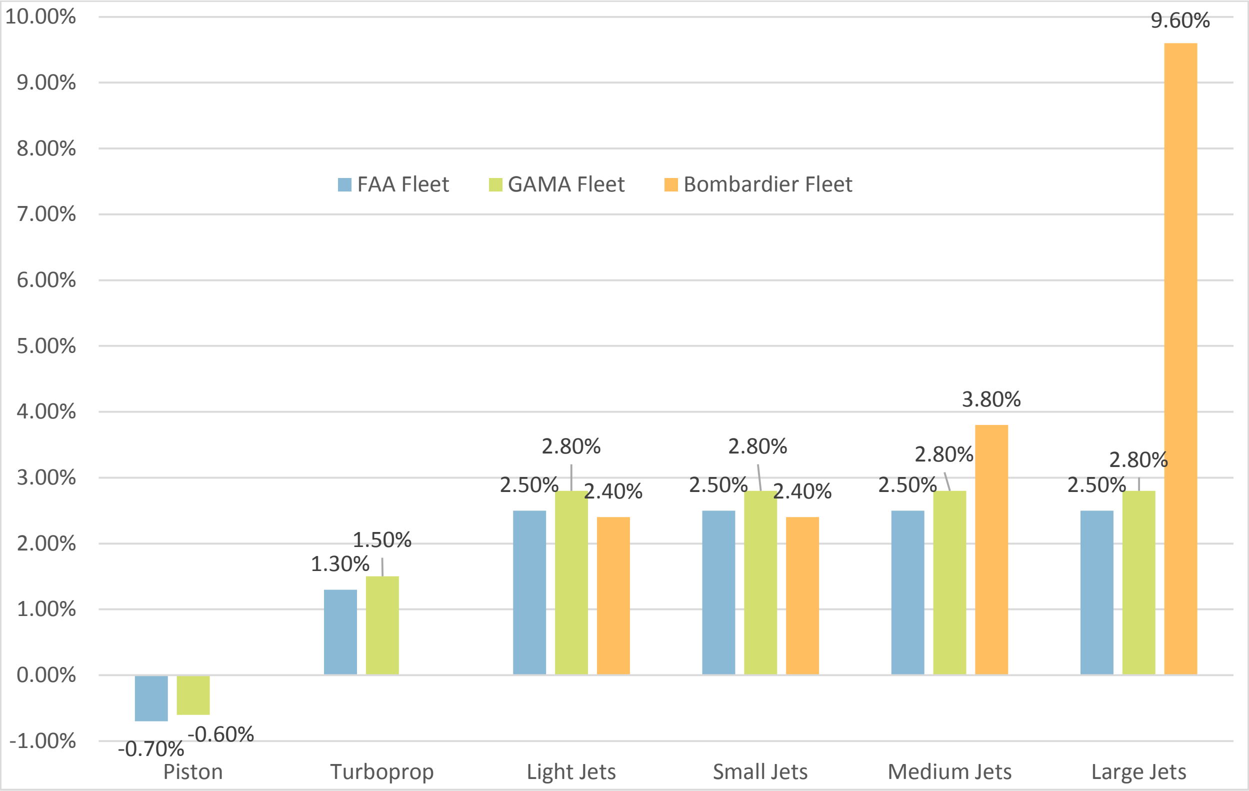
Summary

Between the projected growth rates in fleet growth and hours flown among each forecast, there are three primary takeaways regarding the future general aviation industry.

1) Steady and to marginal decline in piston aircraft
2) Moderate growth in Turboprop aircraft
3) High growth in business jets with an emphasis on growth in large, long stage length jets.

Figure 3-3 provides the industry fleet growth percentages for each aircraft classification.

Figure 3-3: Industry Forecast Growth by Aircraft Type



Source: FAA, GAMA, and Bombardier Forecasts (2015/2016)

4.0 Factors Affecting Demand

In addition to determining the constraints, trends, and industry forecasts, it is necessary to determine the factors affecting demand at an airport. With CEA's position as the top reliever in Chicago, there are a variety of potential factors that can influence the forecasted aviation demand. These factors range from large scale locational factors to specific facilities found at the airport. This section will investigate and substantiate a number of factors that will likely have some level of impact on the demand at CEA.

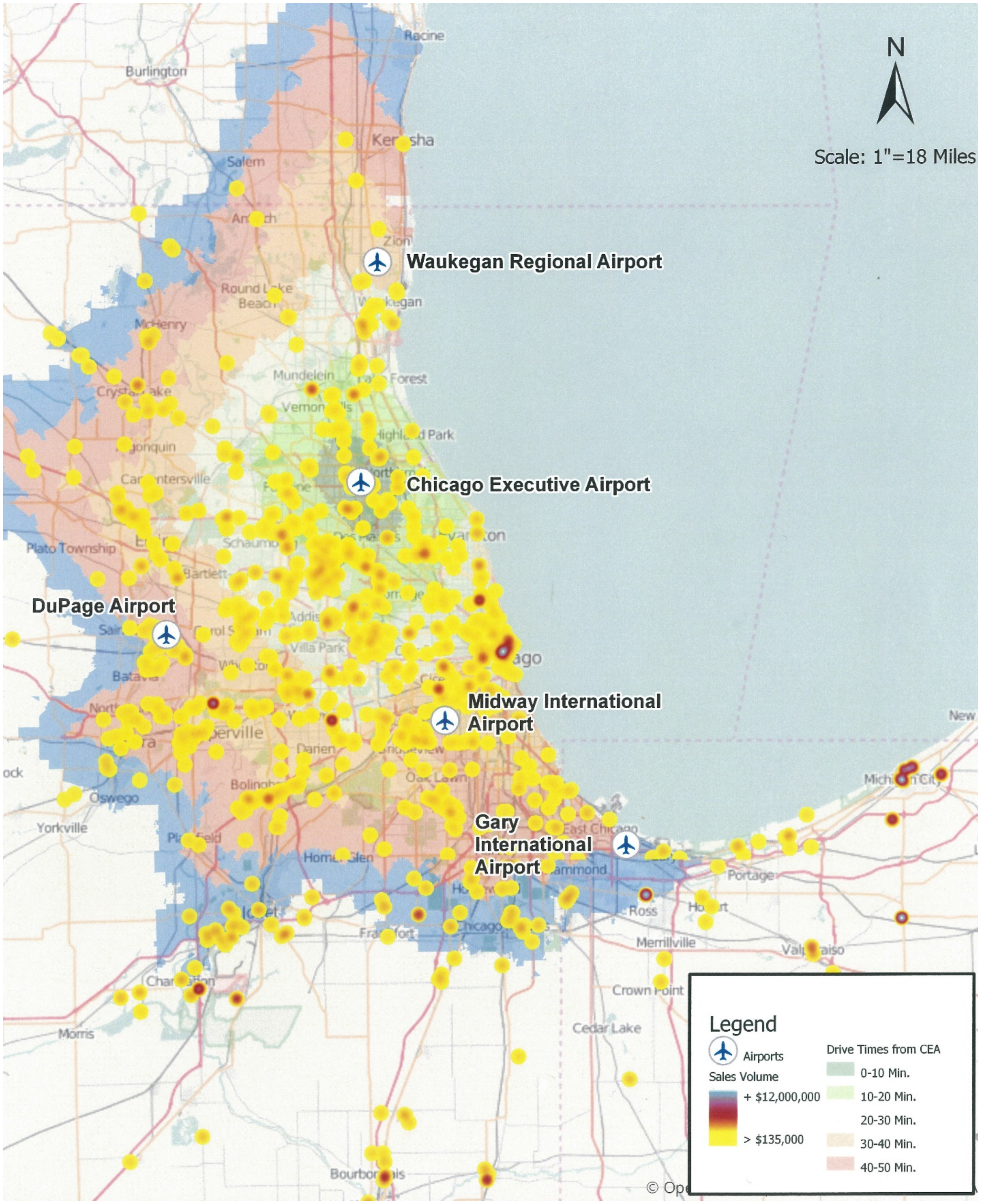
4.1 Location

Business Location

Location and convenience play enormous essential roles in selection by a customer in any transportation related industry. This is especially true for airports that serve corporate aviation users. Being Chicago's busiest reliever, CEA is ideally located for users traveling to the downtown business district or the corporate heavy northern suburbs. As previously mentioned in the economic outlook, the downtown economy is growing at an extraordinary rate due to corporate transitioning and the explosion of tech centers. With CEA's proximity to these core business and tech centers, CEA is optimally positioned to capture the large number of existing and future high stake entities within this area that utilize corporate aviation.

To quantify the benefit of CEA's location is to users within the core Chicago business and tech centers, an analysis was conducted to determine where the concentrations of business sales and average net income are located. These two variables are illustrative gauges of where corporate users work and live. **Exhibit 4-1** has integrated a hot spot analysis of the sales generated in the Chicago metropolitan area with a drive time analysis from CEA.

Exhibit 4-1: Business Sales Hot Spots

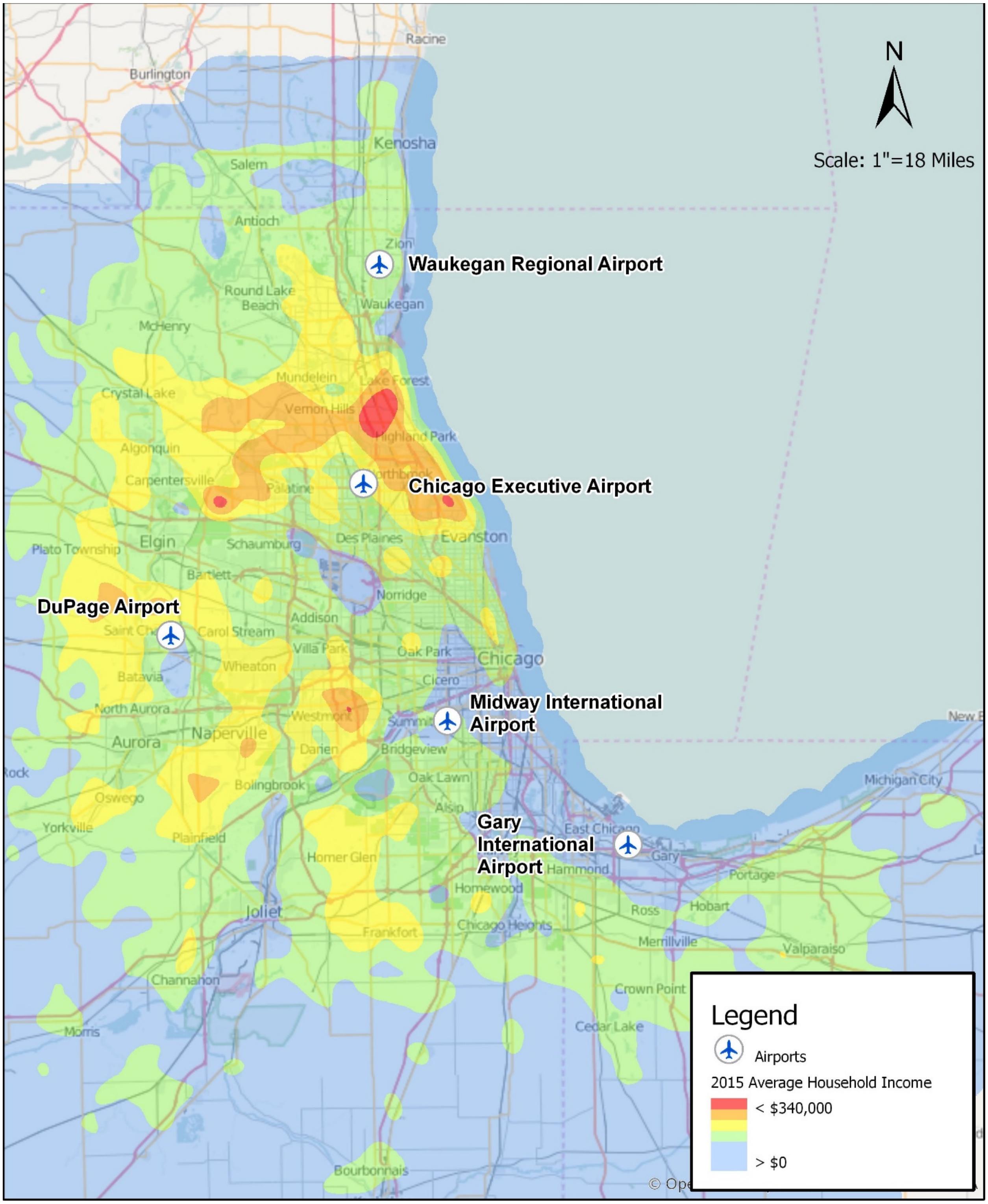


ESRI Business Analyst (2016)

Hot spot analyses are useful in determining the statistically significant clusters within a study area. While there is a distribution of clusters throughout the Chicago area, there is a core clustering in the downtown and north/northwestern suburbs of Chicago. Understanding that corporate users will prefer convenient travel to and from their business headquarters, this places CEA in an ideal location to capture this market.

Not only do corporate users find value in proximity to their place of business, but it is also important to have access to air travel from their place of living. One of the best ways to identify the locations where corporate users may live is to analyze the concentrations of net worth within the Chicago area. Net worth is a good representation because most corporate users are C-level executives and top management in corporations, which earn some of the highest incomes within a given area. Exhibit 4-2 depicts the average net income by half mile grid which shows that the highest concentration of net worth is in the north suburbs of Chicago.

Exhibit 4-2: Average Annual Net Income



Source: ESRI Business Analyst

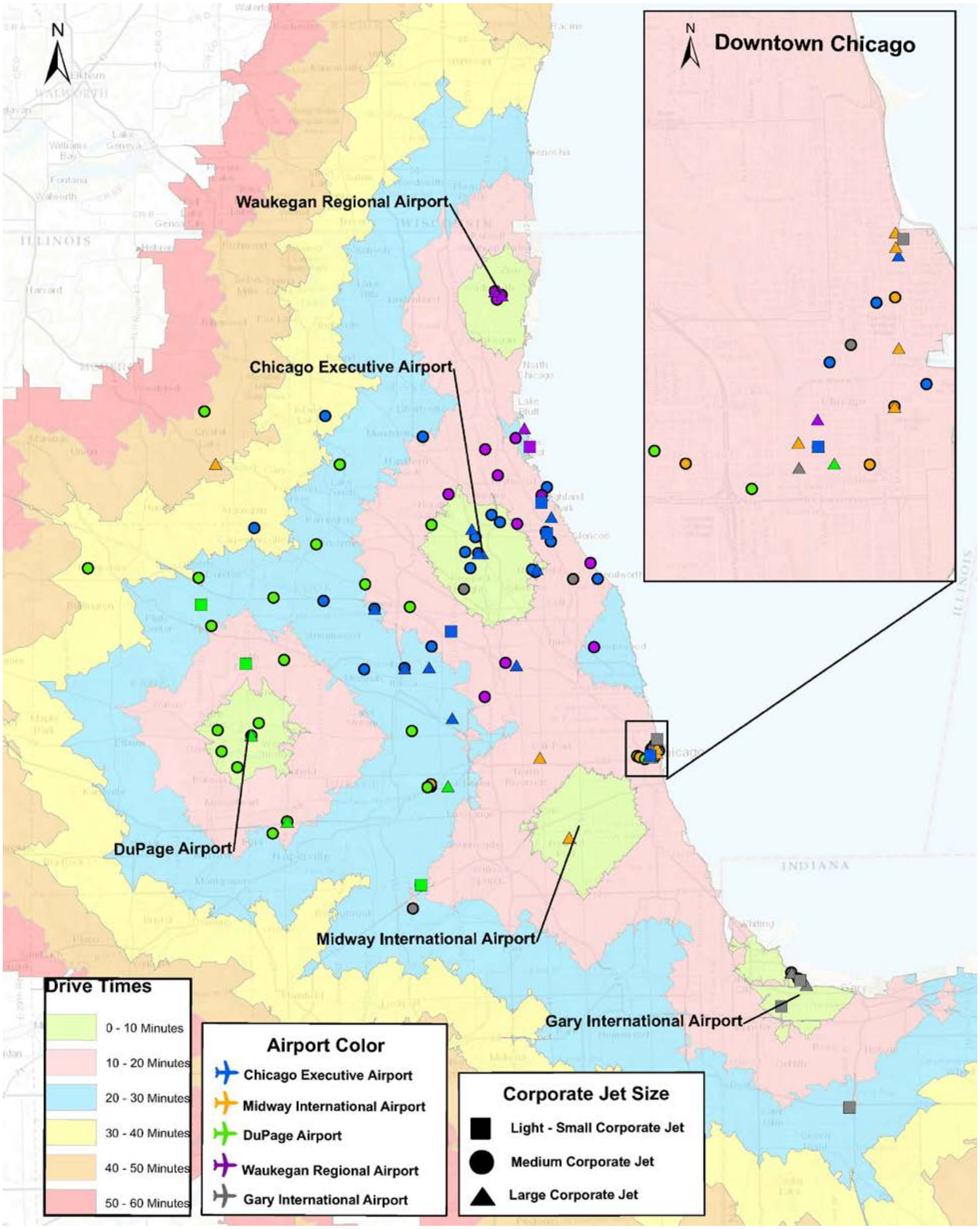
As identified throughout the survey and interview process, location and convenience are heavily weighted among the corporate aviation community. This analysis of high sales business centers and high net income communities shows that there are definite clusters where corporate aviation users are likely to be located. Due to its convenient location for businesses and high net worth individuals, CEA is well positioned to capture significant demand by corporate users.

Based Aircraft Locations:

Another method of defining the relationship between an airport's location and the corporate aviation community is to analyze the location of the existing based aircraft within the Chicago area. This analysis is completed by cross-referencing a known based aircraft's N-Number with the FAA's aircraft registry. The cross-reference provides all of the registration information associated with the aircraft, including the owner's address. These addresses were then applied to a drive-time analysis to the five main corporate airports within the Chicago metropolitan area. Applying the drive time analysis provides insight on a corporate user's emphasis on convenience and efficiency in locating their aircraft relative to their corporate address.

It is important to note, however that not every Chicago-based aircraft has a registered aircraft within Chicago. Approximately one third of the based aircraft are registered in another state which reduces the sample size for analysis. Each of the addresses that are located in Chicago can be found in Exhibit 4-3.

Exhibit 4-3: Corporate Locations with Chicago Based Aircraft



Source: FAA Aircraft Registry, PASSUR, CMT (2015)

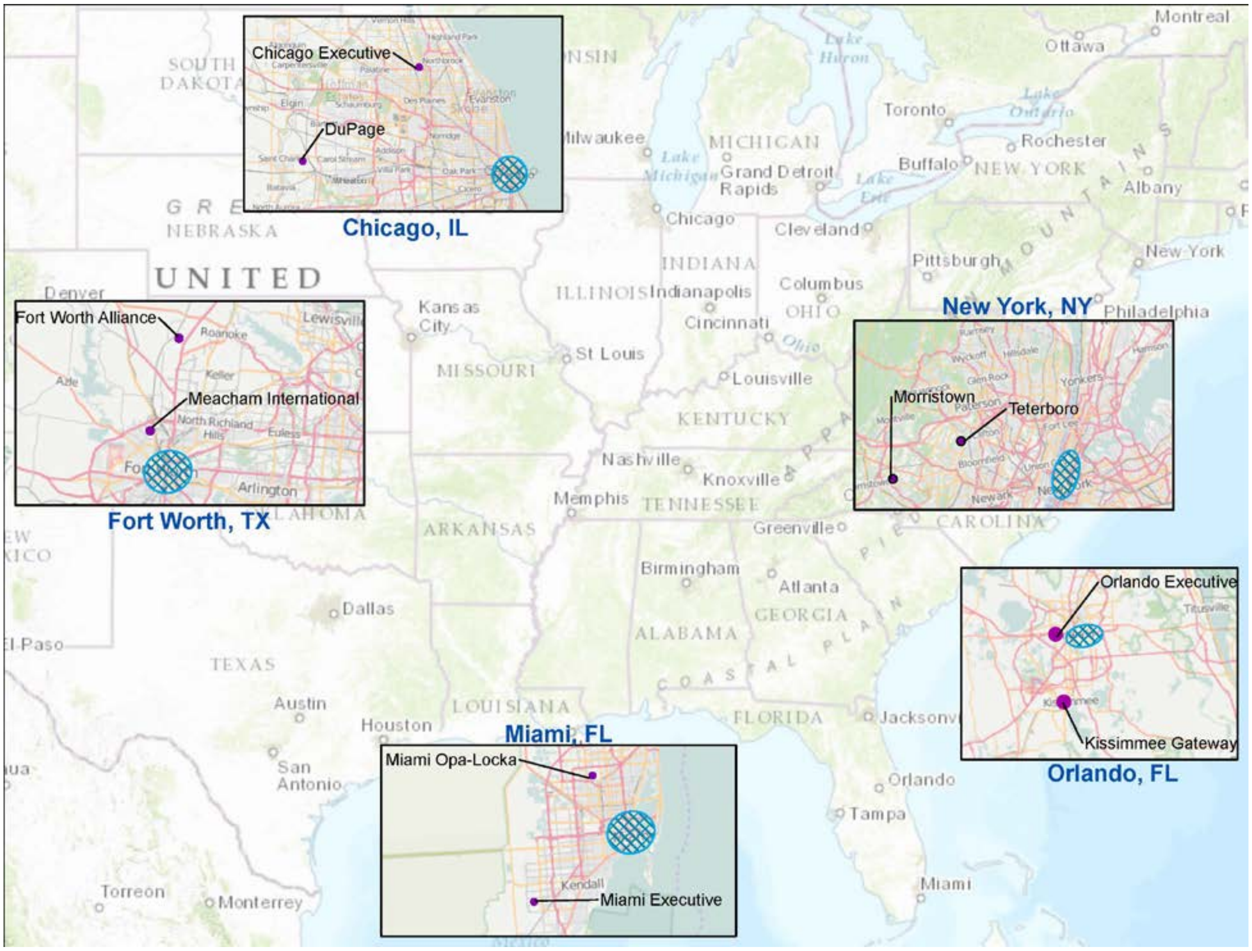
Exhibit 4-3 shows that there is a correlation between a company's physical address and the airport chosen for basing corporate aircraft operations. Distinct clusters of corporate addresses surround the airport in which their aircraft is based.

Despite this general correlation, there are a number of corporate users that are located within closer proximity to CEA but have their based aircraft at a competing airport. This is particularly evident with aircraft based at DPA and UGN. Excluding the aircraft located downtown, there are approximately 3 DPA aircraft and 11 UGN aircraft that are located within a closer drive time to CEA yet based further away. All of these aircraft are medium or large aircraft, which may support the concerns voiced in the user surveys and interviews related to constraints at CEA. Another noteworthy observation is that there are no CEA aircraft that have corporate addresses within a closer drive time to a competing airport (excluding downtown).

City Case Studies – Locational Analysis

A reoccurring factor for demand within this forecast is the relationship between an airport's location and a city's central business district. In an attempt to further refine this relationship, five case study cities were chosen for analysis. Each of these five cities were chosen because they host two out of the top 25 IFR reliever airports identified in Section 3. This creates a uniquely similar comparison to Chicago, which also hosts two of the top 25 IFR relievers: CEA and DPA. Exhibit 4-4 depicts each of these five case study cities and the location of their top two corporate reliever airports in relation to the central business district.

Exhibit 4-4: Case Studies Cities



Source: CMT (2016)

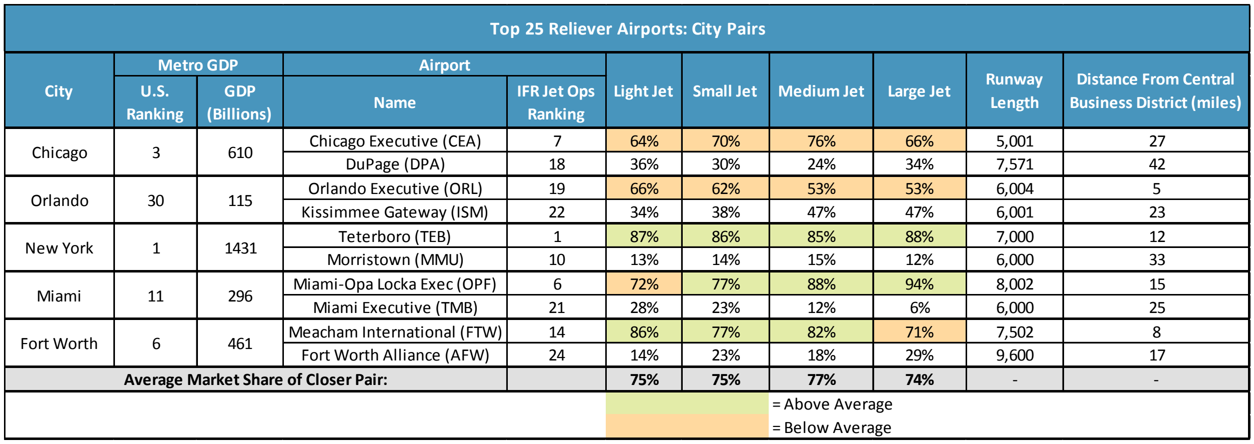
The IFR operations at each of the above airports were analyzed, as well as number of highway miles each airport is from the central business district. In all five of the case study cities, there is a correlation between the proximity of the reliever airport to the central business district and number of corporate jet operations. This correlation shows that the closest reliever airport captures the majority of the corporate jet traffic.

The locational connection between airport and central business district is most apparent when considering medium and large corporate jet operations. In New York, Miami, and Fort Worth, three-quarters or more of the medium and large jet operations operate at the reliever airport closest to the central business district.

In Orlando and Chicago, there is a substantially lower average of corporate jet operations at the airport closest to the central business district. In Chicago, this lower proportional average may be due to the constraints identified in the surveys and interviews. In Orlando, the lower proportional average of corporate jet traffic may be due to two factors. First, Kissimmee

Gateway's (ISM) proximity to Disney World and the other vacation attractions south of Orlando may draw a large percentage of Orlando's jet traffic. Second, Orlando has a relatively small GDP compared to the GDP of the other case study cities which generates less overall corporate activity.

Table 4-1: Top 25 IFR Reliever Airports Comparison



Top 25 Reliever Airports: City Pairs

City	Metro GDP		Airport		Light Jet	Small Jet	Medium Jet	Large Jet	Runway Length	Distance From Central Business District (miles)
	U.S. Ranking	GDP (Billions)	Name	IFR Jet Ops Ranking						
Chicago	3	610	Chicago Executive (CEA)	7	64%	70%	76%	66%	5,001	27
			DuPage (DPA)	18	36%	30%	24%	34%	7,571	42
Orlando	30	115	Orlando Executive (ORL)	19	66%	62%	53%	53%	6,004	5
			Kissimmee Gateway (ISM)	22	34%	38%	47%	47%	6,001	23
New York	1	1431	Teterboro (TEB)	1	87%	86%	85%	88%	7,000	12
			Morristown (MMU)	10	13%	14%	15%	12%	6,000	33
Miami	11	296	Miami-Opa Locka Exec (OPF)	6	72%	77%	88%	94%	8,002	15
			Miami Executive (TMB)	21	28%	23%	12%	6%	6,000	25
Fort Worth	6	461	Meacham International (FTW)	14	86%	77%	82%	71%	7,502	8
			Fort Worth Alliance (AFW)	24	14%	23%	18%	29%	9,600	17
Average Market Share of Closer Pair:					**75%**	**75%**	**77%**	**74%**	-	-

🟩 = Above Average

🟧 = Below Average

Source TFMSC (2015)

4.2 Fixed Base Operator Influence

When owning or operating a multi-million dollar business asset that is a business jet, corporate users expect the highest class in services to accompany their travel. This means that corporate aviation users place significant value on the number, type, and quality of services that are provided at an airport. One of the best representations of the quality and number of services provided at an airport includes the Fixed Base Operator(s) (FBO).

Chicago Executive Airport is home to three state of the art fixed based operators. These FBOs include Atlantic Aviation, Signature Aviation, and Hawthorne Aviation. Each is a full service FBO that provides a number of services, including but not limited to:

- Maintenance and Inspection
- Fueling
- Aircraft Hangars
- Air Charter
- Aircraft Detailing
- Flight Planning and Lounge Facilities
- Local Transport/Rental Cars

The corporate aviation community places heavy emphasis on the availability and convenience to stay within a specific FBO chain to maintain their flight experience and simplicity in securing aviation services. For example, if a corporate user flies of out of Teterboro (TEB) and frequently uses Signature Aviation at their base airport, the user is more likely to select an airport in the destination city with a Signature Aviation location. This is further promoted by the individual FBOs with their incentive-based membership programs that promote recurring customers across their network of locations.

Having three well established FBOs opens increased opportunity for user loyalty capture. Out of all the corporate airports in Chicago, CEA has the largest globally-extended network. Not only does this increase potential user capture, but it also represents the FBO's confidence to have selected and maintained a location at CEA. For comparison, **Table 4-2** represents the primary corporate relievers and the FBOs based at each corporate reliever airport within the Chicago area.

Table 4-2: Chicago Fixed Base Operator Networks

Fixed Base Operator Networks			
Airport	**Total FBOs**	**FBO Network**	**Location Extents**
Chicago Executive Airport	3	171+	Global
Midway International Airport	2	165+	Global
Waukegan Airport	1	100+	Global
DuPage Airport	1	23	National
Gary International Airport	2	2	Airport Only

Source: FBO Websites

4.3 Contaminated Runway Landing Considerations

There have been several regulations and advisory documents established over the last few decades to enhance operational safety of turbine powered aircraft during takeoff and landing operations. The majority of these regulations and/or publications are related to landing operating procedures on a contaminated runway (wet, snow, or icy pavements). Contaminated runways present a higher probability of aircraft overruns because there is impaired effectiveness of aircraft breaking action on a contaminated surface. Due to the relationship between aircraft weight, breaking action, and landing distance/performance, the contaminated runway length regulations apply to turbine aircraft. Recognizing that many of CEA users operate turbine aircraft, operations by corporate jets are severely impacted when contaminated runway conditions are present.

<u>Regulation – 14 CFR 135.385 and 121.195</u>: The fundamental regulation that impacts operators during contaminated runway conditions are 14 CFR 135.385 and 121.195. These regulations specifically apply to fractional and charter ("for hire") operators. The regulation, also known throughout the industry as "factored" runway lengths, does not allow the aircraft to *depart* if the following conditions do not exist for landing at the <u>destination</u> airport:

1) In dry conditions, the airplane must be able to land within 60% of the usable runway
2) In wet conditions, landing usable runway must be at least 115% the length of the "factored" dry runway length.

When applied at CEA, the runway length available for dry landing is approximately 3,000' (5,000*0.6) and 2,610' (3,000/1.15) for a wet landing. Landing corporate jet aircraft in less than 3,000 feet places significant restrictions on "for hire" operator's choice to use or base at CEA.

Advisory Circulars (AC) and Safety Alerts for Operators (SAFO): In addition to the regulatory requirements, there are several guidance documents the FAA has published that prescribe additional landing restrictions and considerations for turbine aircraft operators. The following includes a summary of each of these documents.

- SAFO 06012 (2006): This SAFO recommends that flight crews assess conditions at time of arrival. Once the landing calculation is made with existing conditions, add at least a 15% safety margin to the "actual" landing distance.

- Advisory Circular 91-79A (2014): This AC is a revision of the 2007 AC 91-79. Both ACs provide enhanced guidance on developing Standard Operating Procedures (SOPs) for turbine aircraft to prevent overruns on runways. This incorporates additional restrictions based on runway conditions.

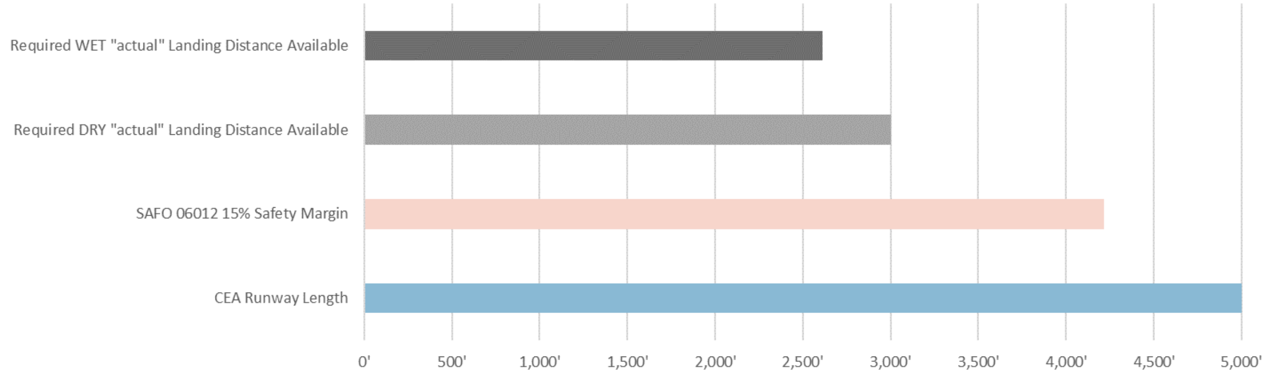
- Advisory Circular 25-32 (2015): This AC focuses on developing more accurate and standardized methods of establishing the landing performance at the time of arrival. A significant portion of this AC involves clarification on contaminated runway nomenclature.

- SAFO 15009 (2015): The SAFO strongly recommends that directors of flight operations take the appropriate action to address safety concerns on wet runways. This includes the notion that the 15% safety margin from SAFO 06012 may not be sufficient.

Each of the advisory documents summarized above encourage turbine powered operators to incorporate some level of additional landing restrictions into their SOPs during contaminated runway conditions. Whether this is 15% or more than 15% depend on the actual operator and their SOP. Regardless, there is immense pressure for turbine aircraft operators to restrict operations on constrained runways during contaminated runway conditions.

Figure 4-1 represents the effect of the Code of Federal Regulations ("factored lengths") and SAFO 06012 (15% safety margin) on CEA's runway length of 5,001' during contaminated runway conditions. It does not take into consideration any additional restrictions an operator may have initiated into their SOP for compliance with the remaining ACs and SAFOs.

Figure 4-1: Contaminated Runway Landing Distance Considerations



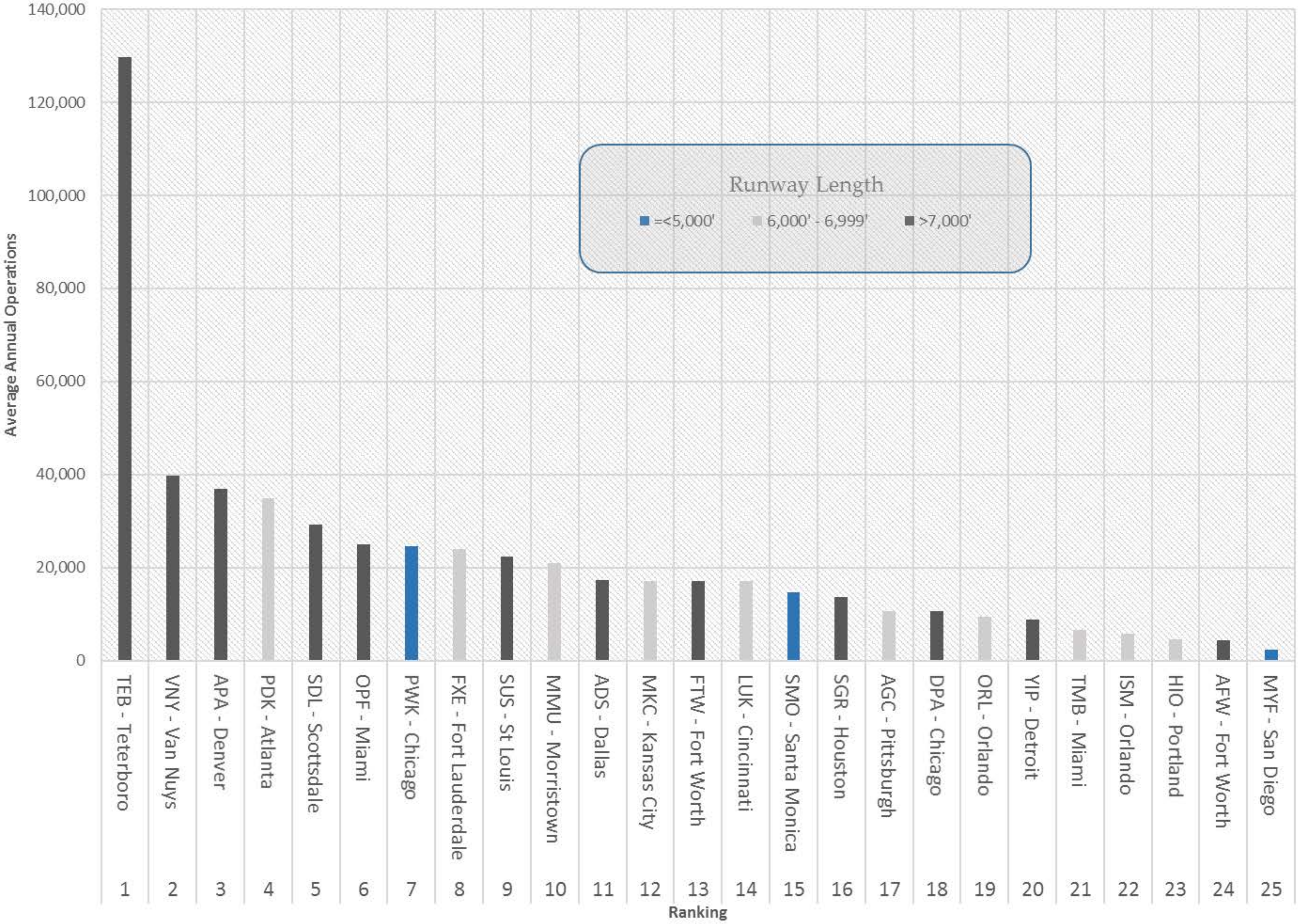
Source: FAA, CMT (2016)

4.4 Reliever Runway Length Comparison

As discussed previously in this report, the top 25 IFR relievers are relatively homogenous in terms of airport operations and fleet mix. Despite the operational similarities, it has been established that CEA is considered constrained by corporate users relative to the other relievers within the nation. To better understand the primary identified constraint, runway length, an analysis has been conducted to better understand what relationships exist between primary runway length and the Top 25 IFR relievers.

Figure 4-2 depicts the ranking of the top IFR relievers by total corporate jet operations. It further identifies which airports among the top 25 IFR airports have less than 5,000' of runway. Out of the 25 airports, only 3 have 5,000' or less of runway length. These three airports include CEA, Santa Monica Municipal Airport (SMO), and San Diego Montgomery Field Airport (MYF).

Figure 4-2: Top 25 IFR Reliever Airports by Average Corporate Jet Operations



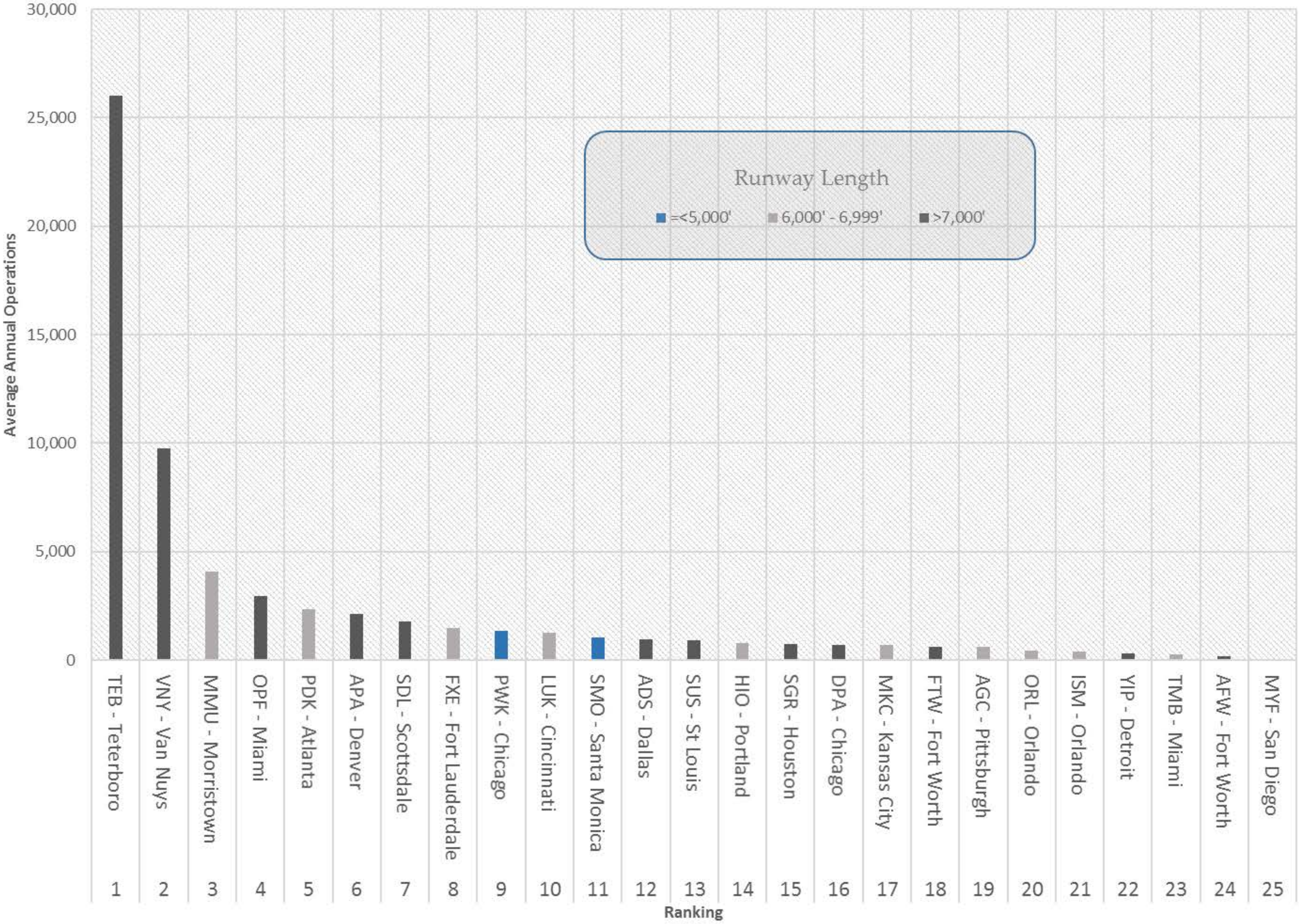
Source: TFMSC, Airnav, CMT (2016)

To further refine the effect of runway length, only large jets were analyzed to determine if there was a disproportionate impact on use for these aircraft. Figure 4-3 displays the average annual large aircraft operations by airport. MYF, one of the three airports with less than 5,000’ of runway, has had zero large jet operations over the last 5 years. Although both CEA and SMO retain their relative rankings, there remains a clear distinction that the airports with less than 5,000’ are anomalies in the realm of corporate relievers.

Ultimately, this reliever analysis provides insight into the relation between primary runway lengths and the most utilized corporate reliever airports in the country. The low number of top

25 relievers with 5,000′ of runway or less corroborates the notion in the interviews and surveys that CEA's runway is constrained for its status as the top corporate reliever in a major metropolitan area.

Figure 4-3: Top 25 IFR Reliever Airports by Average Large Corporate Jet Operations



Source: TFMSC (2015)

5.0 Fleet Mix & Critical Aircraft

A major theme in this forecast is identifying trends between different classifications of aircraft. These classifications, established in Section 3, provide insight into how the airport is being used and how to appropriately accommodate each classification. This section helps define the critical aircraft and fleet mix at CEA.

5.1 Fleet Mix

An analysis of TFMSC data from 2011-2015 was conducted to determine the average percentage of operations at CEA by each aircraft classification established in Section 3. Once the average percentages of each aircraft classification were determined, they were applied to the total operational count established in the TAF. The intention of this was to produce the most consistent fleet mix with the TAF that allocated the appropriate number of operations to each aircraft classification. The ultimate operational distribution per classification can be shown in Table 5-1.

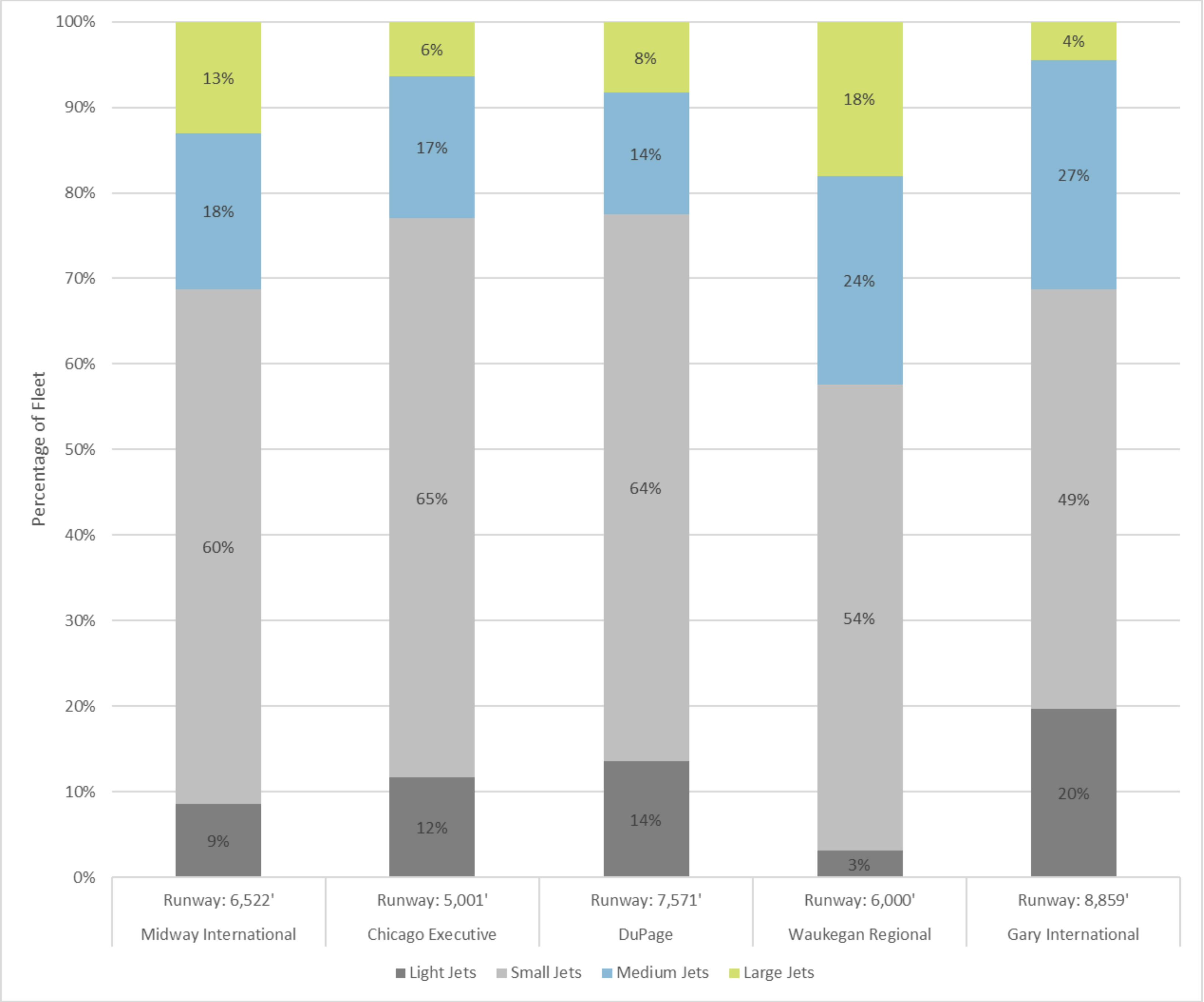
Table 5-1: CEA Fleet Mix

Aircraft Type	Propeller		Jet			
Aircraft Classification	**Piston**	**TurboProp**	**Light Jet**	**Small Jet**	**Medium Jet**	**Large Jet**
2015 Operations	15,572	9,614	6,401	34,423	7,726	2,861
% of Fleet	20%	13%	8%	45%	10%	4%
	33%		67%			

Source: TFMSC & TAF (2015)

While the majority of CEA's fleet mix consists of jet traffic at 67%, the number of medium and large jets have relatively small proportions. To some extent, this disproportion is the result of the high number of small corporate jets in the aviation system. However, to compare CEA's proportions of corporate jet sizes, an analysis was performed to identify the fleet mix of other corporate airports in the Chicago area. Figure 5-1 depicts the comparison between the Chicago corporate airport's operations proportionated by corporate jet classification.

Figure 5-1: Chicago Corporate Airports - 2015 Operations by Business Jet



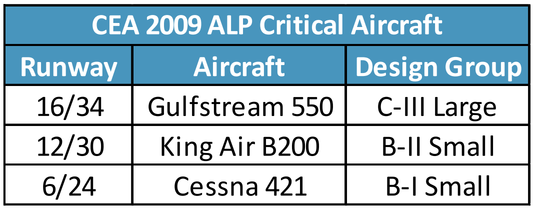
Source: TFMSC (2015)

Out of the four other Chicago airports within this analysis, the average percentage of combined large and medium corporate aircraft is 32%. In comparison, CEA's percentage of medium and large corporate jet operations is a mere 23%. This disparity between CEA and the other Chicago area corporate airports may indicate that CEA is losing a number of medium and large corporate jet operations to the competing Chicago airports due to the aforementioned constraints.

5.2 Existing Critical Aircraft

The critical aircraft is defined by the FAA as the most demanding aircraft that has over 500 annual itinerant operations at an airport.[6] Table 5-2 contains the critical aircraft established in CEA's 2009 ALP by runway.

Table 5-2: 2009 Airport Layout Plan – Critical Aircraft



CEA 2009 ALP Critical Aircraft		
Runway	**Aircraft**	**Design Group**
16/34	Gulfstream 550	C-III Large
12/30	King Air B200	B-II Small
6/24	Cessna 421	B-I Small

Source: CEA 2009 ALP

To determine if the critical aircraft has changed since the 2009 ALP, an analysis of PASSUR IFR data was conducted. PASSUR IFR Data allows for analysis of aircraft movement specific to each runway.

Runway 16/34: As the primary runway, 16/34 has the most operations. The most demanding aircraft that utilizes Runway 16/34 with over 500 annual itinerant operations is the Gulfstream 550. In 2015, the Gulfstream 550 had a total of 546 operations, meeting the requirement of the critical aircraft (Design Group: C-III).

Runway 12/30: From an initial analysis of the data, there appears to be enough B-II large aircraft operations to change the critical aircraft from what is shown on the ALP. Since the existing critical aircraft is a B-II small aircraft, this would have several effects on the airfield and surfaces. The potential of changing the critical aircraft from a B-II small to a B-II large aircraft will be further evaluated in the Facility Requirements section.

Runway 6/24: The utilization of Runway 6/24 is relatively infrequent compared to the other runways at CEA. The majority of the aircraft operating on Runway 6/24 are B-I Small aircraft and smaller. The critical aircraft is recommended to remain a Cessna 421.

6.0 Forecast

When forecasting activity at general aviation airports, based aircraft and operations are the common metrics to best represent overall demand for facility needs. As previously presented, prior to any forecasting effort, it is critical to understand market dynamics which will influence the individual facility demand due to their interconnectivity. It is also important to complete a comparative analysis of similar facilities to understand commonalities and uniqueness that will influence demand at CEA. Lastly, it is important to select the most applicable industry forecasts and trends to accurately define growth scenarios for the two forecast components. This forecasts integrates each of the previously described trends and industry forecasts, and applies the various factors that affect demand to establish the most realistic forecast for CEA.

The FAA prescribes a forecasting process to represent unconstrained demand (i.e. demand independent of individual airport constraints). As it was noted through the user survey process that many users operate in a constrained fashion at CEA or choose other airports in the area due to constraints at CEA, it is relevant to also prepare a demand forecast assuming the current constraints exist in a future condition. In addition to the constrained forecast, there will also be projections to factor in a potential unconstrained scenario. While unconstrained facilities will be determined in a later phase of this Master Plan, this forecast will also include projections to consider an unconstrained scenario at CEA.

6.1 Forecasting Method

In order to create a consistent quantitative-based forecast, a procedural method was developed for both the based aircraft and operations forecast. The following steps outline how each growth rate for each aircraft classification was determined.

Step 1 – Industry Forecasts/Trends: Establish the growth rates in the industry forecasts and industry trends for each aircraft classification

Step 2 – Forecast Mix: Develop a forecast range by utilizing the lowest, average, and highest industry forecast/trends and apply them to a low, medium, and high CEA forecast, respectively.

Step 3a – Constrained Growth Rates: Apply the Constrained Scenario factor multipliers to each of the forecast ranges.

Step 3b – Unconstrained Growth Rates: Apply the Unconstrained Scenario factor multipliers to each of the forecast ranges

Step 4 – Forecast Development: Apply the growth rates to the existing based aircraft/operations mix proportionated from the 2015 TAF records.

Step 5 (Operations forecast only) - Operations per Based Aircraft: Apply the operations per based aircraft that are defined in the following subsection "Operations Per Based Aircraft"

Forecast Multipliers

The multipliers applied to steps 3a and 3b in the method above are intended to account for operators' decisions in both the constrained and unconstrained scenarios. The multipliers differ for both the based aircraft and operations forecasts because the separate forecasts involve different considerations by the operator.

As an operator deciding to base an aircraft at an airport, there is more that goes into the decision than choosing to operate out of CEA from another based location. In an effort to accurately represent the magnitude of these decisions, the multipliers vary depending on the forecast type, growth scenario, and aircraft classification.

Each multiplier is approximately derived from survey and interview responses, corresponding to the approximate percentage of participant responses. There is additional consideration that incorporates the factors for demand within the rationale. The specific multiplier values and rationales with reference to surveys are provided in Table 6-1.

Table 6-1: Forecast Multipliers

Based Aircraft Forecast Multipliers - Constrained Scenario				
Aircraft Classification	Multiplier	Rationale	Survey Question Reference	
			MP Phase 1	MP Phase 2
Piston	1.25	Ideal Location/Services; Less Influence on Piston	5a	-
Turboprop	1.3	Ideal Location/Services	5a	3
Light Jet	1.3	Ideal Location/Services	5a	3
Small Jet	1.3	Ideal Location/Services	5a	3
Medium Jet	1	Constraints Negate the Ideal Location/Services for Unchanged Trend	1, 3, 5a, 7	3, 5 -17
Large Jet	0.5	Constraints Impact - Runway Takeoff, Stage Length, and Wet Runway Landing	1, 3, 5a, 7	3, 5 -17
*Question 5a relates to basing aircraft				

Based Aircraft Forecast Multipliers - Unconstrained Scenario				
Aircraft Classification	Multiplier	Rationale	Survey Question Reference	
			MP Phase 1	MP Phase 2
Piston	0.75	Mitigates the declining (-%) industry to adjust for the ideal location	5a	-
Turboprop	1.3	Ideal Location/Services	5a	3
Light Jet	1.3	Ideal Location/Services	5a	3
Small Jet	1.3	Ideal Location/Services	5a	3
Medium Jet	1.3	Ideal Location/Services; Influx of Previously Uncaptured Market	1,5a	3
Large Jet	1.3	Ideal Location/Services; Influx of Previously Uncaptured Market	1, 5a	3
*Question 5a relates to basing aircraft				

Operations Forecast Multipliers - Constrained Scenario				
Aircraft Classification	Multiplier	Rationale	Survey Question Reference	
			MP Phase 1	MP Phase 2
Piston	1	Operations Continue as Existing; Unconstrained	-	-
Turboprop	1	Operations Continue as Existing; Unconstrained	-	-
Light Jet	1	Operations Continue as Existing; Unconstrained	-	-
Small Jet	1	Operations Continue as Existing; Unconstrained	-	-
Medium Jet	0.3	Constraints Impact - Runway Takeoff, Stage Length, and Wet Runway Landing	1, 3, 5b, 7	3, 5-11, 14-17
Large Jet	0.25	Constraints Impact - Runway Takeoff, Stage Length, and Wet Runway Landing	1, 3, 5b, 7	3, 5-11, 14-17
*Question 5b relates to operating aircraft				

Operations Forecast Multipliers - Unconstrained Scenario				
Aircraft Classification	Multiplier	Rationale	Survey Question Reference	
			MP Phase 1	MP Phase 2
Piston	0.25	Increase of Unconstrained Jet Aircraft Ops Deter Small Piston Ops	5b	-
Turboprop	0.85	Increase of Unconstrained Jet Aircraft Ops Deter Turboprop Ops	5b	3
Light Jet	1.05	Ideal Location/Services	5b	3
Small Jet	1.05	Ideal Location/Services	5b	3
Medium Jet	1.15	Ideal Location/Services; Influx of Previously Uncaptured Market	1, 5b	3
Large Jet	1.25	Ideal Location/Services; Influx of Previously Uncaptured Market	1, 5b	3
*Question 5b relates to operating aircraft				

Source: CMT (2016)

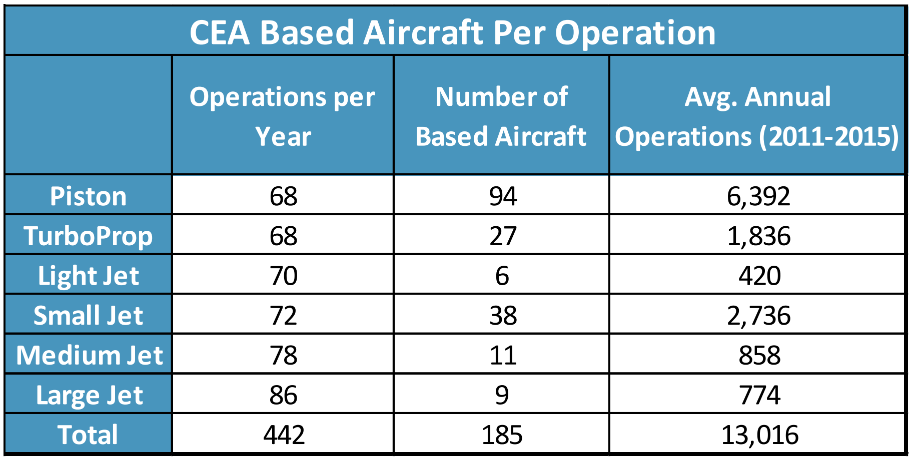
Operations per Based Aircraft

The operations per based aircraft referenced in Step 5 of the forecasting method are used to determine the operational impact on an airfield by based aircraft.

To quantify the effect of based aircraft on operations, an analysis of the existing based aircraft at CEA was conducted. Each N-Number of an existing based aircraft was cross-referenced against the N-Numbers of the PASSUR IFR data to determine the number of annual operations each aircraft performed. Then, each aircraft was classified and an average operation per year was established.

Since each aircraft classification has different operational characteristics, each classification also has different operational utilization. Generally, the larger the aircraft, the more frequent the operations. Each aircraft classification is depicted with the associated annual operations in Table 6-2.

Table 6-2: Number of Operations per Based Aircraft



CEA Based Aircraft Per Operation

	Operations per Year	Number of Based Aircraft	Avg. Annual Operations (2011-2015)
Piston	68	94	6,392
TurboProp	68	27	1,836
Light Jet	70	6	420
Small Jet	72	38	2,736
Medium Jet	78	11	858
Large Jet	86	9	774
Total	442	185	13,016

Source: CMT (2016)

The existing based aircraft at CEA contribute to approximately 15% of all operations at the airport. As the based aircraft within this forecast grows, the corresponding operations forecast incorporates the number of operations per year for each additional based aircraft.

6.2 Based Aircraft Forecast

Based aircraft counts serve as good indicators of overall airfield demand. When there is an influx or high number of based aircraft at an airfield, it is often a positive indicator that the airport offers "greater benefits" than the competing airports. Additionally, there is a connection between the number of based aircraft at an airfield and the number of operations. The type of operation, including the aircraft model, can have a sizeable impact on operations.

In order to forecast based aircraft, the most representative data sets are industry fleet projections. These forecasts can be used as one of the "factors" in identifying airfield demand by based aircraft. The industry forecasts being used in this report are outlined in Section 3 and provide a forecast of the total change in based aircraft throughout the forecasting period. Since there are several different industry forecasts with varying growth rates, different growth scenarios have been developed. The scenarios generated include low, medium, and high. Each scenario takes different combinations of the industry forecasts to develop a realistic spread of possible forecasted based aircraft.

Constrained Based Aircraft Forecast

Using the forecasting method described in Section 6.1, the following constrained forecasts have been developed:

Low Growth (1.3%): The low growth scenario is based on the lowest industry forecast and constrained based aircraft multipliers. The overall based aircraft CAGR is 1.3% while the jet CAGR is higher at 2.8%. The low growth rates are primarily due to the declining propeller aircraft and constrained jets.

Medium Growth (1.5%): The medium growth scenario uses an average of the industry forecasts and applies the constrained based aircraft multipliers. The overall CAGR is 1.5% while the jet CAGR 3.2%. This applies the above multipliers to the average of the industry forecasts. The overall based aircraft CAGR is 1.5% while the Jet CAGR is 3.1%. The majority of the jet growth is in the unconstrained light and small jets.

High Growth (1.7%): The high growth scenario uses the highest industry growth rate and applies the constrained based aircraft multiplier. There is a marginal increase from the medium growth scenario with an overall CAGR of 1.7% and jet CAGR of 3.5%. The minor increase from the medium forecast is due to the constrained growth of medium and large jets.

The chosen based aircraft forecast growth in the constrained scenario is the high rate of 1.7%. This forecast shows a strong growth in the turboprop, small, and light jets. Medium and large jets show somewhat lower growth compared the industry forecasts due to the constraints. This forecast also aligns with the FAA's TAF. The TAF shows a compound annual growth rate of 1.6% throughout the forecasting period. The 5 year interval of the chosen high growth based aircraft forecast are shown in the following Table 6-3.

Table 6-3: Constrained Based Aircraft Forecast – High Growth Scenario

Year	2015	2016	2021	2026	2031	2036
Piston	94	94	93	92	91	91
TurboProp	27	28	30	33	37	41
Light Jets	6	6	7	8	10	12
Small Jets	38	40	48	57	68	81
Medium Jets	11	11	14	17	20	24
Large Jets	9	9	10	12	13	15
Total	185	187	202	219	239	263

Source: CMT (2016)

Unconstrained Based Aircraft Forecast

Using the same method as the constrained scenario, the unconstrained based aircraft multipliers in Table 6-1 were applied to the industry forecasts.

Low Growth (1.2%): The low growth scenario is based on the lowest industry forecast which results in an overall based aircraft CAGR of 1.4%. The jet growth is higher with a CAGR of 3.1%. The large increase in jet CAGR compared to the constrained forecast is due to the influx of previously uncaptured medium and large jet aircraft.

Medium Growth (1.8%): The medium growth uses an average of the industry forecasts. The overall CAGR is 1.6% while the jet CAGR is significantly higher at 3.9%. This scenario predicts a strong growth in each jet aircraft classification.

High Growth (3.1%): The high growth scenario is based on the highest of the industry forecasts which results in an overall CAGR of 3.1%. There is a tremendous growth in jets with a CAGR of 6%. This growth in jets is due to a strong growth in light, small, and medium jets with the most robust growth in the large jets. Now unconstrained the large jet growth should meet the highest industry forecast of 9.6% (Bombardier).

The chosen based aircraft forecast for the unconstrained scenario is the medium growth of 1.8%. The unconstrained condition at CEA will provide significantly more development area and incentive for corporate jet users. These factors will lead to a growth representative of the medium forecast scenario, as shown in Table 6-4.

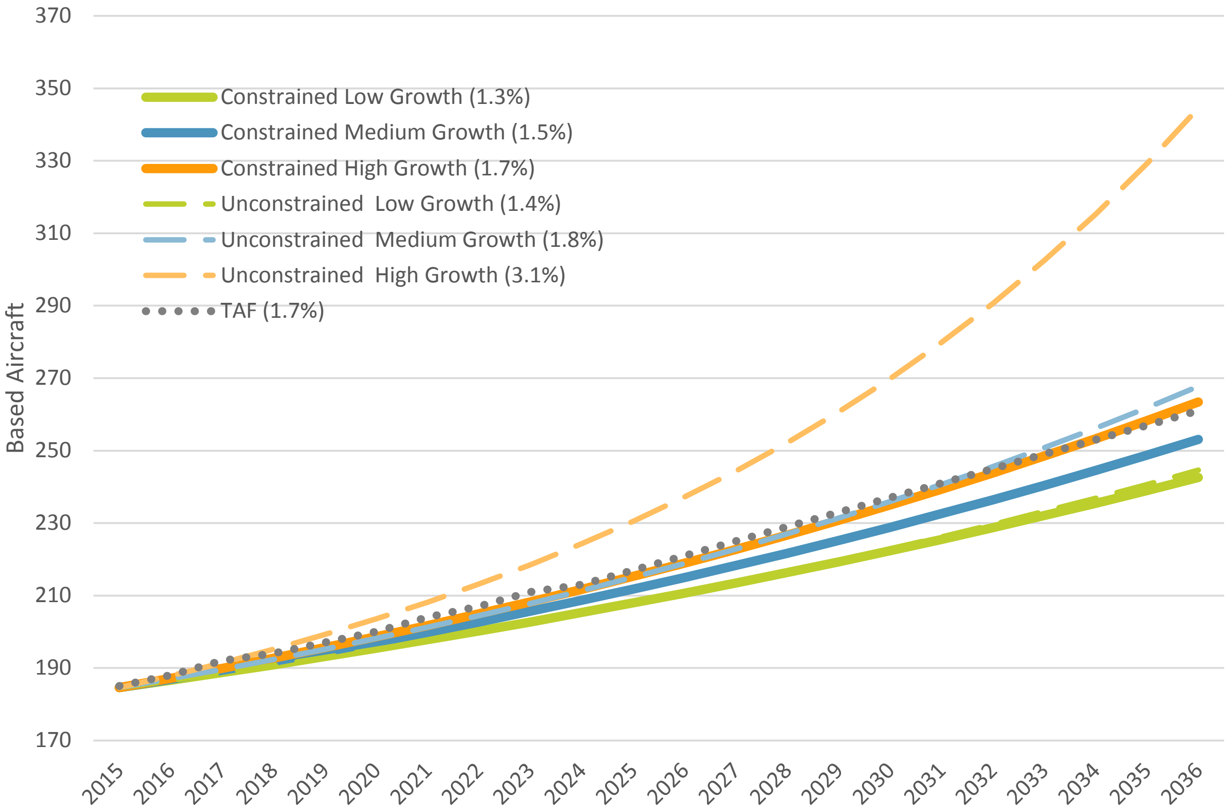
Table 6-4: Unconstrained Based Aircraft Forecast - Medium Growth Scenario

Year	2015	2016	2021	2026	2031	2036
Piston	94	93	91	89	87	85
Turbo -Prop	27	27	30	33	36	39
Light Jets	6	6	7	8	9	11
Small Jets	38	40	47	55	65	77
Medium Jets	11	11	14	17	20	25
Large Jets	9	9	13	17	23	31
Total	185	187	201	219	241	268

Source: CMT (2016)

To compare the constrained forecast scenarios with the unconstrained forecast scenario, see the following Figure 6-1. The constrained scenarios are represented by the solid lines and the unconstrained by the dashed line. The TAF has been included as the dotted line to benchmark each forecasted scenario.

Figure 6-1: Based Aircraft Growth Scenarios – Constrained and Unconstrained



Source: CMT (2016)

6.3 Operations Forecast

The ultimate gauge in planning the future viability of an airport is assessing the number of aircraft operations. Aircraft operations provide a direct representation of the aeronautical demand that an airport will need to facilitate in both the near and long term future.

As Chicago's top reliever in terms of both local and itinerant operations, CEA has established itself as reputable destination for all aviation users. However, the aviation industry is continually evolving and CEA must take the appropriate steps to meet the future demand of the aviation system. The best way to proactively prepare for this future demand is to develop a forecast that will provide insight on future scenarios.

To accurately project future demand, an operations forecast should be based on operations-related data. As such, the operational forecast scenarios found within this forecast are founded upon on the operational trends identified in Section 3, which include trends from CEA, the corporate airports in Chicago, and the top 25 IFR reliever airports. These trends provide a basis in which to identify existing trends and then extrapolate realistic growth scenarios. To further improve upon the validity of operational forecast, industry fleet growth forecasts are incorporated into demand by function of including the associated low, medium, and high based aircraft forecasts. By applying the growth in operations per growth in based aircraft, the industry fleet growth is effectively being incorporated into the operations forecast.

In addition to developing a forecast based on the existing CEA facility, there must also be a component of this report that forecasts a CEA facility that would be unconstrained. As identified in the surveys and interviews, there are both real and perceived existing constraints that exist at CEA. Several analyses have been conducted within this report to further identify these constraints, as well as establish additional factors that may affect demand. The following elements within the operations forecast integrate all of these components to establish a constrained and unconstrained forecast of operations at CEA.

Constrained Operations Forecast

Through application of the methods established in the beginning of this section, the following forecasted growth rates were defined under the constrained conditions.

<u>Low Growth (-0.6%)</u>: The low growth scenario is based on the lowest trend rates with an overall compounded annual growth rate of -0.6%. This rate is attributed to the sharp decline in piston and turboprop operations and the relatively low jet growths, partially due to the constrained runway at CEA. The CAGR of the jets is 0.4% which is made up mostly by small and light jets.

Medium Growth (0.4%): The medium growth scenario is based on an average of the trend rates with an overall CAGR of 0.4%. This low growth is due to the continued decline in piston aircraft and the constrained growth of the large jets. The jet CAGR of 1.1% has a modest increase in growth which is further attributed to the constrained medium and large jets.

High Growth (2.1%): The high growth scenario is based on the highest of the trend growth rates with a total CAGR of 2.1%. This significant growth compared to the low and medium scenarios is based on the nationwide positive trend in piston aircraft. While this is unlikely at CEA, it is important to take into consideration. This scenario still constrains the medium and large jets, resulting in a corporate jet CAGR of 1.9%.

The chosen constrained forecast for this report is the medium growth scenario of 0.4%. When considering all of the constrained factors, the majority of the growth will be limited to only turboprops, light jets, and small jets. Further, this aligns well with the FAA's TAF CAGR of 0.3%.

Table 6-5: Constrained Operations Forecast – Medium Growth

Year	2015	2016	2021	2026	2031	2036
Piston	15,572	15,047	12,675	10,669	8,974	7,541
TurboProp	9,614	9,658	9,887	10,136	10,407	10,700
Light Jet	6,401	6,470	6,831	7,222	7,645	8,106
Small Jet	34,423	34,693	36,113	37,665	39,371	41,255
Medium Jet	7,726	7,814	8,282	8,793	9,352	9,965
Large Jet	2,861	2,929	3,291	3,699	4,158	4,675
Total	76,597	76,611	77,080	78,184	79,907	82,242

Source: CMT (2016)

Unconstrained Operations Forecast

The unconstrained operations forecast utilizes the previously established method using the unconstrained multipliers.

Low Growth (0.1%): The low growth scenario is based on the lowest trend rate and unconstrained operations multiplier. This results in an overall operations CAGR of 0.1%. The unconstrained medium and large jet growth significantly increases compared to the constrained forecast. This effectively negates the negative trend of the piston aircraft. The total jet CAGR is 1.3%, which grows quickly when unconstrained.

Medium Growth (1.4%): The medium growth scenario takes the averages of the trend mixes and applies the unconstrained operations multipliers. This results in a total operational

CAGR of 1.4% and corporate jet CAGR of 2.4%. The influx of medium to large corporate jet aircraft help positively influence the further declining piston aircraft operations.

High Growth (3.3%): The high growth scenario takes the highest percentages in the trend mixes and applies the unconstrained multipliers. This results in a healthy total operational CAGR of 3.3% which is primarily represented by the growth in jet aircraft. The corporate jet CAGR is a strong 3.9%. This is attributed to combining the highest industry jet trend with the increase in operations from the highest based aircraft forecast.

The chosen growth for the unconstrained forecast is the medium growth of 1.2%. This is a modest overall CAGR that is supported by a robust growth in jets that would likely occur in an unconstrained scenario.

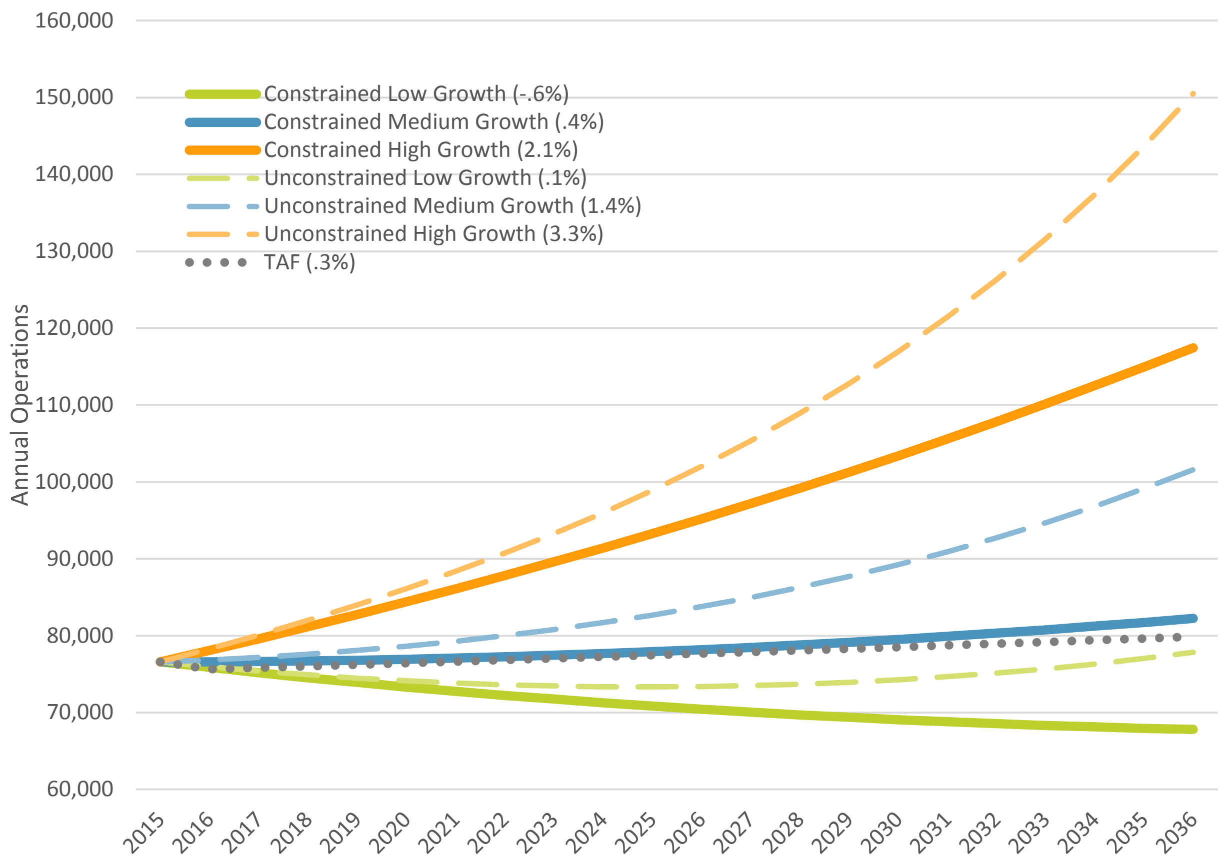
Table 6-6: Unconstrained Operations Forecast – Medium Growth

Year	2015	2016	2021	2026	2031	2036
Piston	15,572	14,898	11,928	9,525	7,582	6,011
Turbo -Prop	9,614	9,657	9,881	10,125	10,391	10,679
Light Jet	6,401	6,473	6,849	7,255	7,697	8,177
Small Jet	34,423	34,702	36,166	37,766	39,523	41,462
Medium Jet	7,726	7,979	9,377	11,029	12,980	15,287
Large Jet	2,861	3,152	5,071	8,073	12,745	19,984
Total	76,597	76,860	79,272	83,774	90,918	101,599

Source: CMT (2016)

A comparison of the constrained operations forecasts and the unconstrained operations forecast can be found in the following Figure 6-4. The constrained scenarios are represented by the solid lines and the unconstrained by the dashed line. The TAF has been included as the dotted line to benchmark each forecasted scenario.

Figure 6-2: Constrained and Unconstrained Operations Forecast



Source: CMT (2016)

7.0 Forecast Summary

This forecast has reviewed a number of industry forecasts, trends, and factors so that CEA can better prepare for future demand. While this establishes a justifiable baseline for CEA, the ultimate impact on aviation demand at CEA is dependent on the Airport's constraints. In order for CEA to continue serving the Chicago area as the top corporate reliever, these constraints need to be further evaluated.

Regardless of unconstrained considerations, the forecasts chosen within this report best represents the potential demand at CEA under the current conditions at the airport. The high based aircraft forecast was chosen under the constrained scenario because of the strong growth in turboprop, light jet, and small jet aircraft. Despite this strong growth in the smaller corporate traffic, the medium and large corporate aircraft remain constrained, which ultimately curbs the growth of the high scenario to a CAGR of 1.7% by the end of the planning period. When comparing the based aircraft forecast to the FAA's TAF, they are nearly identical. Both have a CAGR of 1.7%, and the TAF only has 2 less based aircraft by 2036.

The medium forecast was selected for the operations forecast with a total CAGR of 0.4%. This marginal growth is primary attributed to the declining piston operations and the constrained medium and large corporate jet aircraft. Although the constraints restrict the larger corporate traffic, there is still a healthy growth in the small corporate traffic. The FAA's TAF shows an operational growth of 0.3%, only one tenth of a percent below the forecast established in this report. A comparison of these growth rates can be shown in Table 7-1.

Since the number of instrument approaches has a direct relationship to the number of operations at CEA, the anticipated number of instrument approaches have also been included in Table 7-1. The 2015 instrument approaches are based upon a dataset that records the instrument flights at an airport.

Table 7-1: Forecast Summary

Forecast Summary							
Operations		**2015**	**2016**	**2021**	**2026**	**2031**	**2036**
CEA Forecast	Jet Operations	51,412	51,907	54,518	57,379	60,526	64,001
	Total Operations	76,597	76,611	77,080	78,184	79,907	82,242
	Instrument Approaches	65,600	65,612	66,013	66,959	68,434	70,434
FAA TAF	Total Operations	76,597	75,632	76,630	77,667	78,745	79,868
Comparison: % Difference		0%	1%	1%	1%	1%	3%
Based Aircraft		**2015**	**2016**	**2021**	**2026**	**2031**	**2036**
CEA Forecast	Jet Based Aircraft	64	66	79	93	111	132
	Total Based Aircraft	185	187	202	219	239	263
FAA TAF	Total Based Aircraft	185	188	204	221	241	261
Comparison: % Difference		0%	0%	1%	1%	1%	1%

Source: CMT (2016)

References

---

[1] IHS Global Insights. June, 2015. “GMP and Employment 2014-2016.” The U.S Conference of Mayors. Available at: http://usmayors.org/metroeconomies/0615/report.pdf

[2] Jones Lang LaSalle. February, 2015. “Tech Center: Driving Chicago Economy and Office Demand.” Available at: http://www.us.jll.com/united-states/en-us/Research/Chicago-Tech-Sector-Report_Final-Feb2015.pdf

[3] Moody’s Analytics & Economic Consumer Credit Analytics. January, 2015. “State of Illinois Economic Forecast.” Illinois Commission on Government Forecasting & Accountability. Available at: http://cgfa.ilga.gov/Upload/2015MoodysEconomyILforecast.pdf

[4] Federal Aviation Administration. “FAA Aerospace Forecast – Fiscal Years 2016-2036.” Available at: https://www.faa.gov/data_research/aviation/aerospace_forecasts/media/FY2016-36_FAA_Aerospace_Forecast.pdf

[5] International Air Transport Association. “Aviation Economic Benefits.” Available at: https://www.iata.org/publications/economics/Documents/890700-aviation-economic-benefits-summary-report.pdf

[6] General Aviation Manufacturers Association. “2015 General Aviation Statistical Databook & 2016 Industry Outlook. “ Available at: https://www.gama.aero/media-center/industry-facts-and-statistics/statistical-databook-and-industry-outlook

[7] Bombardier Business Aircraft. “Market Forecast 2015-2024.” Available at: http://www.bombardier.com/content/dam/Websites/bombardiercom/supporting-documents/BA/Bombardier-Business-Aircraft-2015-2024-Market-Forecast-en.pdf

Section 2

Facility Requirements

1.0 Introduction

The facility requirements act as an essential part of the planning process to assess the ability of existing facilities to meet current and future demand. These facility requirements are founded upon the demand established in the Chicago Executive Airport (CEA) forecast. Any difference between the forecast demand and the existing capacity will be identified to determine future facility requirements.

The two primary components of facility requirements are separated into airside and landside facilities. Airside facilities support aircraft related activities, which include runways, taxiways, hangars, and aprons. Landside facilities are areas that support the operation of the airport, but are not directly involved with aircraft movement. These landside facilities include, but are not limited to, terminals, vehicle parking, access roadways, local economic development, and protection of environmental or airspace dedicated land.

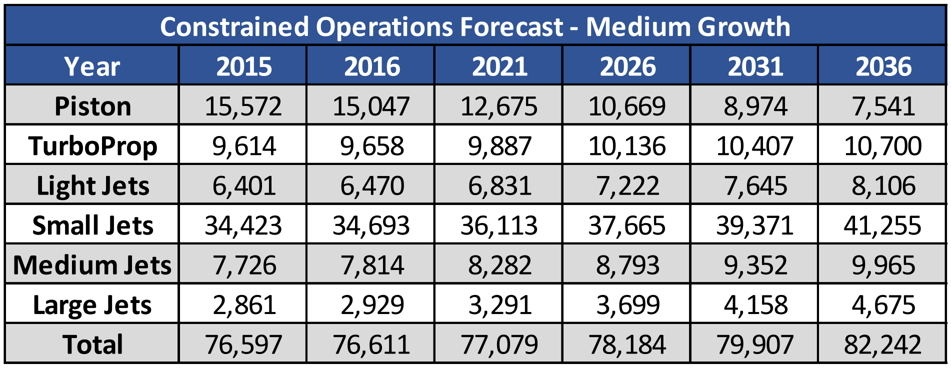
2.0 Forecast Review

It is important to establish the amount of demand by aircraft classification when developing an airfield's facility requirements due to the facilities required for a large range in aircraft type at an airport. Once the demand by specific aircraft is identified, it can be compared to existing facilities to determine if they will be able to accommodate the demand or if new facilities will be required. This section will review the aircraft operations and based aircraft forecasts from the previous section.

Aircraft Operational Demand

In the previous section, forecast, the constrained medium growth scenario was selected as the forecast on which to base future facilities. Since this forecast is based on the constrained scenario, it limits the growth in the large aircraft operations. However, all categories of aircraft except for piston aircraft, are forecast to grow through the planning period. These specific growth trends for each aircraft size group are important to reference when developing future facility requirements. Table 2-1 depicts the selected operational forecast.

Table 2-1:
Constrained Operations Forecast – Medium Growth



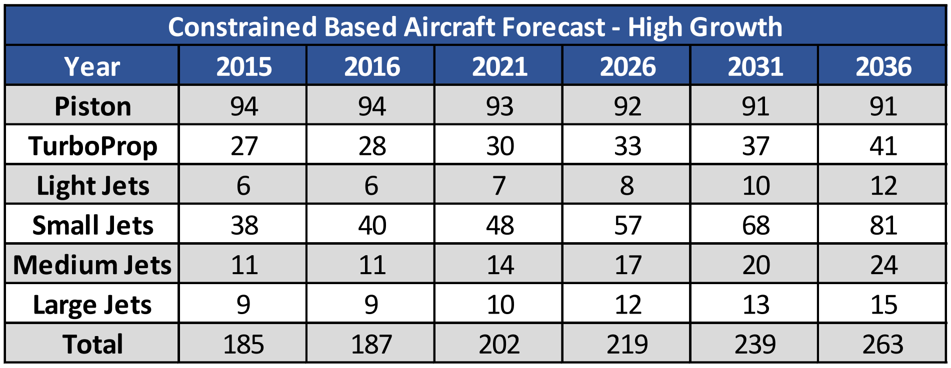
Constrained Operations Forecast - Medium Growth						
Year	**2015**	**2016**	**2021**	**2026**	**2031**	**2036**
Piston	15,572	15,047	12,675	10,669	8,974	7,541
TurboProp	9,614	9,658	9,887	10,136	10,407	10,700
Light Jets	6,401	6,470	6,831	7,222	7,645	8,106
Small Jets	34,423	34,693	36,113	37,665	39,371	41,255
Medium Jets	7,726	7,814	8,282	8,793	9,352	9,965
Large Jets	2,861	2,929	3,291	3,699	4,158	4,675
Total	76,597	76,611	77,079	78,184	79,907	82,242

Source: CMT (2016)

Based Aircraft Demand

In addition to the operational forecast, the based aircraft forecast is important to determine future needs at CEA. The chosen based aircraft forecast was the constrained high growth. Similar to the operations forecast, all categories of aircraft, except piston, are forecast to grow, with small and medium jets seeing the largest percentage increase. The piston aircraft showed slight reduction in based aircraft at the end of the forecast period. The based aircraft forecast is shown in Table 2-2.

Table 2-2:
Constrained Based Aircraft Forecast – High Growth



Constrained Based Aircraft Forecast - High Growth						
Year	**2015**	**2016**	**2021**	**2026**	**2031**	**2036**
Piston	94	94	93	92	91	91
TurboProp	27	28	30	33	37	41
Light Jets	6	6	7	8	10	12
Small Jets	38	40	48	57	68	81
Medium Jets	11	11	14	17	20	24
Large Jets	9	9	10	12	13	15
Total	185	187	202	219	239	263

Source: CMT (2016)

3.0 Airside Facility Requirements

This section will first examine the airfield layout to determine if any changes are required to the physical layout of the airfield. Runway configuration, taxiway layout, apron and ramp locations, and navigational aids will be further examined. Doing so will also determine if the runway's critical aircraft and airport reference code need to change.

3.1 Airport Reference Code

The Airport Reference Code (ARC) is defined as the airport's highest Runway Design Code (RDC) of all runways. Currently, CEA is classified as a D-III ARC, and as shown by Table 3-1, will remain a D-III.

Table 3-1:
Airport Reference Code Classification System

Runway			
	Rwy 6/24	**Rwy 12/30**	**Rwy 16/34**
Existing Critical Aircraft	Cessna 421	King Air B200	Gulfstream 550
Existing RDC	B-I Small	B-II Small	D-III
Future Critical Aircraft	Cessna 421	Cessna Citation Sovereign	Gulfstream 550
Future RDC	B-I Small	B-II Large	D-III

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

Critical Aircraft

The critical aircraft determination is an important aspect of airport planning and design. It sets dimensional requirements on an airport, such as the distance between taxiways and runways. An accurate determination of the critical aircraft helps to ensure the proper development of airport facilities. Each runway is designated a critical aircraft based on runway operational usage.

Critical aircraft represent the most demanding Aircraft Approach Category (AAC) and Aircraft Design Group (ADG) with 500 or more operations on a single runway. The AAC is represented by a letter that signifies the approach speed of the particular aircraft. The ADG is represented by a roman numeral and indicates the size of the wingspan or tail height. The combination of these two attributes is also known as the RDC.

A preliminary analysis of the critical aircraft at CEA was conducted in the forecast. These critical aircraft have been further evaluated in this section using updated and new data sources. Based on a departure and arrival analysis using PASSUR data, the critical aircraft classification for

Runway 12/30 is recommended to change, while Runway 16/34 and Runway 6/24 are recommended to remain the same.

Runway 12/30

Runway 12/30 has historically been developed as a B-II Small runway while utilizing the King Air B200 as the critical aircraft. Analysis of operational PASSUR data has revealed that there are sufficient B-II Large operations on Runway 12/30 to require a change in critical aircraft. Table 3-2 presents the five-year average annual operations on Runway 12/30 for the eight most common B-II Large aircraft.

Table 3-2:
Runway 12/30 Operational Data

Runway 12/30			
Aircraft	**Aircraft**	**RDC**	**Avg Annual Operations**
C680	**Cessna Citation Sovereign**	B-II Large	132
C56X	**Cessna Citation Excel**	B-II Large	103
C560	**Cessna Citation V**	B-II Large	66
H25B	**Raytheon Hawker 800**	B-II Large	63
F2TH	**Dassault Falcon 2000**	B-II Large	54
C550	**Cessna Citation II/Bravo**	B-II Large	41
CL30	**Bombardier Challenger 300**	B-II Large	40
BE40	**Beech Jet 400**	B-II Large	39
TOTAL		B-II Large	**537**

Source: CMT (2017)

The core difference between B-II Small and B-II Large aircraft is their weight classification. B-II Small aircraft have a weight classification less than 12,500 lbs while B-II Large aircraft have a weight classification more than 12,500 lbs. Therefore, it is recommended that Runway 12/30 be changed to a B-II Large RDC and the recommended critical aircraft change to the Cessna Citation Sovereign.

Runway 16/34

Runway 16/34 has historically been developed as a D-III runway while utilizing the Gulfstream 550 as it's critical aircraft. An analysis of 2015 operational data indicated that there were 244 departures of aircraft in the Gulfstream 550 and 650 families. According to FAA's Aircraft Characteristics Database from September 2016, these aircraft families are classified as D-III aircraft. Assuming operations are equivalent to double the number of departures, there were 488 total operations of D-III aircraft in 2015. The approved forecast for CEA projected aggressive growth (2.3% annual growth rate) in the large aircraft segment of CEA's fleet mix. Based on this growth rate, it is anticipated that the total operations of D-III aircraft will exceed 500 annual operations by 2017. Based on this analysis, no change is recommended to the RDC of Runway 16/34. Likewise, the current critical aircraft for Runway 16/34 is recommended to remain the Gulfstream 550.

Runway 6/24

Runway 6/24 is recommended to remain B-I small. Previous planning efforts at CEA have utilized the Cessna 421 as the critical aircraft. Because there have not been any significant changes to the runway in recent years, it is recommended that the Cessna 421 be maintained as the critical aircraft.

3.2 Runway Orientation and Weather Conditions

The runway configuration at CEA has been constructed to minimize the percentage of time that strong crosswinds make the use of the airport inadvisable. In FAA Advisory Circular 150/5300-13A (13A) *Airport Design*, the FAA states "a crosswind runway is recommended when the primary runway orientation provides less than 95% percent wind coverage." The 95% wind coverage is computed on the basis of crosswinds not exceeding10.5 knots for RDC A-I and B-I aircraft, 13 knots for RDC A-II and B-II aircraft, and 16 knots for RDC A-III, B-III, C-I, II, III and D-I, II, III aircraft. It is at these thresholds that a pilot may choose to use a more favorable runway, or if none are available, an alternative airport.

To determine if the existing runway configuration at CEA is sufficient to accommodate aircraft under the local wind conditions, weather data from the National Climactic Data Center (NCDC) was analyzed. It is necessary to calculate wind coverage for all aircraft types that consistently use the airport. In cases where the runway provides adequate wind coverage for the larger aircraft, but not for smaller aircraft, a crosswind runway may be maintained to ensure that all aircraft are accommodated during 95% of airport operations. Table 3-3 provides a summary of the all-weather wind condition analysis for existing Runway 6/24, 12/30 and 16/34 at CEA. The wind information obtained is from the NCDC for the period between 2006 and 2015.

Table 3-3:
Wind Coverage (All Weather Conditions)

All Weather Wind Coverage Table				
Runway	**Crosswind Component**			
	10.5 Knot	**13 Knot**	**16 Knot**	**20 Knot**
16/34	91.72%	95.96%	99.02%	99.82%
12/30	89.29%	93.88%	98.33%	99.69%
6/24	90.65%	95.17%	98.77%	99.79%

Source: NCDC data for CEA 2006-2015; CMT analysis (2017)

As Table 3-3 illustrates, individually, runways 6/24, 12/30, and 16/34 do not provide 95% wind coverage at a 10.5 knot maximum crosswind, as required for RDC A-I and B-I aircraft. However, when all three runways are analyzed, they in total provide 99% wind coverage for each runway's RDC crosswind component threshold.

IFR weather conditions are defined by the FAA as having a ceiling less than 1,000 feet above ground level and/or when visibility is less than three miles. According to historical wind and weather data for CEA that was obtained from the FAA Airports Geographic Information System (Airports GIS) Wind Analysis database, IFR conditions occur approximately 18.3% of the time. Poor visibility and low ceiling conditions (less than 300 feet and 1-mile visibility based on current approach minimums) occur 1.4 % of the time. CEA has one runway end that is equipped with an instrument approach for inclement weather conditions. Runway 16 is equipped with a Category I ILS with minimums of 300 feet and 1-mile visibility.

Table 3-4 provides a summary of IFR wind conditions that occur during IFR operations.

Table 3-4:
Wind Coverage (IFR Weather Conditions)

IFR Weather Wind Coverage Table				
Runway	Crosswind Component			
	10.5 Knot	13 Knot	16 Knot	20 Knot
16/34	92.40%	96.00%	98.70%	99.66%
12/30	88.65%	93.73%	98.42%	99.70%
6/24	89.84%	94.45%	98.45%	99.67%

Source: NCDC data for CEA 2006-2015; CMT analysis (2017)

This wind analysis concludes that the current runway layout provides adequate wind coverage for the existing and forecasted aircraft fleet operating at CEA, while also meeting FAA standards.

While it is the Airport's current desire to maintain all three active runways, FAA has previously stated that future AIP funds cannot be used to maintain Runway 6/24. Combined with the existing geographical constraints which face CEA , it is plausible that a runway could be decommissioned in the future for more efficient land utilization. This scenario analyzed the two most utilized runways – Runway 16/34 and 12/30. As shown in Tables 3-5 and 3-6, runways 16/34 and 12/30 combined provide more than 95% wind coverage, for both all-weather and IFR, thereby meeting operational needs and FAA standards.

Table 3-5:
Two Runway - Wind Coverage (All Weather Conditions)

All Weather Wind Coverage Table Runways 16/34 & 12/30				
Runway	Crosswind Component			
	10.5 Knot	13 Knot	16 Knot	20 Knot
16/34	91.72%	95.96%	99.02%	99.82%
12/30	89.29%	93.88%	98.33%	99.69%
Combined Runway Coverage	95.52%	98.38%	99.69	99.97

Source: NCDC data for CEA 2006-2015; CMT analysis (2017)

Table 3-6:
Two Runway - Wind Coverage (IFR Weather Conditions)

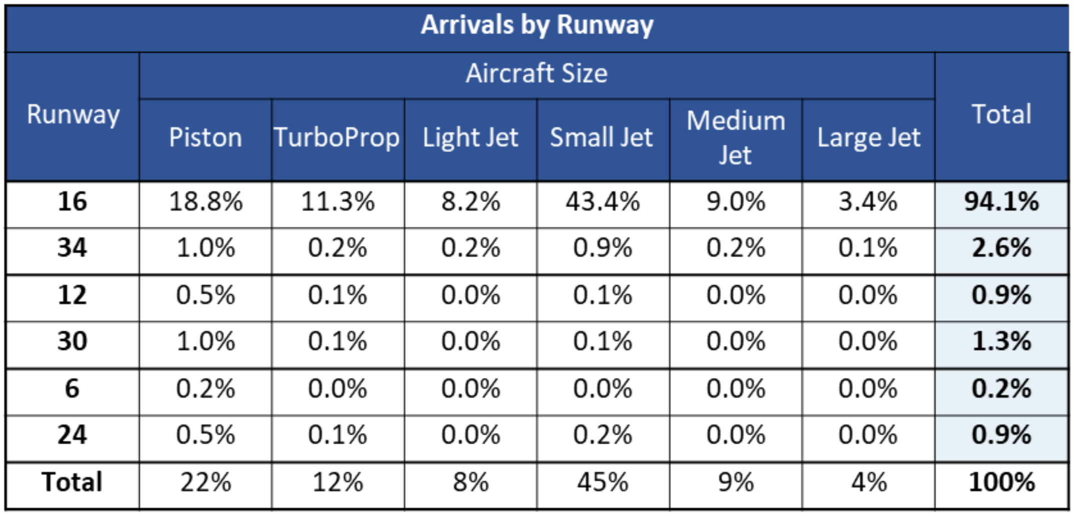
IFR Wind Coverage Table Runways 16/34 & 12/30				
Runway	Crosswind Component			
	10.5 Knots	13 Knots	16 Knots	20 Knots
16/34	92.40%	96.00%	98.70%	99.66%
12/30	88.65%	93.73%	98.42%	99.70%
Combined Runway Coverage	95.10%	97.98%	99.44	99.91

Source: NCDC data for CEA 2006-2015; CMT analysis (2017)

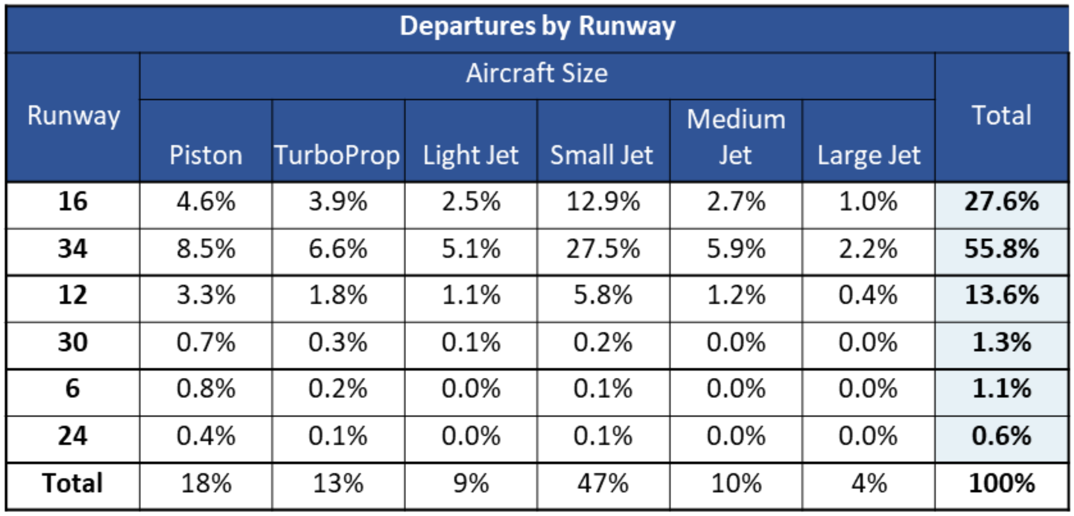
3.3 Runway Requirements

Runway 16/34 functions as the primary runway at CEA, primarily due to its length and instrument approach capability. As shown in Table 3-7 below, based on five years of operational data, Runway 16/34 is utilized for nearly 97% of all arrivals into CEA. For departures, Runway 16/34 and Runway 12 comprise approximately 97% of all departures from CEA. Runway 6/24 is utilized for 1.2% of all arrivals and for 1.7% of all departures.

Table 3-7:
Runway Utilization



Arrivals by Runway							
Runway	Aircraft Size						Total
	Piston	TurboProp	Light Jet	Small Jet	Medium Jet	Large Jet	
16	18.8%	11.3%	8.2%	43.4%	9.0%	3.4%	**94.1%**
34	1.0%	0.2%	0.2%	0.9%	0.2%	0.1%	**2.6%**
12	0.5%	0.1%	0.0%	0.1%	0.0%	0.0%	**0.9%**
30	1.0%	0.1%	0.0%	0.1%	0.0%	0.0%	**1.3%**
6	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.2%**
24	0.5%	0.1%	0.0%	0.2%	0.0%	0.0%	**0.9%**
Total	22%	12%	8%	45%	9%	4%	**100%**



Departures by Runway							
Runway	Aircraft Size						Total
	Piston	TurboProp	Light Jet	Small Jet	Medium Jet	Large Jet	
16	4.6%	3.9%	2.5%	12.9%	2.7%	1.0%	**27.6%**
34	8.5%	6.6%	5.1%	27.5%	5.9%	2.2%	**55.8%**
12	3.3%	1.8%	1.1%	5.8%	1.2%	0.4%	**13.6%**
30	0.7%	0.3%	0.1%	0.2%	0.0%	0.0%	**1.3%**
6	0.8%	0.2%	0.0%	0.1%	0.0%	0.0%	**1.1%**
24	0.4%	0.1%	0.0%	0.1%	0.0%	0.0%	**0.6%**
Total	18%	13%	9%	47%	10%	4%	**100%**

Source: CMT Analysis (2017)

Runway Length

Runway length requirements should be designed to accommodate the most demanding aircraft (critical aircraft) expected to regularly use an airport. There are many variables that need to be considered when calculating runway length requirements. Some of the most influential variables include:

- Aircraft performance characteristics such as flap settings, gross takeoff/landing weights, anti-icing and engine bleeds operations
- Airport elevation above Mean Seas Level (MSL)
- Meteorological conditions such as temperature, pressure, and wind velocity

- Runway surface conditions and contaminations such as wet or dry pavement, and snow or ice on the runway
- Runway gradient
- Obstructions in the runway and airport vicinity

Generally speaking, aircraft performance decreases as airport elevation, temperature and runway gradient increases, and also when runways are contaminated. These variables all need to be considered when aircraft takeoff and landing performance calculations are computed, and are therefore an integral part of the runway length planning process. The process of determining an appropriate runway length that will accommodate the future fleet mix at CEA utilizes three distinct methodologies. Each method and the resulting recommended runway length is described in the subsequent sections.

<u>*METHOD 1*</u> This method was guided by the recommendations in FAA Advisory Circular 150/5325-4B, *Runway Length Requirements for Airport Design.* The advisory circular states that runway length should be able to accommodate the most demanding aircraft, with a Maximum Certificated Takeoff Weight (MTOW) between 12,500 lbs – 60,000 lbs, within a specified fleet mix of aircraft operating at the airport. However, the most demanding aircraft operating a CEA is the G550, and it has a MTOW more than 60,000 lbs. In this case, the advisory circular advises to use airplane flight manuals to determine runway lengths, which will be detailed in the description of the next method. While the G550 represents the most demanding aircraft, according to operational data, the majority of aircraft operating at CEA do have a MTOW between 12,500 and 60,000 lbs. This "grouping" of aircraft represents more of a general fleet mix rather than using specific aircraft performance data.

When the parameters and variables were placed on the nomograph in the advisory circular, the recommended runway length is computed to fall within the range shown in Table 3-8. These results are consistent with feedback received from CEA users collected during previous study phases; the existing runway length is sufficient for short-haul flights where loads are minimized, but additional length is needed when longer-haul flights with higher loading is required.

Table 3-8:
Takeoff Length Requirements (Aircraft MTOW less than 60,000 pounds)

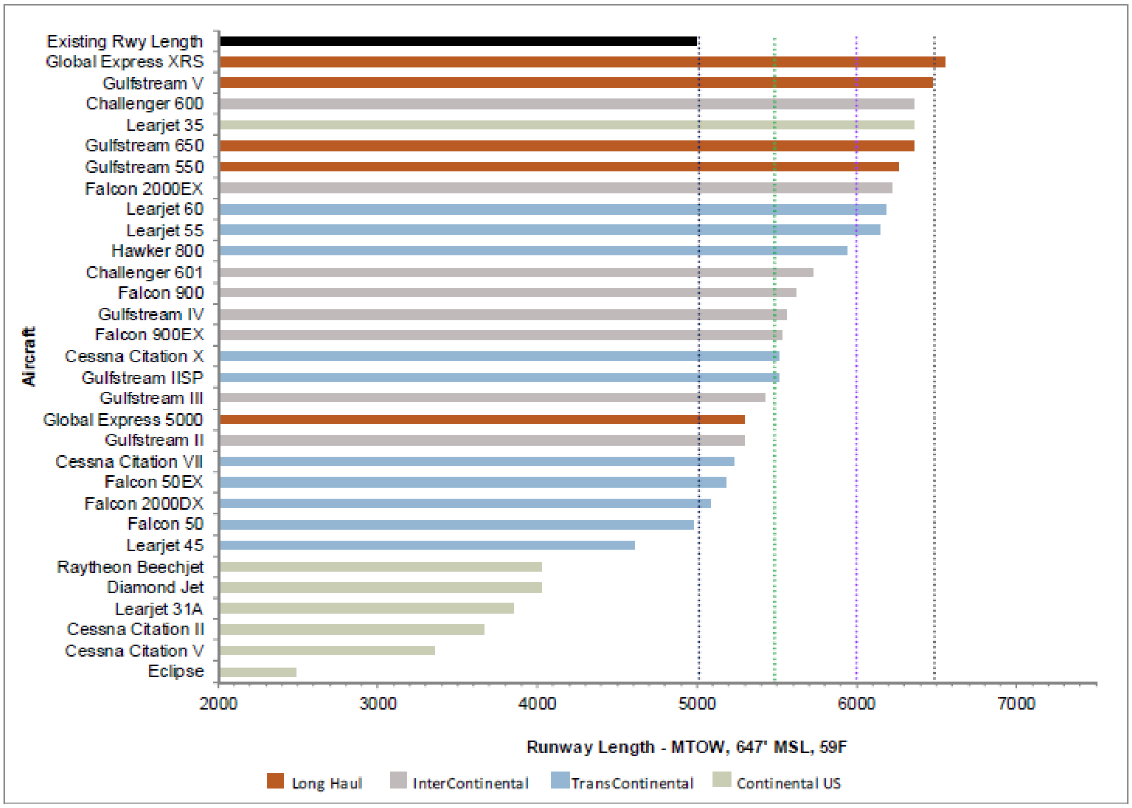
		Takeoff Rwy Length (ft)	
Fleet Mix	Useful Load	59°F	84°F
75%	60%	4,600	4,800
100%	60%	4,800	5,400
75%	90%	5,900	6,600
100%	90%	7,000	8,100

Source: FAA Advisory Circular 150/5325-4B, CMT Analysis (2017)

METHOD 2 The second method used to determine the required runway length at CEA utilizes aircraft specific Standard Aircraft Operating Charts. The calculations to this method were conducted in and published in the CMT 2011 *Airport Planning Report.* Since the completion of the report, there have been minimal changes to both the airfield and aircraft fleet mix operating at CEA that would potentially invalidate the report findings. Therefore, the calculations used in the report are being carried forward. The calculation procedure is described as follows.

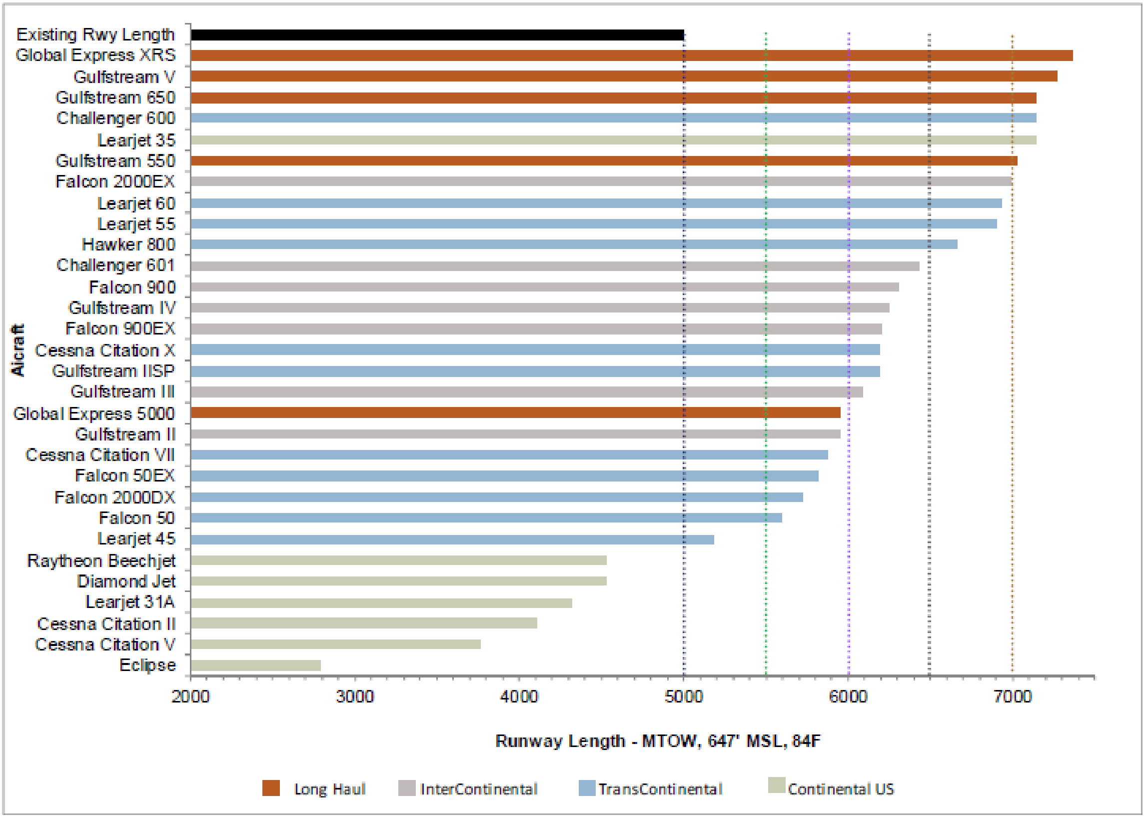
Standard Aircraft Operating Charts are charts produced by aircraft manufacturers and are aircraft specific. They are statements about aircraft performance and capabilities given different scenarios. Similar to the previous method, the first step is determining the most demanding aircraft(s) that will be utilizing the airport. After establishing the group of aircraft to use in the calculations, the next step was utilizing aircraft manufacturer's performance manuals to determine the required runway length needed for each aircraft using different scenarios. Figure 3-1 depicts the required runway lengths for various aircraft departing at MTOW at 647 MSL, CEA's approximate elevation, and at 59 degrees Fahrenheit, CEA's standard temperature for its elevation above sea level according to the International Standard Atmosphere. Figure 3-2 represents the runway lengths for takeoff at MTOW, at 647 feet MSL, and at 84 degrees Fahrenheit, the mean temperature for CEA's hottest month. According to Method 2, the recommended runway length that would allow 100% of the fleet mix to operate out of CEA is 7,400 feet long.

Figure 3-1: Runway Length Recommendations per Standard Aircraft Operating Charts at 59°F



Source: 2011 CMT "Airport Planning Report"

Figure 3-2:
Runway Length Recommendations per Standard Aircraft Operating Charts at 84°F



Source: 2011 CMT "Airport Planning Report"

<u>*METHOD 3*</u> The third method of determining runway length at CEA was aircraft performance modeling. The analysis was conducted by Lean Engineering, an industry leader in runway length and payload range assessments. The process that was used in this methodology is identical to the engineering analysis used by corporate and fractional operators who operate under FAR Part 91, 91-K and 135. The intent of this analysis is to combine specific aircraft performance characteristics that directly simulate the FAR Part 23 and FAR Part 91, 91-K and 135 rules with historical environmental conditions (temperature, wind, pressure), historical field conditions (FICON and runway contamination conditions) and operational and airspace limitations (obstacle clearance, missed approach procedures, etc.) to develop an optimal runway length range.

Three aircraft were selected for the analysis that best represent the current fleet mix operating at CEA. The three aircraft chosen were the Cessna Citation 560XLS, Hawker 800XP and Global Express 6000. The Citation 560XLS and Hawker 800XP represent the first and third most commonly operated aircraft, respectively, at CEA, while the Global Express 6000 represents the largest aircraft commonly operated at CEA. Specific aircraft configurations such as thrust, flap settings, engine bleeds, acceleration altitude, decision speed, thrust reversers and brake applications were all considered for the assessment.

Lean Engineering utilized a proprietary software application for the analysis. The performance modeling analysis recommends a runway length range of 5,700 feet to 6,700 feet, with 6,200 feet being considered optimal. The complete report from Lean Engineering can be found in the Appendix.

Runway Length Summary

Three methods of varying complexity were utilized to compute the required runway length at CEA. Each method resulted in values or ranges that exceeded the length of CEA's longest existing runway, Runway 16/34 at 5,000 feet. For this reason, it is recommended that future project phases study potential ways that additional runway length could be provided. Because Method 3, aircraft performance modeling, utilizes both CEA-specific data related to existing conditions and aircraft performance, and methodology identical to that of operators routinely operating at CEA, its resulting optimal runway length of 6,200 feet is recommended to be used for future study. It should be noted that 6,200 feet of runway length would also significantly enhance runway utility when compared to the results of Methods 1 and 2.

Runway Width

The runways at CEA have been analyzed to determine if existing facilities meet future requirements. Runway widths are determined by the standards set forth in AC 13A and are based off a runway's RDC.

Runway 16/34 is 150 feet wide and is in compliance with FAA design standards. Runway 6/24 is a RDC B-I Small runway and FAA design standards for this RDC is a 60-foot-wide runway - currently runway 6/24 is 50 feet. Therefore, it is recommended that runway 6/24 be widened ten feet to meet FAA designs standards.

Runway 12/30 is 75 feet wide and while this is in compliance with FAA design standards, coordination with CEA users have indicated that widening Runway 12/30 to 100 feet would provide a substantial runway safety and utility benefit. As discussed in Section 3.3, nearly 15% of all departures at CEA utilize Runway 12/30. Historically, the Dassault Falcon family of corporate aircraft fell into the B-II RDC and would routinely use Runway 12/30 at its current 75-foot width. Recent guidance published by Dassault indicates that 75-foot width runways are considered "narrow." The guidance has recommended that their aircraft not utilize runways less than 100 feet wide. Dassault cites a statistic indicating that the most common type of accident observed in Falcon aircraft is a runway excursion. Only utilizing wider runways is intended to mitigate the risk associated with runway excursions. It is recommended that CEA further evaluate the feasibility of widening Runway 12/30 in future report sections.

Runway Capacity

FAA Guidance Circular 150/5060-5, *Airport Capacity and Delay*, provides guidance to measure an airports ability to accommodate the number of future operations. This circular provides approximate hourly aircraft capabilities for VFR and IFR conditions, and the annual service volume (ASV) for different common runway configurations. When an airport reaches 60% of ASV, the airport should begin to plan for additional runway capacity.

Based on CEA's runway layout configuration, it would be capable of accommodating up to 230,000 annual operations. 60% of this ASV equates to 138,000 operations. Based on forecasted operations, CEA has sufficient runway capacity to meet current and future levels of operations.

3.4 Runway Design Standards

An airport is developed to specific standards defined by the Federal Aviation Administration (FAA). The main source for defining the airside facilities at an airport is FAA Advisory Circular 13A. Use of 13A is required for all projects funded with federal grants. 13A acknowledges, however, that it may not always be feasible to meet all current standards at existing airports. Due to a number of factors such as development constraints and funding prioritization, some facilities may remain non-standard for a period of time.

At CEA, the greatest consideration when evaluating facility compliance with 13A is development constraints. CEA’s origins as a privately-owned facility, combined with a location that is bound by several types of high-use public infrastructure, limits the existing facility’s compliance with 13A standards. Regardless of these constraints, it is important to understand the future requirements of enhancing compliance. This chapter of the facility requirements will establish the existing standards that are established in 13A and what future development will be needed to enhance compliance.

Runway Safety Areas

The Runway Safety Area (RSA) is a rectangular area around a runway that enhances the safety in the event an aircraft undershoots, overruns, or veers off the runway. The dimensions of an RSA are established in 13A and vary based on the RDC. 13A requires the clearing of objects in an RSA, except for objects that need to be located in the RSA because of their function (primarily navigational aids for the runway). CEA’s three runways each have a different RDC (B-I, B-II and D-III) and therefore each have different RSA dimensions which are listed in Table 3-9.

Table 3-9:
Runway Safety Area (RSA) Dimensions

Runway Safety Area Dimensions

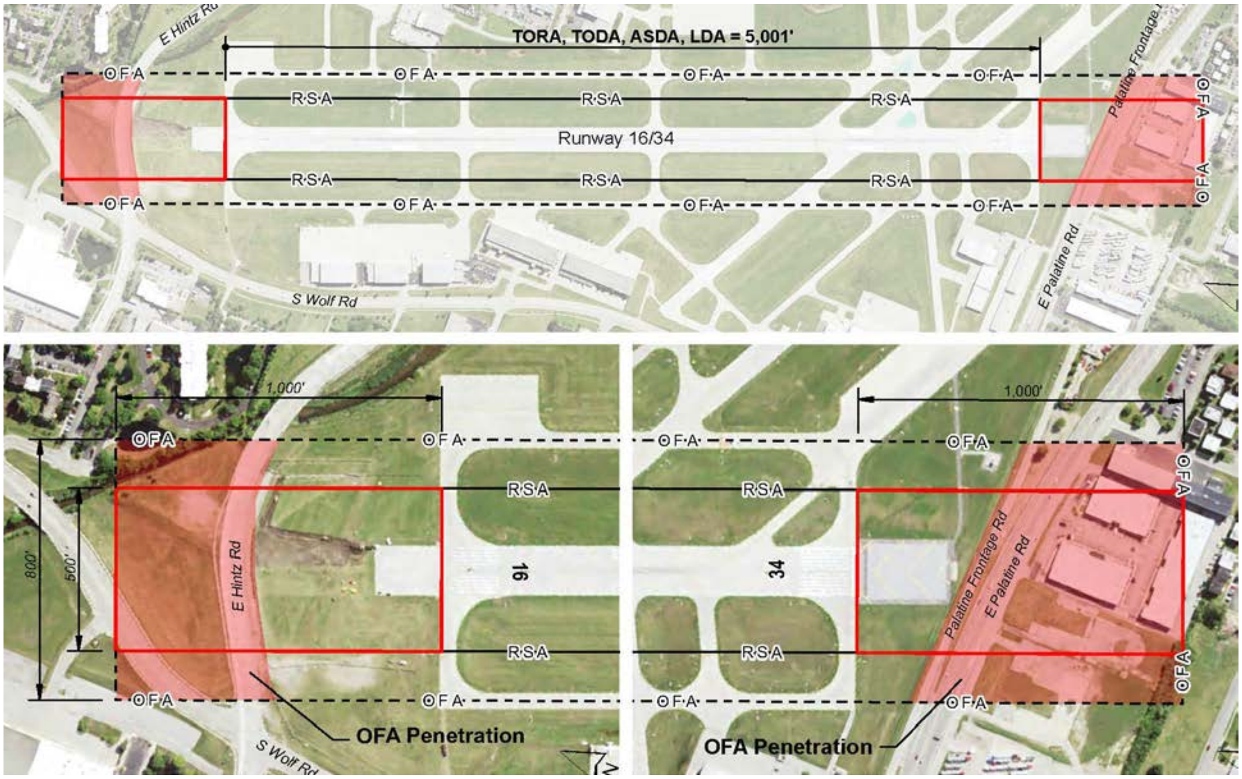
Design Surface	AC 150/5300-13A Standards		
	Runway 16/34	Runway 12/30	Runway 6/24
RSA Length Beyond End	1,000'	300'	240'
RSA Length Prior to Threshold	600'	300'	240'
RSA Width	500'	150'	120'

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

Runway 16/34 Runway Safety Area

Throughout the past two decades, CEA has a credible record of enhancing safety and making strides towards RSA compliance, specifically for Runway 16/34. Since the last full RSA determination for Runway 16/34 was issued in 2001, CEA has worked with IDA and FAA to enhance safety on Runway 16/34 by installing EMAS. However, because FAA approved the beds as "non-standard," they only constitute partial RSA compliance. Therefore, a full-length RSA is required and the existing RSA does not fully comply with FAA standards. Exhibit 3-1 depicts the Runway 16/34 safety area and the non-compliant areas.

Exhibit 3-1:
Runway 16/34 RSA & OFA

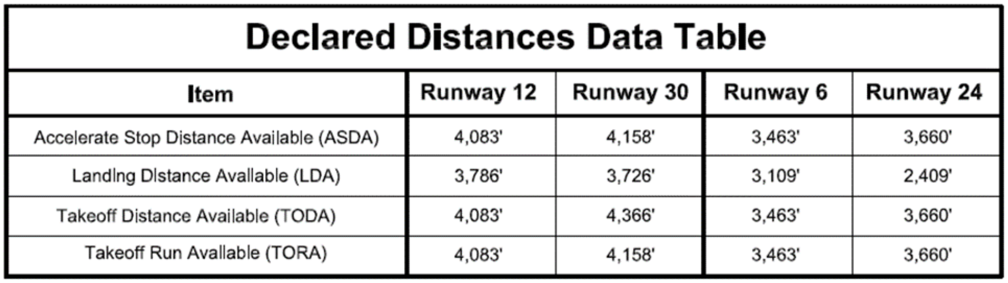


Source: CMT Analysis (2017)

<u>Runway 12/30 and Runway 6/24 Runway Safety Areas</u>

Both Runway 6/24 and Runway 12/30 use the declared distance concept to provide the required RSA dimensions. Declared distances are a methodology used to mitigate non-compliance issues pertaining to RSA and Runway Object Free Area (ROFA) requirements. Due to land constraints, CEA cannot utilize the full-length pavement of either runway as there is not sufficient space for a fully compliant RSA off the end of runways 12, 30 and 24. The existing declared distances are shown in Table 3-10.

Table 3-10: Existing Declared Distances



Declared Distances Data Table

Item	Runway 12	Runway 30	Runway 6	Runway 24
Accelerate Stop Distance Available (ASDA)	4,083'	4,158'	3,463'	3,660'
Landing Distance Available (LDA)	3,786'	3,726'	3,109'	2,409'
Takeoff Distance Available (TODA)	4,083'	4,366'	3,463'	3,660'
Takeoff Run Available (TORA)	4,083'	4,158'	3,463'	3,660'

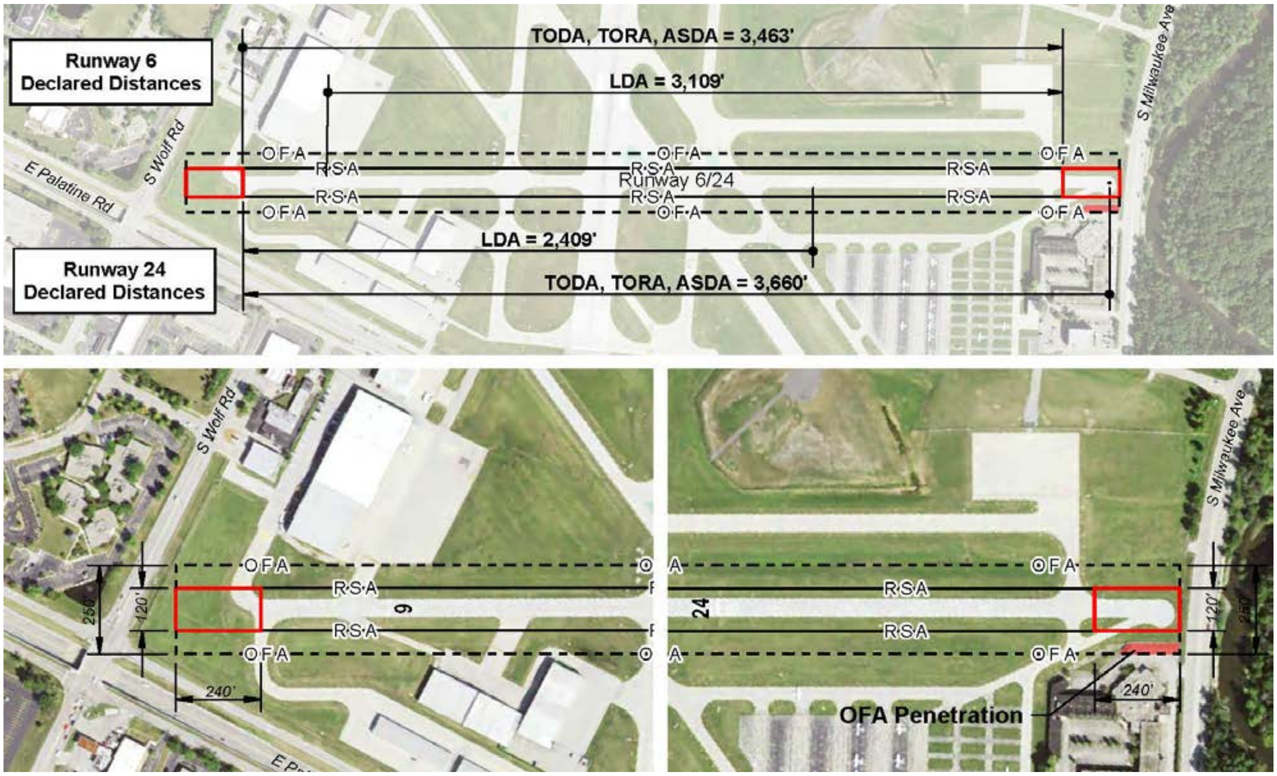
Source: FAA Approved ALP 2009

Additionally, Exhibits 3-2 and 3-3 depict the RSA's of Runway 12/30 and Runway 6/24.

Exhibit 3-2: Runway 12/30 RSA & OFA

Source: CMT Analysis (2017)

Exhibit 3-3:
Runway 6/24 RSA & OFA



Source: CMT Analysis (2017)

Runway Object Free Area

The Runway OFA is similar in shape and purpose to the RSA. It establishes a rectangular buffer around a runway from objects and operating aircraft. Airport facilities required for navigation or maneuvering such as NAVAIDs and taxiways are allowed within the ROFA. Some facilities that are typically not allowed within the ROFA can be permitted with an approved Modification To Standard (MOS). Table 3-11 shows the ROFA dimensions at CEA based on 13A standards.

Table 3-11:
Runway Object Free Area (ROFA) Dimensions

Runway Object Free Area Dimensions			
Design Surface	AC 150/5300-13A Standards		
	Runway 16/34	Runway 12/30	Runway 6/24
ROFA Length Beyond End	1,000'	300'	240'
ROFA Length Prior to Threshold	600'	300'	240'
ROFA Width	800'	500'	250'

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

Runway 16/34 Object Free Area

Similar to the RSA for Runway 16/34, a full-length ROFA is required and the existing ROFA does not fully comply with FAA standards. Exhibit 3-1 depicts the Runway 16/34 Object Free Area and the non-compliant areas.

Runway 12/30 and Runway 6/24 Object Free Areas

While both Runway 12/30 and Runway 6/24 achieve RSA compliance by utilizing declared distances to mitigate non-compliant RSAs, the declared distances do not completely mitigate non-compliant OFAs for Runways 12, 30 and 24. Exhibits 3-2 and 3-3 depict the OFAs and areas of non-compliance for Runway 12/30 and Runway 6/24.

Runway Protection Zone (RPZ)

The Runway Protection Zone (RPZ) is a trapezoid located on each end of the runway. The RPZ acts as a protective horizontal surface to people and property on the ground. Similar to the RSA, RPZ dimensions are established in AC 13A and are based on the RDC. For runways with declared distances, there are both a "departure" and "approach" RPZ. Runway 16/34 ends have two different approach visibility minimums (Runway 16 is 1-mile and Runway 34 is a visual) and therefore have two different size Approach RPZs. Table 3-12 depicts the RPZ dimensions at CEA based on 13A standards.

Table 3-12:
Runway Protection Zone (RPZ) Dimensions

Approach RPZ Dimensions				
Surface	Runway 16	Runway 34	Runway 12/30	Runway 6/24
Length	1,700'	1,700'	1,000'	1,000'
Inner Width	1,000'	500'	250'	250'
Outer Width	1,510'	1,010'	450'	450'

Departure RPZ Dimensions				
Surface	Runway 16	Runway 34	Runway 12/30	Runway 6/24
Length	1,700'	1,700'	1,000'	1,000'
Inner Width	500'	500'	250'	250'
Outer Width	1,010'	1,010'	450'	450'

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

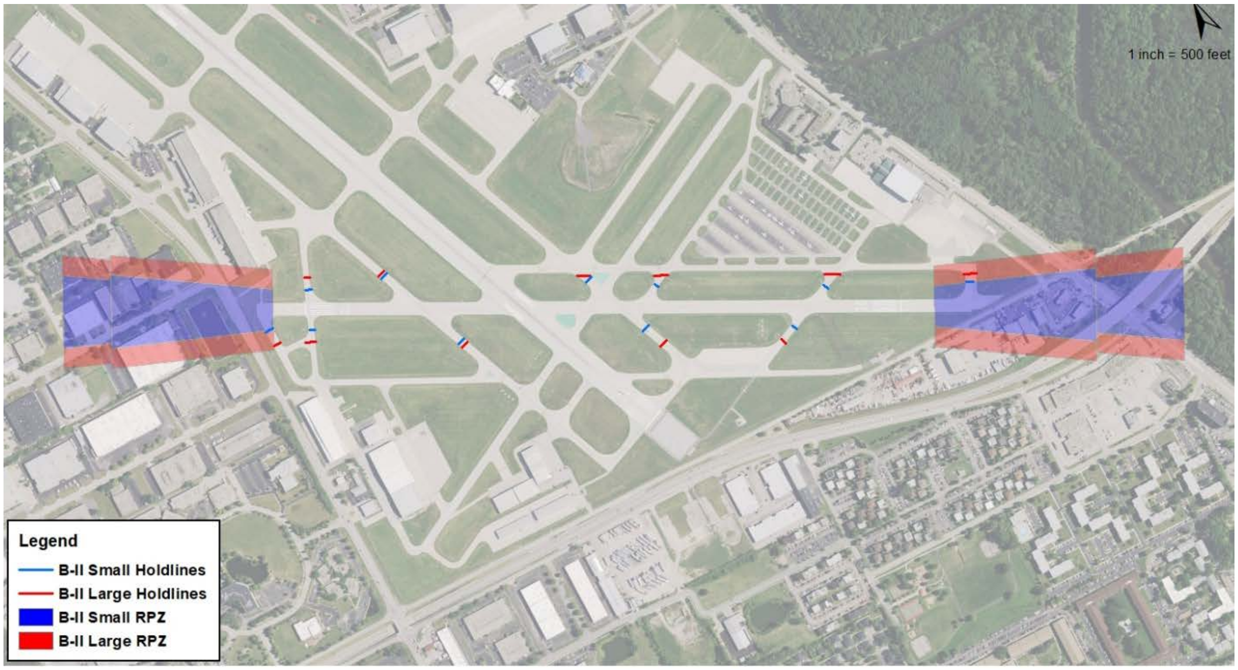
Due to the constrained nature of CEA, each RPZ contains some level of incompatible land use. At the time that this facility requirements was written, the FAA memorandum, "Interim Guidance on Land Uses within an RPZ," allows for incompatible land to exist within RPZs that were established prior to the publication of the memo. The language in this memo appears to exempt Runway 16/34 and Runway 6/24 from needing future modification because these runways will remain unchanged. However, since the critical aircraft for Runway 12/30 is recommended to increase in size from B-II Small to B-II Large, the inner and outer width dimensions of the RPZ will increase as well. Table 3-13 shows existing dimensions of a B-II Small runway RPZ and a future B-II Large runway RPZ, and Exhibit 3-4 graphically depicts the RPZ dimensions. While the RSA and OFA do not change when the Runway 12/30 RDC increases, the runway holding position markings will change in addition to the RPZ dimensions. The holding position marking changes are also shown on Exhibit 3-4. It is recommended that CEA coordinate with FAA and IDA during review of this section to understand the requirements (if any) pertaining to the Runway 12/30 RPZ.

Table 3-13:
Existing and Future RPZ Dimensions – Runway 12/30

Runway 12/30 RPZ Dimensions for increased RDC		
Design Surface	AC 150/5300-13A Standards	
	Exsisting B-II Small	Future B-II Large
RSA	300' x 300' x 150'	300' x 300' x 150'
ROFA	300' x 300' x 500'	300' x 300' x 500'
RPZ	1,000' x 250' x 450'	1,000' x 500' x 700'

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

Exhibit 3-4:
Runway 12/30 RDC B-II Small vs. B-II Large RPZ & Holding Position Markings



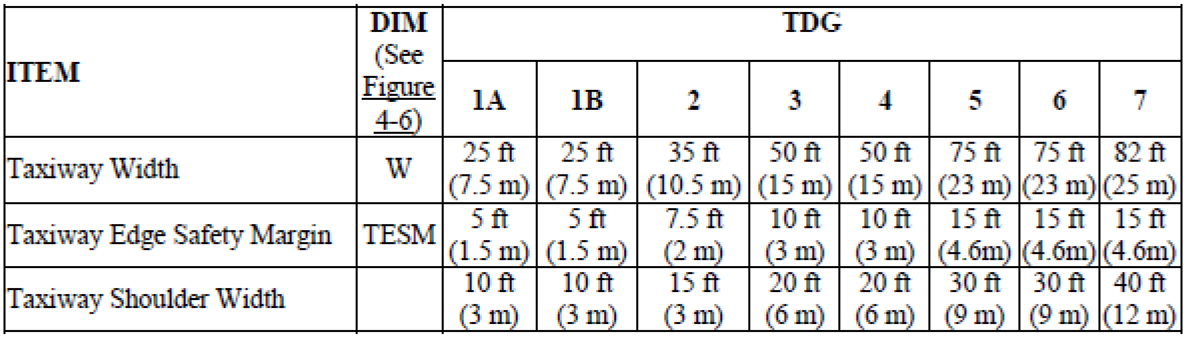
Source: CMT Analysis (2017)

3.5 Taxiway Design Standards

Taxiway design at CEA should meet the standards set forth in 13A, *Airport Design*. Taxiways should be able to accommodate the most demanding aircraft anticipated at the airport, for both existing and anticipated aircraft. Sufficient taxiway width, taxiway safety area, taxiway object free (TOFA) area and taxiway/runway and taxiway/taxiway separation distances should be met.

Taxiway Design Groups (TDG) are established by aircraft characteristics of the aircraft operating on the taxiway. The TDG is a byproduct of the RDC and the type of aircraft operating on the runway (ADG), as a taxiway associated with the runway should be able to accommodate the same type aircraft. The TDG and ADG will determine the taxiway design standards that should be used. Table 3-14 illustrates taxiway design standards based on TDG.

Table 3-14:
Design Standards Based on Taxiway Design Group (TDG)



ITEM	DIM (See Figure 4-6)	TDG							
		1A	1B	2	3	4	5	6	7
Taxiway Width	W	25 ft (7.5 m)	25 ft (7.5 m)	35 ft (10.5 m)	50 ft (15 m)	50 ft (15 m)	75 ft (23 m)	75 ft (23 m)	82 ft (25 m)
Taxiway Edge Safety Margin	TESM	5 ft (1.5 m)	5 ft (1.5 m)	7.5 ft (2 m)	10 ft (3 m)	10 ft (3 m)	15 ft (4.6m)	15 ft (4.6m)	15 ft (4.6m)
Taxiway Shoulder Width		10 ft (3 m)	10 ft (3 m)	15 ft (3 m)	20 ft (6 m)	20 ft (6 m)	30 ft (9 m)	30 ft (9 m)	40 ft (12 m)

Source: FAA Advisory Circular 150/5300-13A Airport Design

3.6 Taxiway Requirements

The RDC for Runway 16/34 is D-III, and of the largest aircraft in the D-III group (ex. Gulfstream 550 family) require a TDG 3 to operate. Therefore, all taxiways associated with Runway 16/34, and any other taxiways on the airfield that would be used by this group of aircraft, should be to the standards of TDG 3. Other taxiways on the airfield would include taxiways that are utilized to taxi to and from the FBOs and other corporate aircraft hangars.

The RDC of Runway 12/30 is recommended to be upgraded from a B-II Small to a B-II Large. The larger aircraft (ex. Cessna Citation Excel) using the runway and associated taxiways have characteristics that recommends a TDG 2. Table 3-15 illustrates all the taxiway widths and TDG categories at CEA.

Table 3-15:
CEA Taxiway Design Group

Taxiway	Width	TDG
A between Twy E & Twy F	35'	2
A between Twy E & Rwy 12/30	40'	2
A south of Rwy 12/30	35'	2
B between Rwy 12/30 & NE corner of ramp	35'	2
B between Rwy 24 hold & NE corner of ramp	23'-27'	1
C between Twy K & C-Ramp	50'	3
C between C-Ramp & Rwy 6/24	35'	2
D east of 34 Pad	40'	2
D west of 34 Pad	35'	2
D between Twy Y & Twy L	35'	2
D between Rwy 12/30 & Twy Y	50'	3
E	35'	2
E1	35'	2
F	30'	1
K	50'	3
K2	50'	3
K3	50'	3
K5	50'	3
L	50'	3
L1	50'	3
L2	50'	3
L3 east of Twy L	50'	3
L3 west of Twy L	35'	2
L4	50'	3
L5	50'	3
P	35'	2
Q	35'	2
T	35'	2
Y	35'	2
Z	35'	2

Source: CMT (2017)

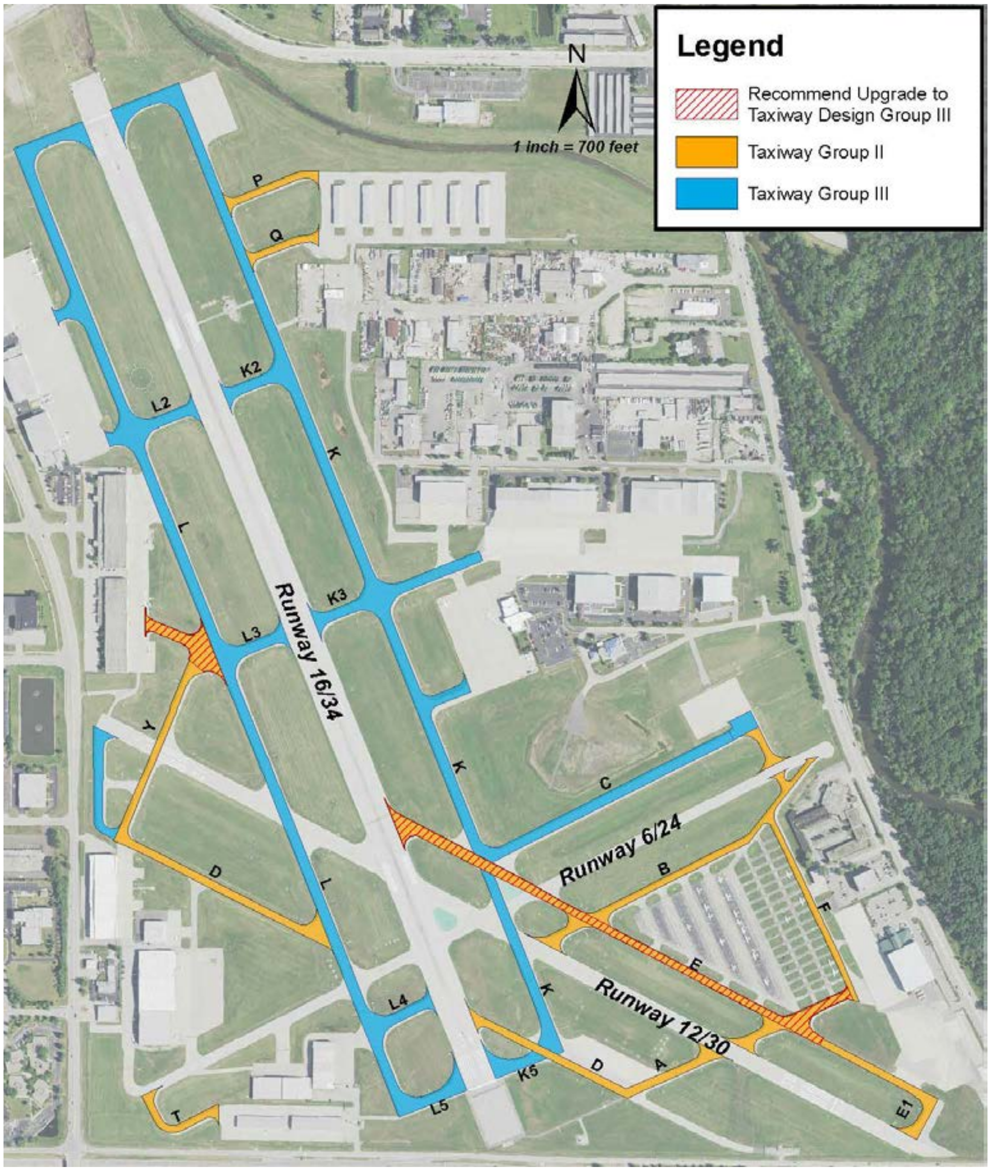
As shown in Table 3-15, with an exception to part of Taxiways B and F, the smallest taxiway width is 35 feet which falls under TDG 2.

As discussed in the forecast section, based aircraft and aircraft operations are projected to have negative growth in the piston aircraft segment, while showing positive growth within the turboprop and jet categories. For this reason, it is recommended that at a minimum, all taxiways not associated with Runway 16/34, the FBOs and other corporate hangars be designed per TDG2 standards

Taxiway Width and Shoulder Requirements

Taxiways that utilize the TDG 3 design standard require a taxiway width of 50 feet and taxiways that utilize the TDG 2 design standard require a taxiway width of 35 feet. Taxiway A, Taxiway E, and Taxiway L3 west of Taxiway L are all TDG II taxiways. Given their proximity to FBOs or corporate hangars, these taxiways could be utilized by ADG III aircraft. Therefore, it is recommended that Taxiway A between Taxiways E and F, Taxiway E between Taxiway A and Runway 16/34, and Taxiway L3 between Taxiway L and the west ramp be upgraded to TDG III as Exhibit 3-5 illustrates.

Exhibit 3-5:
Recommended TDG Upgrades



Source: FAA Advisory Circular 150/5300-13A Airport Design & CMT Analysis (2017)

According to AC 13A, paved shoulders are only required for taxiways accommodating ADG-IV or higher. Since CEA's highest ADG will be ADG-III, the advisory circular states that paved shoulders are not required for ADG-III. Because of this, no upgrades to the existing turf shoulders are recommended.

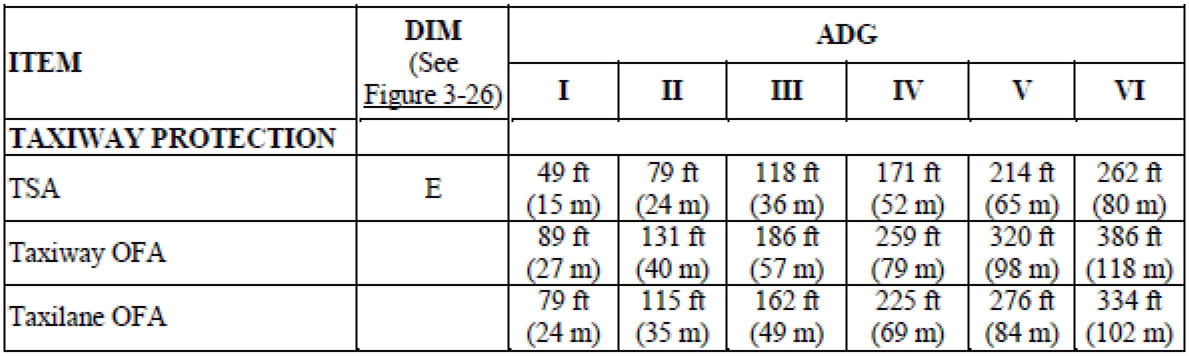
Taxiway Safety Area

The Taxiway Safety Area (TSA) is an area surrounding the area of a taxiway that prevents damage to aircraft that veer from the taxiway. The TSA dimension is based on the ADG of the aircraft. There are currently no penetrations to the airfield TSAs. Table 3-16 represents the TSA dimension requirements.

Taxiway Obstruction Free Area

The Taxiway Object Free Area (TOFA) is similar to the TSA but wider. It is also based on the ADG of aircraft that uses the taxiway. Table 3-16 depicts the TOFA dimension of each taxiway at CEA. There are no existing penetrations to the CEA TOFA.

Table 3-16:
Design Standards Based on Airplane Design Group (ADG)



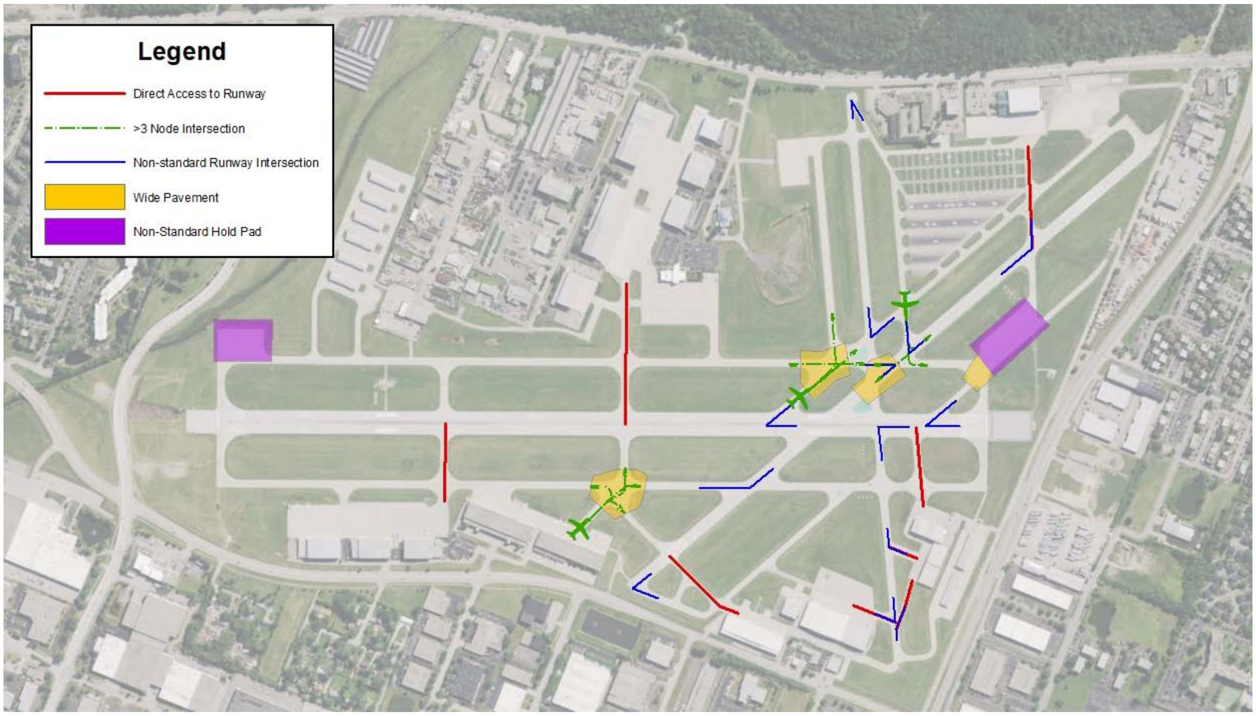
ITEM	DIM (See Figure 3-26)	ADG					
		I	II	III	IV	V	VI
TAXIWAY PROTECTION							
TSA	E	49 ft (15 m)	79 ft (24 m)	118 ft (36 m)	171 ft (52 m)	214 ft (65 m)	262 ft (80 m)
Taxiway OFA		89 ft (27 m)	131 ft (40 m)	186 ft (57 m)	259 ft (79 m)	320 ft (98 m)	386 ft (118 m)
Taxilane OFA		79 ft (24 m)	115 ft (35 m)	162 ft (49 m)	225 ft (69 m)	276 ft (84 m)	334 ft (102 m)

Source: FAA Advisory Circular 150/5300-13A Airport Design

Taxiway Geometry

AC 13A includes new guidance on taxiway geometry. The guidance contained in 13A strives to enhance airfield safety by avoiding runway incursions through the use of airfield geometric improvements that require more deliberate taxi movements and increase pilot situational awareness. An analysis of this geometry was conducted at CEA to determine the number of non-compliant elements. Exhibit 3-6 shows the locations of non-compliant geometry.

Exhibit 3-6:
Taxiway Geometry Compliance Assessment



Source: FAA Advisory Circular 150/5300-13A Airport Design

Potential mitigation options for the following non-compliant locations will be further evaluated in the Alternatives section of this master plan. The locations of non-compliant geometry areas shown above are described below.

<u>Direct Access to Runway</u>

As stated in 13A "do not design taxiways to lead directly from an apron to a runway without requiring a turn." As shown in Exhibit 3-6, there are eight locations that do not comply with direct access guidance. The eight direct access locations are also displayed as a matrix in Table 3-17.

<u>3 Node Intersection</u>

This concept states that a pilot should be presented with no more than three choices at an intersection – ideally, left, right, and straight ahead. There are three areas, as shown in Exhibit 3-6, that are non-compliant with the 3-node concept. These three locations are also displayed as a matrix in Table 3-17.

Non-standard Intersection Angles

Taxiway and runway intersections should be designed so that turns are at 90-degree angles wherever possible. This gives a pilot the best view, both to the left and right, when approaching or crossing a runway. The preferred standard intersection angles are 30, 45, 60, 90, 120, 135, and 150 degrees. There are 13 taxiway/runway intersection that are non-standard as in Exhibit 3-6. The 13 locations are also displayed as a matrix in Table 3-17.

Wide Pavement

AC 13A states "taxiway to runway interface encompassing wide expanses of pavement is not recommended." Wide expanses of pavement can cause a loss of situational awareness as signs and other visual cues are placed farther from the pilot's view. There are four areas that have been identified as "wide expanses of pavement" as shown on the map in Exhibit 3-6. The four areas locations are also displayed as a matrix in Table 3-17.

Non-standard Hold Pad

A holding pad (or holding bay) is used to provide a space for aircraft waiting clearance and to permit aircraft already cleared to move to their runway takeoff position. The design of a holding pad should have clearly marked entrance/exit points and allow for aircraft to bypass one another to taxi to the runway. As shown is Exhibit 3-6 there are two non-standard hold pads. These locations are also displayed as a matrix in Table 3-17.

Table 3-17:
Taxiway Geometry Compliance Assessment

Intersecting Taxiway Location	Direct Access Ramp to Runway	More than 3 Node Intersection	Non-Standard Intersection Angles	Wide Expanses of Pavement	Non-Standard Holding Pad
Taxiway A					
12/30	✓		✓		
Taxiway B					
K & 12/30		✓			
6/24			✓		
12/30			✓		
Taxiway C					
E/K		✓		✓	
Taxiway D					
K/K5				✓	
12/30			✓		
16/34			✓		
34 Pad					✓
Taxiway E					
6/24			✓		
16/34			✓		
Taxiway K					
6/24 & 12/30				✓	
12/30			✓		
16 Pad					✓
Taxiway K3					
16/34	✓				
Taxiway L					
L3/Y		✓		✓	
12/30			✓		
Taxiway L2					
L					
16/34	✓				
Taxiway L4					
16/34	✓				
Taxiway Y					
12/30	✓				
Runway 6/24					
16/34			✓		
Hangar 6 Access Pavement					
6/24	✓		✓		
Hangar 7 East Access Pavement					
6/24	✓		✓		
Hangar 7 West Access Pavement					
6/24	✓		✓		

Source: CMT Analysis (2017)

3.7 NAVAIDS

Weather Analysis

An airport's NAVAIDs serve the important function of aiding aircraft with the safe navigation, approach, and operation at an airport. NAVAIDs can include radio navigation facilities, approach lighting systems, and airfield lighting. NAVAIDS are also important to providing all weather access to the airport.

Most NAVAIDs are utilized under inclement weather or under Instrument Flight Rules (IFR) operations. These conditions are associated with lower visibility and cloud clearances at an airport which increase a pilot's reliance on NAVAIDs to operate. As such, an assessment of historical weather at CEA was made to evaluate whether upgrades to the existing NAVAIDs are needed to accommodate future demand.

Five years of CEA's historic weather data from the NCDC was evaluated to estimate the number of times an instrument approach would be needed under different visibilities. Further analysis of this assessment will be evaluated in the following section.

Instrument Approaches

Instrument approaches are developed at an airport to guide an aircraft for landing under instrument weather conditions. There are many requirements that the airport and surrounding airspace must meet in order for an instrument approach to be implemented. CEA's location in Chicago's airspace is unique. CEA is immediately adjacent to Chicago O'Hare's Class Bravo airspace. Because of this location, CEA's airspace is constrained and limits accessibility by instrument approaches.

CEA currently has three instrument approaches – an ILS/LOC, RNAV (GPS) and VOR. Each of these approaches only serve Runway 16 and have visibility minimums of 1 mile.

To determine the degree at which visibility conditions would warrant lower visibility minimums to instrument approaches at CEA, an analysis of instrument weather conditions was conducted. This analysis calculated the average number of arrivals per hour under visibility conditions that would require an instrument approach. Table 3-18 displays the analysis for potential approaches impacted when visibility conditions fell below 1 mile in 2016. Using the constrained forecast, Table 3-18 also displays the approximate number of impacted approaches in 2036 when visibility conditions fall below 1 mile.

Table 3-18:
Instrument Approach Analysis 2016 & 2036

	Estimated Annual Impacted Approaches 2016				
Time	Average Hourly Arrivals	*0 Vis*	*.25 Vis*	*.5 Vis*	*.75 Vis*
12:00 AM	1	0	2	4	5
1:00 AM	1	0	1	2	2
2:00 AM	0	0	1	0	1
3:00 AM	0	0	0	0	1
4:00 AM	0	0	1	1	3
5:00 AM	1	0	2	1	4
6:00 AM	2	0	4	4	10
7:00 AM	4	1	8	7	28
8:00 AM	5	0	7	9	16
9:00 AM	5	1	7	3	25
10:00 AM	6	0	7	5	16
11:00 AM	6	1	15	6	22
12:00 PM	7	3	14	20	22
1:00 PM	7	0	17	15	35
2:00 PM	8	0	17	11	30
3:00 PM	9	0	14	24	26
4:00 PM	9	0	16	21	48
5:00 PM	8	0	2	8	32
6:00 PM	7	0	4	8	26
7:00 PM	6	0	4	12	27
8:00 PM	4	0	3	9	16
9:00 PM	3	0	1	3	11
10:00 PM	3	0	2	5	13
11:00 PM	2	0	3	2	8
	Impacted Approaches	766	758	608	425

	Estimated Annual Impacted Approaches by 2036				
Time	Average Hourly Arrivals	*0 Vis*	*.25 Vis*	*.5 Vis*	*.75 Vis*
12:00 AM	1	0	2	4	6
1:00 AM	1	0	2	2	2
2:00 AM	0	0	1	1	1
3:00 AM	0	0	0	0	1
4:00 AM	0	0	1	1	3
5:00 AM	1	0	2	1	4
6:00 AM	2	0	5	4	10
7:00 AM	4	2	9	8	31
8:00 AM	5	0	8	10	17
9:00 AM	6	1	8	3	27
10:00 AM	6	0	7	5	17
11:00 AM	7	1	17	7	24
12:00 PM	7	3	15	22	23
1:00 PM	7	0	18	16	37
2:00 PM	8	0	18	12	32
3:00 PM	9	0	15	26	28
4:00 PM	10	0	17	23	52
5:00 PM	9	0	2	9	35
6:00 PM	7	0	4	9	28
7:00 PM	7	0	4	13	30
8:00 PM	4	0	4	10	17
9:00 PM	3	0	1	4	12
10:00 PM	3	0	2	5	14
11:00 PM	2	0	3	2	8
	Impacted Approaches	825	817	655	458

Source: CMT Analysis (2017)

In previous project phases, CMT conducted a CEA user survey to gain a better understanding of facility needs by users. One of the top two constraints users identified in the survey was the need for improved runway instrumentation. Based on this feedback combined with the analysis in Table 3-18, it is recommended CEA further investigate the feasibility of an improved instrument approach below 1-mile visibility.

Approach Lighting and Visual Aids

Runway 16 is currently equipped with a Non-Standard Lead-In Approach Light system (LDIN) and is the only runway equipped with approach lighting system (ALS).

Due to property ownership and airspace constraints, Runway 16 is considered the only runway where it would be feasible to enhance ILS approach capabilities. Should CEA desire to improve Runway 16 visibility minimums, a Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights (MALSR) is recommended to be installed. A MALSR is a type of ALS and is the standard for category I precision runways. A MALSR is capable of reducing visibility minimums for an instrument approach to .75-mile visibility.

4.0 Aircraft Parking and Storage

Aircraft parking and storage requirements are largely driven by aircraft size and owner preference. At CEA, aircraft are stored inside of a hangar or on an apron. The previous section, forecast, illustrates the trend that piston aircraft will be declining while turboprop and jet aircraft will be growing throughout the forecast period. The requirements of this section rely on the forecast demand and compare it with existing facilities to determine the future requirements for aircraft hangar space and apron space at CEA.

Hangar and Apron Space Assessment

To define how future aircraft storage space should be allocated, an assessment of the current aircraft parking inventory was completed. The assessment shows that there is approximately 1,000,000 – 1,230,000 square feet of existing apron space, and approximately 700,000 – 750,000 square feet of existing hangar space at CEA. The existing hangar space is aircraft storage and parking space only, and does not include additional space in hangars. Many hangars at CEA have additional space in the hangar buildings that are dedicated to office space, training rooms, pilot lounges, flight planning, parts inventory, etc. (non-aircraft storage areas). The "non-aircraft storage" areas appear to account for approximately an additional 20% space requirement, which brings the square footage of existing hangar buildings to approximately 876,000 square feet. Table 4-1 depicts the existing hangar space, calculating both aircraft and non-aircraft storage areas, and the existing apron space.

Table 4-1:
Hangar and Apron Space

Hangar & Apron Space	
Hangar Space (sq.ft.)	**Apron Space (sq.ft.)**
876,000	1,169,000
Total Space	**2,045,000**

Source: CMT Analysis (2017)

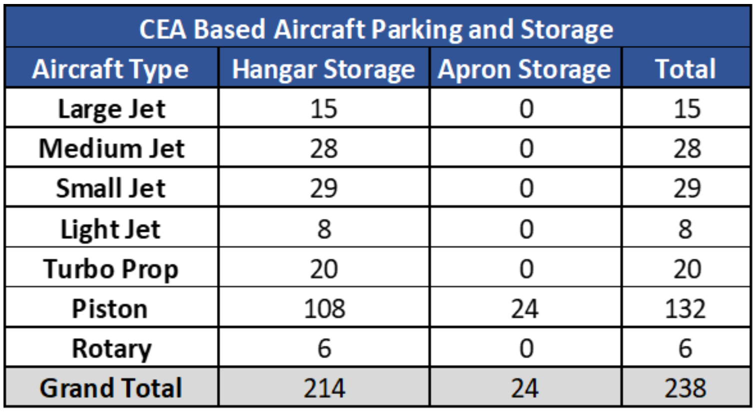
Apron areas at CEA vary greatly in size, configuration and use. For the purpose of the forthcoming analysis, it is assumed that any new apron area required to support proposed hangar storage area will be of equal size to the hangar storage area it supports.

4.1 Aircraft Hangar Requirements

In order to determine existing and future parking and storage space requirements, the approximate footprint of the aircraft utilizing the parking and storage can be determined. There are many ways aircraft can be stored inside of hangar; various sized aircraft can be staggered with minimal space in between, maximizing the usage of hangar space, or aircraft can be parked independently, with large clearances in between. The first step is to identify how many and what type of aircraft are based at CEA, and then determine the footprint each aircraft consumes.

The current Based Aircraft/Hangar Tenant list provided by CEA shows that 100% of based rotary, turbo prop, and jet aircraft are stored inside of hangars. Of the based piston aircraft, only 18% utilize tiedowns. Based on CEA's Based Aircraft/Tenant list Table 4-2 illustrates how aircraft parking and storage is allocated CEA.

Table 4-2:
Based Aircraft Parking Allocation



CEA Based Aircraft Parking and Storage			
Aircraft Type	**Hangar Storage**	**Apron Storage**	**Total**
Large Jet	15	0	15
Medium Jet	28	0	28
Small Jet	29	0	29
Light Jet	8	0	8
Turbo Prop	20	0	20
Piston	108	24	132
Rotary	6	0	6
Grand Total	214	24	238

Source: CEA Based Tenant/Hangar List

It should be noted that there is a significant variance between the FAA count of based aircraft and the airport's Based Tenant/Hangar list. The FAA count from CEA's 5010 Form, which was used in the previous forecast section of this report, shows 185 based aircraft at CEA, while the airport's Based Tenant/Hangar list shows 238. Additionally, FAA's National Based Aircraft Inventory Program was consulted as part of the planning process. The number of based aircraft shown in the Program fell in the range between the FAA 5010 count and the CEA count. For planning purposes, the FAA 5010 count and the CEA counts were utilized, as they represented the high and low ends of the based aircraft range. Table 4-3 illustrates the based aircraft count from both the FAA 5010 and CEA.

Table 4-3:
Based Aircraft Count – FAA & CEA

CEA Based Aircraft		
Aircraft Type	**FAA Count**	**CEA Count**
Large Jet	9	15
Medium Jet	11	28
Small Jet	38	29
Light Jet	6	8
TurboProp	27	20
Piston	94	132
Rotary	0	6
Grand Total	185	238

Source: FAA and CEA Based Tenant/Hangar List

The top five most common aircraft models from each aircraft type that operate at CEA were used as the sample to establish a baseline for calculating aircraft parking and storage requirements. To establish a square footage footprint of space each type of aircraft would approximately utilize, the average of all five aircraft's length times the width was used. 13A suggests using a minimum of 10 feet wingtip clearance when parking general aviation aircraft on aprons. This would add an additional 20 feet to the length and width of each aircraft when calculating the square footage. It appears that a more realistic scenario that mirrors the way aircraft are currently parked at CEA, would be to add only 10 feet to the total length and width of aircraft when calculating square footage. Table 4-4 illustrates the square footage requirements by aircraft type that were calculated.

Table 4-4:
Aircraft Square Footage

Aircraft Type & Space Requirements							
Aircraft Size	Rotary	Piston	Turbo-Prop	Light	Small	Medium	Large
Square Feet	2,650	2,118	3,582	2,957	4,105	5,713	10,011

Source: CMT Analysis (2017)

With the baseline of aircraft square footage space requirements established, it can be determined how existing and future aircraft utilize aircraft parking and storage at CEA.

4.2 Future Aircraft Hangars

When planning future aircraft parking and storage requirements, both constrained and unconstrained growth scenarios from the forecast section should be considered. Additionally, since there is a discrepancy in the total based aircraft count between the FAA and airport, this section will examine both of these scenarios as well.

Table 4-5 illustrates the minimum requirements needed to park and store aircraft only in hangars, and does not consider any office or "non-aircraft" storage areas. The table depicts approximate hangar square footage required when applying both forecasting methods, constrained and unconstrained, and the aircraft square footage values computed in Table 4-4 above to both the FAA's and CEA's based aircraft count.

Table 4-5:
Forecasted Aircraft Storage Requirements

Constrained Based Aircraft Forecast (FAA Count)							Total Hangar Sq.Ft. Req'd
Year	Piston	Turbo -Prop	Light Jet	Small Jet	Medium Jet	Large Jet	
2015	94	27	6	38	11	9	**620,588**
2036	91	41	12	81	24	15	**998,160**
Additional Hangar Space Required							**377,571**

Unconstrained Based Aircraft Forecast (FAA Count)							Total Hangar Sq.Ft. Req'd
Year	Piston	Turbo -Prop	Light	Small	Medium	Large	
2015	94	27	6	38	11	9	**620,588**
2036	85	39	11	77	25	31	**1,141,126**
Additional Hangar Space Required							**520,538**

Constrained Based Aircraft Forecast (CEA Count)							Total Hangar Sq.Ft. Req'd
Year	Piston	Turbo Prop	Light	Small	Medium	Large	
2015	132	20	8	29	28	15	**804,046**
2036	128	30	16	62	61	25	**1,287,626**
Additional Hangar Space Required							**483,580**

Unconstrained Based Aircraft Forecast (CEA Count)							Total Hangar Sq.Ft. Req'd
Year	Piston	Turbo -Prop	Light	Small	Medium	Large	
2015	132	20	8	29	28	15	**804,046**
2036	118	29	15	59	29	52	**1,356,253**
Additional Hangar Space Required							**552,207**

Source: CMT Analysis (2017)

It is important to note that the calculations above represent area required to store aircraft in hangars and are not intended to represent total development area.

Although the difference in square footage requirements differ based on forecast method and the number of based aircraft, the areas calculated provide a range that can serve as a foundation for additional calculations.

When additional hangar development items like non-aircraft space and apron space are added to the calculations above, the required total hangar and apron development area can be computed. Table 4-6 shows the hangar and apron space requirement. The next step is to assess the quantity of existing undeveloped land at CEA.

Table 4-6:
Future Hangar and Apron Space Requirements

Forecast Scenario	Hangar Space		Apron Space	Total Additional Hangar/Apron Space Required (sq.ft.)
	Aircraft Storage (sq.ft.)	Non-Aircraft Storage (sq.ft.)**	Equivalent Apron Space (sq.ft)	
FAA Constrained	377,571	75,514	377,571	830,656
FAA Unconstrained	520,538	104,108	520,538	1,145,184
CEA Constrained	483,580	96,716	483,580	1,063,876
CEA Unconstrained	552,207	110,441	552,207	1,214,855

** 20% used in calculation

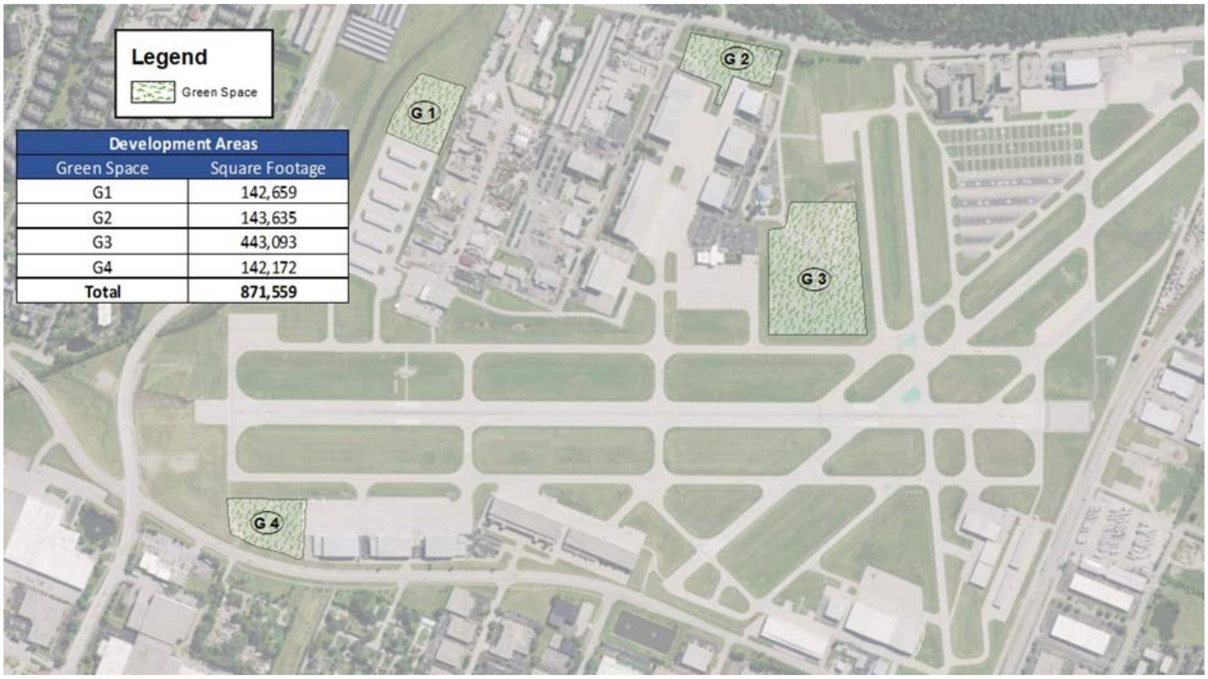
Source: FAA and CEA Based Tenant/Hangar List; CMT Analysis (2017)

4.3 Existing Development Space

For the purpose of this analysis, it is assumed that all new based aircraft will desire covered storage. This results in a greater future need for large box hangars rather than additional apron space. While specific aircraft storage will be further analyzed in the Alternatives section, the ability of the existing available development space at CEA to accommodate future demand can be assessed.

"Green space" at CEA consists of land that currently is undeveloped and would not require any change in airport surfaces or facilities to develop aircraft storage. Exhibit 4-1 summarizes these areas and includes the approximate square footage of each area.

Exhibit 4-1:
Green Space – Airfield Development Map



Development Areas	
Green Space	Square Footage
G1	142,659
G2	143,635
G3	443,093
G4	142,172
Total	**871,559**

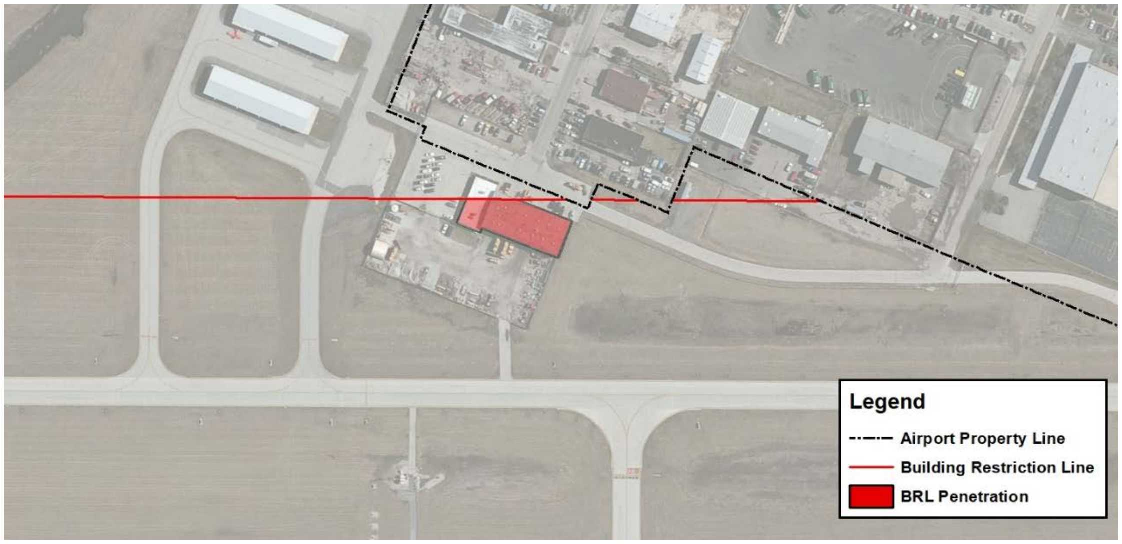
Source: CMT (2017)

While there is a total of approximately 872,000 square feet of available green space, it should also be noted that three of the four areas of green space may not be configured in a manner that would be suitable for a large corporate hangar development. For that reason, only Area G3 above is considered viable to accommodate the forecasted growth in based medium and large jet aircraft.

4.4 Building Restriction Line

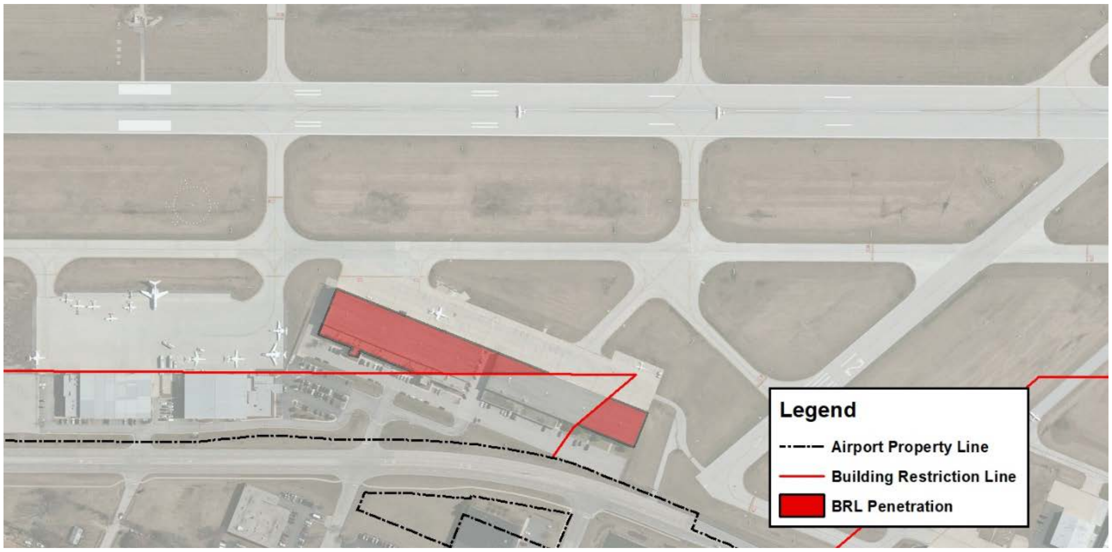
When planning for future facility locations, it is important to consider the Building Restriction Line (BRL). The BRL is the line that identifies suitable and unsuitable building locations at the airport. The BRL must be setback and clear of the RPZ, OFZ, OFA, runway visibility zone, NAVAID critical areas, areas required for terminal approach procedures (TERPS) and the air traffic control tower line of sight. There are several areas on the airfield where a building/facility penetrates the BRL. Exhibits 4-2, 4-3 and 4-4 depict these penetrations. It is recommended that potential feasible mitigation options be evaluated in future report sections, and that any future development on the airfield does not penetrate the BRL.

Exhibit 4-2:
BRL Penetrations – NE Quadrant



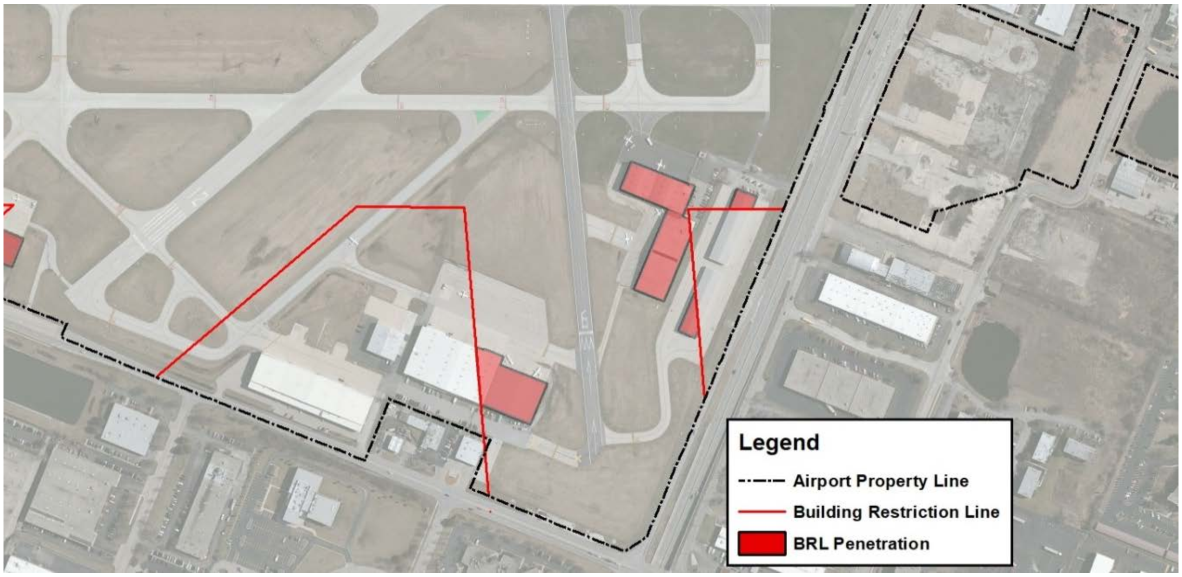
Source: CMT (2017)

Exhibit 4-3:
BRL Penetrations – NW Quadrant



Source: CMT (2017)

Exhibit 4-4:
BRL Penetrations – SW Quadrant



Source: CMT (2017)

4.5 Automobile Parking

Planning for adequate vehicle parking requirements is a necessary element for CEA. Vehicle parking is used by employees who work at the airport, based aircraft tenants, and transient passengers utilizing the airport facility. A vehicle parking analysis was conducted at CEA to determine future vehicle parking requirements.

In the previously conducted CEA user survey, automobile parking capacity was not raised as a specific concern by the users. Some areas, however, have been observed to be at or near their capacity. For example, it has been observed that vehicle parking near Atlantic Aviation in the northwest quadrant may reach capacity at times, as vehicles have been seen parking in grass areas due to parking stalls being filled. Parking utilization is highly variable. For example, FBOs may utilize the available parking space more than other tenants. Because of this variability, the current ratio of hangar space to parking stalls was assumed to remain constant in the future and will be utilized in this calculation.

Currently, there are approximately 951 parking stalls and approximately 730,000 square feet of hangar space at CEA. This represents one vehicle parking stall per 767 square feet of hangar space. Future hangar space requirements differ based on the forecasting scenarios discussed in Section 4.2 and 4.3. Per the four scenarios illustrated in Table 4-7, CEA will need approximately 591 – 864 additional parking stalls by 2036. General industry standards for parking lot planning and design state that a typical 9 foot by 19 foot parking stall will require approximately 300 square feet of development area when circulation and other miscellaneous items are considered. The total development space required (hangar, apron, and parking lots) is shown in the last column of Table 4-7.

Table 4-7:
Automobile Parking Requirements

Forecast Scenario	Total Addition Hangar Space Required (sq.ft.)	# of Additional Parking Stalls Required	Parking Lot Space Requirement (sq.ft.)	TOTAL DEVELOPMENT SPACE REQUIRED (sq.ft.)
FAA Constrained	453,085	591	177,217	**1,007,873**
FAA Unconstrained	624,646	814	244,320	**1,389,504**
CEA Constrained	580,296	757	226,974	**1,290,850**
CEA Unconstrained	662,648	864	259,185	**1,474,040**

Source: CMT Analysis (2017)

4.6 Aircraft Parking and Storage Summary

Regardless of the forecast scenario, growth is anticipated at CEA. The limited amount of green space available will likely not be sufficient to accommodate future growth. It is recommended that future report sections evaluate alternatives to meet future demand. Table 4-8 shows the additional space requirements needed for each forecast scenario. It should be noted that the total additional storage requirements don't consider taxiways, taxilanes and associated object free areas, stormwater detention requirements and other miscellaneous improvements. It is recommended that these values be considered minimum development requirements and that the alternatives consider providing additional space, if practical.

Table 4-8:
Additional Space Requirements

Forecast Scenario	Total Development Space Required (sq.ft.)	Available Green (sq.ft.)	Additional Space Requirements (sq.ft.)
FAA Constrained	1,007,873	443,000	**564,873**
FAA Unconstrained	1,389,504	443,000	**946,504**
CEA Constrained	1,290,850	443,000	**847,850**
CEA Unconstrained	1,474,040	443,000	**1,031,040**

Source: CMT Analysis (2017)

5.0 Landside Facility Requirements

5.1 Airport Administration Building

The airport administration office is located in the northeast quadrant of the airport off Industrial Lane and Plant Road. The building that is currently occupied is outdated and adjacent to the airport maintenance facility. Additionally, the building is located within the BRL as shown in Exhibit 4-2. Replacement of this facility is recommended. Subsequent sections of this master plan will address the needs and location of a new airport administration building.

5.2 Airport Maintenance

The current maintenance building is adjacent to the airport's administration offices in the northeast quadrant of the airfield just south of Taxiway Q. The maintenance building provides access from landside and airside. It is a dual-purpose facility, doubling as a maintenance building and a Snow Removal Equipment (SRE) storage building. The building is outdated and undersized. Additionally, as shown in Exhibit 4-2, it is within the Building Restriction Line (BRL). It is recommended that CEA plan on building a new, modern facility that can accommodate the airport's needs. Subsequent sections of this master plan will further examine location and size criteria for a new maintenance facility.

5.3 United States Customs and Border Protection

The United States Customs and Border Protection (CBP) is part of the U.S. Department of Homeland Security (DHS) and carries out the mission of facilitating lawful international travel and trade. At CEA, CBP typically provides screening services to accommodate international arriving passengers. CBP is currently occupying space in the Atlantic Aviation FBO facility to conduct screening services, as well as utilizing the apron space for aircraft parking. CEA has been notified by CBP that, due to changes in DHS standards, the airport will be required to develop a new standalone facility to accommodate their operations and services. Additionally, the new facility will also need to incorporate apron space for international arrival aircraft to park while CBP services are being conducted. It is recommended that a new location for a CBP facility be sited in a neutral airfield area, that is not associated with any of the three existing FBOs.

5.4 Aircraft Fueling

Fueling operations at CEA are conducted by and are the responsibility of the FBOs. For this reason, this section will concentrate on fuel capacity requirements as it relates to land and space requirements, and will not focus on the governance of fueling operations. This section will include an examination of the airport's existing fuel capacity and will be compared to the forecasted demand for fuel.

Each FBO has its own fuel farm area located in the vicinity of its building. Currently, there is a cumulative fuel capacity among all the FBOs of 154,000 gallons of Jet-A and 47,500 gallons of 100LL. According to the constrained operations forecast – medium growth, jet and turbo-prop operations are forecast to increase 21% throughout the next 20 years and piston aircraft are forecasted to decline 50% during the same period. Given current capacity and fuel tank refueling schedule, calculations can be made for gallons per operation. Therefore, as shown in Table 5-1, demand for 100LL fuel will decrease while the need for Jet-A will increase according to the constrained forecast. Table 5-1 also illustrates fuel capacity given an unconstrained forecast growth occurs.

Table 5-1:
Aircraft Fuel Storage Requirements

Constrained - Medium Growth Forecast		
100 LL - 50% Decrease		
(Capacity 47,500 gal)		
	2016	2036
Operations	15,047	7,541
Fuel Capacity (gal)	47,500	23,805
Jet-A - 21% Increase		
(Capacity 154,000 gal)		
	2016	2036
Operations	61,564	74,701
Fuel Capacity (gal)	154,000	186,862

Unconstrained - Medium Growth Forecast		
100LL - 40% Decrease		
(Capacity 47,500 gal)		
	2016	2036
Operations	14,898	6,011
Fuel Capacity (gal)	47,500	19,165
Jet-A - 54% Increase		
(Capacity 154,000 gal)		
	2016	2036
Operations	61,963	95,589
Fuel Capacity (gal)	154,000	237,572

Source: CMT Analysis (2015)

In order to accommodate future fuel demand, either the frequency of fuel tank refills will need to increase, or, to reduce or maintain the current refill frequency, additional Jet-A tank capacity will be needed. The analysis above assumes that gallons per operation will remain constant across both constrained and unconstrained forecast scenarios. It should be noted that, in the unconstrained scenario, it is likely that gallons per operation will increase due to changes in the projected fleet mix, particularly in the medium and large jet segments, and the reduction on weight restricted takeoffs. Therefore, the fuel capacity projections for the unconstrained growth scenario may actually underestimate the actual requirement. It is recommended that future master plan phases provide appropriate areas to allow for expansion of each respective FBO fuel farm to accommodate projected increases in future fuel demand.

5.5 Rental Car Facilities

Car rental facilities at an airport provide customers the convenience of being able to rent a vehicle on airport property rather than travel off airport property Car rental facilities at CEA are currently provided through all three FBO's rather than standalone rental companies. Customers can make reservations and rent vehicles from well-known rental agencies, such as National or Hertz, and pick up the vehicle at one of the FBO's. The FBO's do not stock a large inventory of vehicles and therefore do not require many parking stalls for these vehicles. As the airport continues to grow in the future, the number of parking stalls required that are outlined in Section 4.5 should be able to accommodate future rental car parking.

5.6 Airport Access

The airport facilities can be accessed from the East, West and South sides of the airport. Hangars and FBO's on the west side of the airfield are accessible via entrance roads from S. Wolf Rd. The hangars in the southeast corner of the airfield can be accessed from Palatine Frontage Rd. The T-hangars, corporate hangars, airport administration and maintenance building, and air traffic control tower on the east side of the airfield can all be accessed via roads (Industrial Lane, Sumac Road, and Tower Drive) that connect to South Milwaukee Avenue. The existing roadway and ground access appears to be sufficient for the existing airport facilities layout. However, any future airport expansion could potentially warrant new access roadways. It is recommended that future roadways be considered during the Alternatives section of this report.

Direct public access to CEA can be accomplished by either cab (or other car service) or bus. Pace bus Route 272 provides weekday and Saturday service between Golf Mill Shopping Center in Niles and Hawthorn Mall in Vernon Hills via Wheeling along Milwaukee Ave. There are numerous bus stops along Milwaukee Avenue that would provide direct public access to the airport. Additionally, there are two Metra train stations within one and half miles of CEA. The Wheeling train station is north of CEA off of Wheeling Road and the Prospect Heights train station is south of CEA off of Wolf Road. CEA's current role does not warrant enhancements to the existing public transportation network. However, if significant future expansion occurs, it is recommended that CEA coordinate with the various public transportation agencies for future service enhancements.

5.7 Utilities

Utilities at the CEA are anticipated to be sufficient throughout the planning period. Additional utility infrastructure may be required to support construction of new or expanded facilities is specific areas, as depicted in previous sections of this report.

5.8 Drainage

CEA’s existing Master Drainage Study dates back to 2002 and permitted improvements to the airfield and adjacent developments. Most of the improvements that were depicted in the Study have been constructed and the basins permitted in the Study have nearly reached capacity. Should significant expansion occur in the future, it is recommended that a new Master Drainage Study be undertaken as a companion study to create a new roadmap for achieving regulatory compliance.

Appendix A

Facility Requirements

Chicago Executive Airport (PWK) Runway Length Assessment: Runway 16/34

By Lean Engineering

Chicago Executive Airport (PWK) Runway Length Assessment: Runway 16/34

1 Summary

LEAN/DragonFly conducted an initial aircraft performance based optimal runway length assessment for the Chicago Executive Airport on runway 16/34. The analysis considered the takeoff and landing performance characteristics of the Hawker 800XP, Cessna Citation 560XLS and Bombardier Global 6000 aircraft to include an integrated field length and obstacle clearance set of runway length extension recommendations. The optimal runway length determined from this assessment was determined to exist in a range of runway lengths between 5,700ft and 6,700ft based on the ability to deliver a payload range benefit to aircraft that would cover 95% – 99% of all operations at the airport.

Contents

2 Purpose

It should be noted that, while the development of required runway length in a standard Master Plan Facility Requirements section is intended to be irrespective of runway heading, the forthcoming analysis is based on extensions to runway 16/34 at PWK. The modeling effort associated with this runway length assessment utilizes existing conditions in the environment surrounding PWK to develop the optimal runway length. Existing runway 16/34 is utilized because of the availability of existing condition data to include in the simulation. An alternate runway heading (runway 9/27 or 3/21, for example) would not have sufficient existing condition data associated with it to perform a credible simulation. Given the general consistency of terrain and land use in the vicinity of PWK, however, it is anticipated that the recommended runway length associated with runway 16/34 could be applied to alternate runway headings, should subsequent Master Plan steps recommend an alternate heading.

3 Aeronautical Data and Geospatial Deconfliction

3.1 Current Aeronautical Information

The Chicago Executive Airport (PWK/KPWK) is located in Wheeling, IL in the northern suburbs of Chicago, USA. The airport is located within an independent class D airspace which is underneath Class B airspace centered on Chicago O'Hare International Airport (ORD/KORD) (See Figure 1). Because of Chicago Executive's proximity to O'Hare, the aeronautical data necessary to define the aircraft performance related airspace is somewhat more diverse than for airports which do not share a class B airspace.

Certain operational restrictions exist at the airport which are imposed through agreements with the Chicago Air Traffic Control Unit (C90 TRACON) that place non-weather based restrictions on takeoff and landings to some of the runways at Chicago Executive, including runway 16/34. These restrictions can be more clearly spotted in Figure 2, by noticing the wedge of class B airspace of what would otherwise be a 1900ft start to class B airspace immediately surrounding the airport. Due to the extremely close proximity to active approaches and departures at ORD, coupled with a wide range of high performance aircraft operations, require that any performance based runway length analysis need to consider runway preference for traffic purposes as well as the possibility of increased geospatial deconfliction from potential source duplication of obstacle detection between ORD, PWK, C90 and the overarching FAA Electronic Terrain and Obstacle Data (ETOD) program.

Figure 1 Terminal Area Chart for Chicago Depicting Class B Airspace

Figure 2 VFR Chart Depicting O'Hare and Chicago Executive Airports with Flight Corridors

All aeronautical data used in this assessment was compiled in the DragonFly Terminal+ system (shown in Figure 3). Aeronautical data necessary for aircraft performance based runway length assessments was exported from Terminal+ into customized one engine inoperative procedure design extensions of the Global Procedure Design System (GPD). Information included in the export covered:

- Runway definitions
- Airspace definitions
- NAVAID definitions
- Existing waypoints and fixes
- Obstacle information (post deconfliction)
- Terrain information (10m spacing)

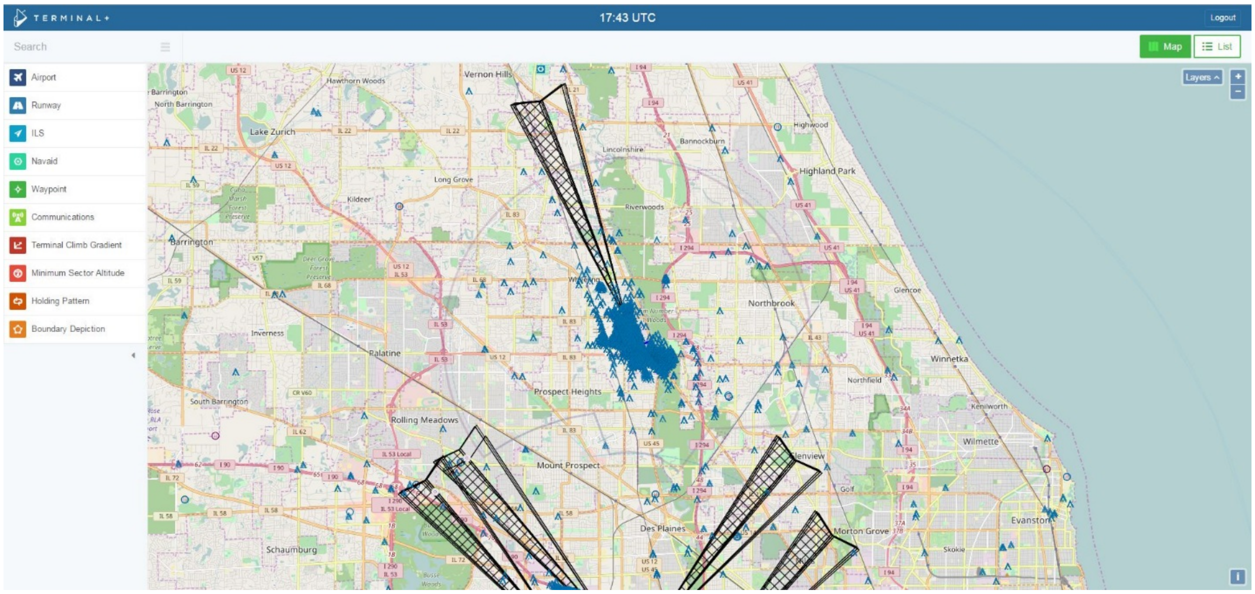


Figure 3 Image of LEAN/DragonFly Terminal+ Interface Centered on KPWK, Blue Triangles are Obstacles

Current runway, NAVAID, airspace and waypoint information was automatically imported into Terminal+ from FAA sources including NFDC, eNASR, AVNIS and the CIFP as updated in the 27APR17 and 25MAY17 half AIRACs.

Runway 16 supports an active ILS approach procedure, however because there are no special departure procedures which require the use of the localizer for lateral guidance, and there are no steep or special missed approach considerations required for the approaches at KPWK (which could affect an aircraft performance based runway length assessment) no further analysis was performed in this assessment regarding the current or future compliance of any instrument approach or NAVAID with TERPS and FAA PBN criteria.

3.1.1 Runway 16/34

Runway 16/34 is the primary runway at the Chicago Executive Airport. It is currently a 5001ft x 150ft with EMAS installed on either end of the runway.

Runway 16 threshold is located at 42-7-23.9845 N, 87-54-25.6585 W at an elevation of 643ft MSL. Runway 16 is oriented in a 159° bearing from true north.

Runway 34 threshold is located at 42-6-37.9908 N, 87-54-1.4556 W an elevation of 644ft MSL. Runway 34 is oriented in a 339° bearing from true north.

For the purposes of this assessment the slope of the runway was considered to be uniform between the two thresholds producing a slope of 0.03% uphill in the runway 16 direction and 0.03% downhill in the 34 direction.

The runway currently does not have any declared distance information, nor does it utilize a displaced threshold for landing. In the absence of airport maintained values, the declared distances assumed for the purposes of aircraft performance considerations are shown below in Table 1 Runway 16/34 Characteristics**.**

Table 1 Runway 16/34 Characteristics

Ident	Elevation (ft MSL)	Slope	Width (ft)	TORA (ft)	TODA (ft)	ASDA (ft)	LDA (ft)
16	643	0.03%	150	5001	5001	5001	5001
34	644	-0.03%	150	5001	5001	5001	5001

Runway 16/34 has a current published weight limitation of 72,000lbs for single gear configured aircraft and 98,000lbs for dual wheel aircraft. For the purposes of this assessment, both runway bearing strength limitations were assumed to be advisory so as not to prevent large cabin aircraft from being restricted to runway length recommendations that were beneath their maximum structural takeoff weight capabilities.

3.1.2 Entry/Exit to Runway 16/34

For the purposes of a runway extension assessment it is necessary to identify the taxiway entry angles that could be considered for the current and future runway orientation. The entry angles are used to compute the point at which the aircraft becomes aligned with the runway centerline which can consume 0ft to 200ft of the available distances depending on whether the taxiway alignment is coincident with the runway centerline (0ft) or the taxiway is 180 degrees off alignment (a hammerhead or turnaround point).

The current runway 16/34 is supported by standard width, 90-degree entry taxiways which would generate an alignment distance of approximately 50ft for the aircraft considered in this assessment. Any possible runway extensions were assumed to also have a 90-degree entrance at the threshold location for the start of the takeoff roll, and the 50ft alignment distance was therefore carried forward as a part of the runway length requirement.

For landing purposes, the alignment of the exit taxiway is not taken into consideration for stopping performance except under unusual circumstances. Therefore, no loss of landing distance for taxiway alignment was assumed in this assessment.

3.2 Current Geospatial Information

3.2.1 Magnetic Variation

The current magnetic variation, per the World Magnetic Model (maintained by NCEI), was calculated at the time of this assessment to be 3.72° W with a 0.06° W growth per year. However, the FAA is maintaining data for the airport based on the year 2000 epoch variation of 2.00° W. The difference between the two modes will only be important for this runway length assessment if an aircraft operator presents a navigation mode for one engine inoperative obstacle avoidance which utilized GPS based heading guidance instead of extended runway centerline or localizer back course guidance. At the time of this assessment, no such procedures were known to exist and therefore the discrepancy between the magnetic variations was not considered. The FAA default value of 2.00° W was used for all subsequent analysis.

3.2.2 Obstacles

Obstacle information was obtained from the following sources for the immediate vicinity surrounding the Chicago Executive Airport:

- PWK AC-150-5300-18, VGA Survey Collected on 26OCT12, Published on 12JUN13
- PWK ANA LPV Survey for runways 12/30 and 16/34 Collected on 10DEC10, Published on 22DEC11
- C90 Airspace FAA Daily Digital Obstacle File 08MAY17

Additional obstacle surveys were also collected and considered for airports that would overlap the one engine inoperative departure corridors along runway 16/34 extended centerline and runway 16 PAL-WAUKEE TWO TERPS areas. These included:

- ORD AC-150-5300-18, VGA Survey Collected on 29AUG13, Published on 03SEP13
- MDW AC-150-5300-18, VGA Survey Collected on 04OCT11, Published on 15JUN12
- UGN NOAA 405 Specification, PIR Survey Collected on NOV87

No consideration was given to potential obstacles identified through the OE/AAA process. It is recommended that any potential, or planned obstacles be taken into consideration should a runway extension project move into a detailed analysis of alternatives.

Close-In obstacle information, located near to the departure end of runway 16/34, was supplemented by a report entitled CEA All Rwy Ends FAA Obs Exhibits 1.3.14. This set of drawings depicted an updated survey of obstructions underneath the runway, approach and departure protection surfaces within a few thousand feet of the runways 12, 16, 30 and 34 thresholds.

The most notable obstacle issues facing the existing runway 16/34 are the presence of uncontrolled roadways located within the departure RPZs for both runway 16 and runway 34. Runway 16 departures, 34 arrivals, encounter potential vehicles up to 14ft above the DER along E Palatine Rd within 290ft of the departure end of the runway. Runway 34 departures encounter vehicles up to 19ft above the DER along Hintz Rd within 611ft of the departure end of the runway. There are also numerous apartment buildings, vegetative obstructions within the first few thousand feet of each runway.

3.2.3 Terrain

Terrain information incorporated into this assessment is based on the USGS National Elevation Dataset and 3DEP results forming a 10m spaced raster elevation set. A general land use land cover additive is applied to the terrain in areas either beneath, or beyond the extent of an airports Part 77 airspace protection program surfaces up to a height of 50ft.

While the terrain itself is not considered to play a major factor in a performance based runway assessment at the Chicago Executive Airport, it is important to point out that any turning departure procedures (current PAL-WAUKEE TWO) do place aircraft over rising terrain starting at the airport elevation of approximately 640ft MSL, and rising steadily to 1000ft MSL as aircraft proceed west into Kane or McHenry counties.

3.3 Geospatial Deconfliction

The primary geospatial deconfliction tasks for this assessment focused on repeated obstacle observations and out of date obstacle definitions along the extended runway centerline of 16/34. Most of the conflicts were created by older obstructions from the 2010 ANA LPV and even a few older obstructions which had been detected in the 1992 NOAA AOC PIR survey which had not been removed from the FAA DDOF files. These obstructions were removed where evidence suggested that the more recent VGA survey or with direct supporting evidence from "CEA All Rwy Ends FAA Obs Exhibits 1.3.14".

However, it should be noted that while no extensive deconfliction was performed along any other runway at Chicago Executive, the LEAN/DragonFly team noticed a significant number of obstacle deconfliction issues on runway 12/30 that could prevent successful aircraft performance or instrument procedure designs in the future. This includes several obstacles which were located "on" the runway itself and still considered to be current by several FAA obstacle databases.

4 Historical Weather Data

4.1 Overview and Sources Used

Historical weather information was compiled from two sources. The first source was the NCEI CDO hourly and off hourly observations of meteorological conditions emanating from the on field ASOS at the Chicago Executive Airport. Data used in this assessment was collected over a 10-year time period. Each historical observation was parsed into time weighted scores based on the duration of time for which the observation at the sensor array was valid. For example, if a weather report was issued at 09:05 and then another report was issued at 09:35, the validity of the specific weather conditions recorded at 09:05 would be considered to exist for 30 minutes. The time weighted entries were then broken into hourly equivalents (e.g. 30 minutes was 50% of an hour) and distributed into descriptive statistical results by hour, per month.

Following the hourly/monthly time weighted methodology, key variables associated with aircraft performance computations were determined including an analysis of temperature, pressure, runway capability and preference (related to wind), wet runway conditions and anti-ice usage. The values for weather conditions which have descriptive statistical values that can be directly applied to performance (e.g. temperature, pressure) were presented directly in table format. Weather conditions which did not have directly applicable descriptive statistics were summarized in terms of a likelihood of occurrence for the hour/month, expressed as a percentage.

A second source of historical weather information was provided for consideration in the form of historical Field Condition NOTAMs from the 2016 – 2017 winter season. This data represents a more detailed look into the kinds of potential runway surface contamination scenarios that aircraft operators would expect to encounter not just at Chicago Executive airport, but specifically on runway 16/34. This data set was meant to compliment, and in some cases, override traditional analysis derived from precipitation data taken from the NCEI CDO ASOS data points.

4.2 Applying Operator Experience and Insight to Historical Likelihoods

To match historical weather data, and derived percentage likelihoods, to operational experience, interviews were conducted with business jet operators that frequent Chicago Executive that helped corroborate past operational experience with statistical likelihoods. These interviews were combined with LEAN/DragonFly's experience interacting with forecasting techniques in place at other airlines, charter operators and promoted by the Society of Aircraft Performance and Operations Engineers. Of particular relevance were interviews conducted with NetJets Aviation regarding differences between their flight planning and operations on what they consider to be performance critical airports like Chicago Executive. The information and insight was used to create color grades which are applied to all the tables in this section.

4.3 NCEI CDO Weather Data

4.3.1 Temperature

The mean (Table 2 Mean Temperature at Chicago Executive Airport) and 85% confidence interval (Table 3 85% Confidence Interval Temperature at Chicago Executive Airport) temperature values were tabulated and presented in the following figures using an aircraft performance based color gradation. Cells presented in green represent temperatures that will not adversely impact aircraft performance, cells which are highlighted in yellow will have a moderate impact and cells highlighted in orange will have a significant impact on aircraft performance.

To achieve a fair assessment of aircraft performance based runway length to be considered at the airport, two temperatures were selected. A "Hot Day" value of 32C was taken from the 85% Confidence Interval analysis stemming from the midday July temperatures. This temperature represents the expected worst case temperature when planning for flights that are more than 7 days in the future and therefore represents a weather condition which aircraft operators would use to determine whether Chicago Executive Airport, and runway 16/34 was going to be suitable for their mission.

A value of 0C was used specifically for the winter months (NOV – MAR) to represent a temperature which could be expected to occur during periods of FICON values less than 5, and during specific runway contamination situations effected by snowfall. By using a temperature which was exactly average for that time period (across NOV – MAR) and still within the temperature range for anti-ice system usage (<10C OAT), this seemed like a good compromise to both ensure that typical engine bleed settings would be utilized without presenting an unrealistic temperature for a potential runway contamination scenario.

Table 2 Mean Temperature at Chicago Executive Airport

Mean Temperature (C)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0:00	-5.3	-4.5	2.1	7.1	12.8	18.1	21.1	20.5	16.2	10.2	4.0	-1.7
1:00	-5.3	-4.7	1.8	6.8	12.4	17.7	20.6	20.1	15.9	9.8	3.8	-2.0
2:00	-5.8	-5.0	1.6	6.5	11.9	17.3	20.4	19.8	15.6	9.5	3.4	-2.3
3:00	-5.8	-5.4	1.2	6.0	11.8	16.9	19.9	19.4	15.0	9.1	3.1	-2.2
4:00	-5.8	-5.5	0.9	5.8	11.5	16.7	19.5	19.2	15.0	9.0	3.0	-2.5
5:00	-6.0	-5.5	0.7	5.5	11.5	16.8	19.5	18.9	14.7	8.8	2.8	-2.5
6:00	-6.1	-5.8	0.8	5.9	12.6	18.0	20.6	19.5	14.7	8.7	2.7	-2.8
7:00	-5.9	-5.0	1.5	7.3	14.2	19.4	22.0	21.1	16.1	9.2	3.6	-2.5
8:00	-5.2	-4.1	2.7	8.6	15.7	20.7	23.6	22.6	17.9	10.8	5.0	-1.8
9:00	-4.6	-3.2	4.2	9.8	16.7	21.9	24.7	23.9	19.4	12.5	6.2	-1.2
10:00	-3.5	-2.3	4.7	10.8	17.7	22.8	25.5	24.9	20.5	13.5	7.1	-0.2
11:00	-2.8	-1.5	5.9	11.5	18.3	23.5	26.4	25.7	21.3	14.5	7.7	0.4
12:00	-2.3	-1.1	6.3	11.9	18.9	24.2	26.9	26.3	22.4	15.2	8.3	0.6
13:00	-2.2	-0.5	6.8	12.6	19.3	24.4	27.5	26.6	22.3	15.5	8.4	1.0
14:00	-2.0	-0.5	6.8	12.8	19.4	24.6	27.4	26.7	22.4	15.7	8.4	0.8
15:00	-2.2	-1.0	6.6	12.7	19.4	24.6	27.4	26.6	22.4	15.5	7.8	0.6
16:00	-3.0	-1.4	6.3	12.5	19.0	24.2	27.2	26.1	22.1	15.2	6.9	-0.3
17:00	-3.5	-1.5	5.6	11.7	18.4	23.7	26.7	25.6	21.2	14.1	6.4	-0.5
18:00	-3.8	-2.7	5.0	11.1	17.6	22.8	25.9	24.8	20.0	13.1	5.7	-0.6
19:00	-4.1	-3.1	4.1	9.9	16.5	21.9	24.9	23.6	18.7	12.1	5.3	-0.8
20:00	-5.6	-4.4	3.7	9.2	15.2	20.5	23.9	22.6	17.9	11.5	5.0	-1.1
21:00	-4.8	-3.9	3.2	8.6	14.4	19.8	22.8	21.9	17.3	11.2	4.5	-1.4
22:00	-4.6	-3.6	2.9	8.1	13.8	19.1	22.1	21.2	16.9	10.7	4.3	-1.4
23:00	-5.2	-3.9	2.5	7.6	13.4	18.5	21.7	20.8	16.4	10.4	4.1	-1.7

Table 3 85% Confidence Interval Temperature at Chicago Executive Airport

85% Temperature (C)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0:00	1.1	1.7	7.8	12.2	19.4	23.3	25.6	23.9	21.1	15.6	10.0	3.9
1:00	1.6	1.1	8.3	12.2	18.9	22.8	24.4	23.3	20.6	15.0	9.5	3.6
2:00	0.6	0.6	7.8	11.7	18.9	22.2	24.4	22.9	20.0	15.0	9.4	2.8
3:00	0.6	0.6	7.8	10.9	18.3	21.9	23.9	22.2	20.0	13.9	9.4	2.8
4:00	0.0	0.6	7.6	10.7	18.2	21.7	23.3	22.2	19.6	13.9	8.9	3.3
5:00	0.5	0.6	6.8	10.4	18.3	21.1	23.3	22.0	20.0	13.9	8.9	2.8
6:00	0.8	0.6	6.7	10.6	19.4	22.2	23.9	22.8	19.4	13.4	8.3	2.8
7:00	-0.1	1.1	7.8	12.2	20.6	23.3	25.6	23.3	20.6	14.4	8.9	2.8
8:00	1.7	2.2	8.9	13.9	22.2	25.6	27.2	25.6	22.4	16.1	11.1	3.3
9:00	2.2	3.3	11.1	15.6	23.9	26.7	28.9	26.7	23.3	18.3	12.2	4.4
10:00	3.8	3.9	12.2	17.6	25.0	27.8	30.0	28.3	25.0	20.0	13.9	6.1
11:00	3.9	5.0	12.8	18.9	26.1	28.3	30.6	29.4	26.7	21.1	14.9	6.1
12:00	5.0	6.4	14.4	20.0	26.7	29.4	31.1	30.0	27.2	21.7	15.3	6.7
13:00	4.4	6.7	15.0	20.6	27.2	30.0	31.7	30.6	27.8	22.2	15.6	7.2
14:00	4.4	6.4	15.5	21.1	27.2	30.0	31.7	30.6	28.3	22.8	15.6	7.2
15:00	4.4	5.6	16.1	21.1	27.2	30.6	31.7	30.6	28.3	22.8	15.0	6.7
16:00	3.9	5.0	15.6	21.1	26.7	30.0	31.7	30.0	27.8	22.2	13.3	5.0
17:00	2.7	3.6	14.4	20.6	26.1	29.4	31.1	29.4	27.2	20.6	13.3	4.4
18:00	2.2	2.8	13.0	19.4	25.2	28.9	30.6	28.3	26.1	19.4	11.7	5.0
19:00	2.2	2.9	10.9	17.2	23.3	27.8	29.4	27.2	24.4	17.8	11.1	5.0
20:00	1.7	2.8	10.0	16.1	22.2	26.1	28.3	26.1	23.3	17.2	10.9	4.4
21:00	1.1	2.2	9.4	15.0	21.1	25.0	27.2	25.0	22.8	16.7	10.6	4.4
22:00	1.7	2.2	9.4	13.8	19.4	24.4	26.1	24.4	22.2	16.2	10.0	3.9
23:00	1.1	2.2	8.6	12.9	19.4	23.9	26.1	24.4	21.1	15.8	9.4	3.9

4.3.2 Pressure

The mean pressure values (Table 4 Mean Pressure at Chicago Executive Airport) were tabulated and presented in the following figures using an aircraft performance based color gradation. Cells presented in green represent pressures that will benefit aircraft performance computations, cells which are highlighted in white will have no impact on aircraft performance and cells highlighted in yellow will have a moderate impact on aircraft performance.

Because Chicago Executive is located at a relatively low elevation (643ft MSL) the effects of non-standard pressure on aircraft performance are going to be significantly less influential to runway length or obstacle clearance than they would be at airports at elevations of 2000ft MSL or higher. Therefore, since the historical pressure values seemed to be mostly positive, and given that many business jet operators will not take non-standard pressure into consideration prior to lining up on the runway for departure, a value of 29.92 in Hg was selected to ensure that no significant benefit was awarded to the runway length assessments.

Table 4 Mean Pressure at Chicago Executive Airport

Mean QNH (inHg)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0:00	30.0436	30.0381	30.0644	29.9616	29.9816	29.9479	29.9884	30.0039	30.0565	30.0136	30.0806	30.0736
1:00	30.0509	30.0389	30.0667	29.963	29.9734	29.9444	29.9823	30.0024	30.0501	30.0147	30.081	30.0725
2:00	30.055	30.0357	30.0638	29.9476	29.9702	29.9457	29.9814	29.9948	30.0443	30.0179	30.0811	30.0205
3:00	30.0501	30.0368	30.0508	29.9626	29.9744	29.9428	29.9817	30.0011	30.0529	30.0103	30.0801	30.0717
4:00	30.0482	30.0434	30.0631	29.9473	29.9758	29.9476	29.9875	30.0035	30.0483	30.0172	30.0826	30.0633
5:00	30.0451	30.0387	30.0646	29.9657	29.9858	29.9553	29.9937	30.0082	30.0568	30.0214	30.0829	30.0815
6:00	30.0575	30.0579	30.0752	29.9687	30.0026	29.966	29.9891	30.0213	30.0622	30.0251	30.097	30.0837
7:00	30.0678	30.0589	30.0808	29.9766	30.0025	29.9697	30.0038	30.0244	30.0777	30.0419	30.1025	30.0763
8:00	30.067	30.0647	30.0892	29.9855	30.0056	29.9771	30.0116	30.0295	30.0734	30.042	30.0963	30.0257
9:00	30.087	30.0632	30.0862	29.9892	30.0077	29.9695	30.0106	30.0272	30.0814	30.0461	30.1004	30.1078
10:00	30.0737	30.0663	30.0927	29.9224	30.0095	29.9716	30.0101	30.0341	30.0798	30.0441	30.1018	30.0971
11:00	30.0491	30.0558	30.0893	29.9815	30.0042	29.9747	30.0079	30.0257	30.0701	30.041	30.079	30.0723
12:00	30.0341	30.0458	30.0806	29.958	29.9933	29.9598	29.9978	30.0163	30.0605	30.0224	30.0686	30.0516
13:00	30.0062	30.0218	30.0532	29.9622	29.9893	29.9539	29.9915	30.0066	30.0483	30.0096	30.0287	30.0551
14:00	29.96	30.0131	29.9392	29.9541	29.9773	29.9425	29.9865	29.9998	30.0437	30.0025	30.056	30.0454
15:00	30.0386	30.0317	30.0458	29.9479	29.9701	29.936	29.9736	29.9912	30.033	29.992	30.0591	30.0591
16:00	30.0471	30.0288	30.042	29.9473	29.9669	29.9326	29.9715	29.987	30.0277	29.9978	30.067	30.0687
17:00	30.051	30.0173	30.0407	29.9521	29.9646	29.925	29.9645	29.9833	30.031	29.9988	30.0749	30.0722
18:00	30.0551	30.0458	30.0514	29.9519	29.9632	29.925	29.9649	29.9573	30.0271	30.0092	30.0522	30.0777
19:00	30.0489	30.0435	30.0488	29.9486	29.9675	29.9295	29.9682	29.988	30.0415	30.0128	30.08	30.0794
20:00	30.053	30.0695	30.065	29.9695	29.9734	29.9322	29.9742	29.9969	30.0478	30.0164	30.0794	30.0733
21:00	30.0439	30.0629	30.0698	29.9701	29.9898	29.9495	29.9881	30.0037	30.0475	30.0216	30.0901	30.0801
22:00	30.0605	30.0321	30.0664	29.9758	29.9844	29.9502	29.9871	30.0084	30.0519	30.0222	30.0802	30.0781
23:00	30.0546	30.0369	30.0678	29.9732	29.9869	29.9503	29.9881	30.0107	30.0541	30.018	30.0776	30.0723

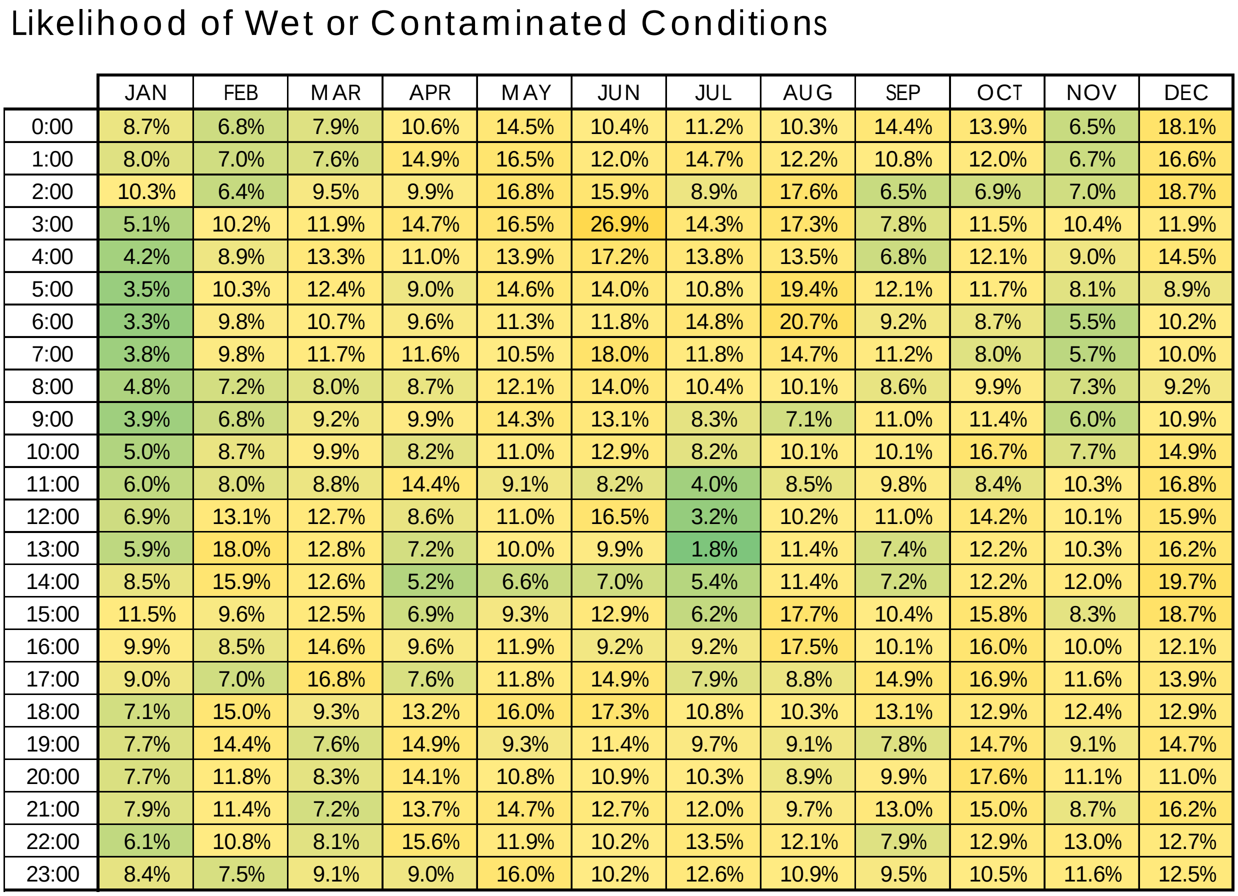
4.3.3 Wet and Contaminated Conditions

An analysis of possible wet and contaminated conditions was calculated from the NCEI CDO data set based on any periods of precipitation, snowfall or fog/low visibility which would result in moisture adhering to the runway surfaces. This data was time weighted to provide a likelihood that wet or contaminated conditions could occur during the hour in which the observations existed.

In Table 5 green cells represent periods of time where an operator would not likely expect a runway to be wet, but it is possible for such events to occur (<5%). Yellow cells represent periods where an operator has been known to experience wet or contaminated conditions on a regular basis and will likely make long range predictions, greater than 7 days, based on the possibility that the runway will be wet (5% - 12%). Orange cells represent time periods where operators are essentially expecting the runway to be wet during their operations, even when a 7-day forecast may indicate dry conditions (>12%).

Based on this analysis, the LEAN/DragonFly team determined that the likelihood of a wet runway at Chicago Executive would be considered by operators to be a likely event at almost any time of the year, or time of day. Therefore, all performance based runway length assessments would need to consider the runway to be either dry, wet, or possibly contaminated. However, this data set alone is insufficient to describe the kinds of runway clutter that could accumulate. Therefore, the runway length assessments could only use this data set to consider the more precise likelihood of dry or wet conditions occurring simultaneous to other observations of interest.

Table 5 Likelihood of Wet or Contaminated Runway Conditions at the Chicago Executive Airport



Likelihood of Wet or Contaminated Conditions

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0:00	8.7%	6.8%	7.9%	10.6%	14.5%	10.4%	11.2%	10.3%	14.4%	13.9%	6.5%	18.1%
1:00	8.0%	7.0%	7.6%	14.9%	16.5%	12.0%	14.7%	12.2%	10.8%	12.0%	6.7%	16.6%
2:00	10.3%	6.4%	9.5%	9.9%	16.8%	15.9%	8.9%	17.6%	6.5%	6.9%	7.0%	18.7%
3:00	5.1%	10.2%	11.9%	14.7%	16.5%	26.9%	14.3%	17.3%	7.8%	11.5%	10.4%	11.9%
4:00	4.2%	8.9%	13.3%	11.0%	13.9%	17.2%	13.8%	13.5%	6.8%	12.1%	9.0%	14.5%
5:00	3.5%	10.3%	12.4%	9.0%	14.6%	14.0%	10.8%	19.4%	12.1%	11.7%	8.1%	8.9%
6:00	3.3%	9.8%	10.7%	9.6%	11.3%	11.8%	14.8%	20.7%	9.2%	8.7%	5.5%	10.2%
7:00	3.8%	9.8%	11.7%	11.6%	10.5%	18.0%	11.8%	14.7%	11.2%	8.0%	5.7%	10.0%
8:00	4.8%	7.2%	8.0%	8.7%	12.1%	14.0%	10.4%	10.1%	8.6%	9.9%	7.3%	9.2%
9:00	3.9%	6.8%	9.2%	9.9%	14.3%	13.1%	8.3%	7.1%	11.0%	11.4%	6.0%	10.9%
10:00	5.0%	8.7%	9.9%	8.2%	11.0%	12.9%	8.2%	10.1%	10.1%	16.7%	7.7%	14.9%
11:00	6.0%	8.0%	8.8%	14.4%	9.1%	8.2%	4.0%	8.5%	9.8%	8.4%	10.3%	16.8%
12:00	6.9%	13.1%	12.7%	8.6%	11.0%	16.5%	3.2%	10.2%	11.0%	14.2%	10.1%	15.9%
13:00	5.9%	18.0%	12.8%	7.2%	10.0%	9.9%	1.8%	11.4%	7.4%	12.2%	10.3%	16.2%
14:00	8.5%	15.9%	12.6%	5.2%	6.6%	7.0%	5.4%	11.4%	7.2%	12.2%	12.0%	19.7%
15:00	11.5%	9.6%	12.5%	6.9%	9.3%	12.9%	6.2%	17.7%	10.4%	15.8%	8.3%	18.7%
16:00	9.9%	8.5%	14.6%	9.6%	11.9%	9.2%	9.2%	17.5%	10.1%	16.0%	10.0%	12.1%
17:00	9.0%	7.0%	16.8%	7.6%	11.8%	14.9%	7.9%	8.8%	14.9%	16.9%	11.6%	13.9%
18:00	7.1%	15.0%	9.3%	13.2%	16.0%	17.3%	10.8%	10.3%	13.1%	12.9%	12.4%	12.9%
19:00	7.7%	14.4%	7.6%	14.9%	9.3%	11.4%	9.7%	9.1%	7.8%	14.7%	9.1%	14.7%
20:00	7.7%	11.8%	8.3%	14.1%	10.8%	10.9%	10.3%	8.9%	9.9%	17.6%	11.1%	11.0%
21:00	7.9%	11.4%	7.2%	13.7%	14.7%	12.7%	12.0%	9.7%	13.0%	15.0%	8.7%	16.2%
22:00	6.1%	10.8%	8.1%	15.6%	11.9%	10.2%	13.5%	12.1%	7.9%	12.9%	13.0%	12.7%
23:00	8.4%	7.5%	9.1%	9.0%	16.0%	10.2%	12.6%	10.9%	9.5%	10.5%	11.6%	12.5%

4.3.4 Anti-Ice Usage

Like the dataset regarding wet or contaminated usage, a likelihood score was also calculated to determine the times and months of the year when an aircraft operator would be likely to have to consider the use of engine bleeds to supply an anti-ice protection on the critical surfaces of the aircraft. Anti-Ice usage is almost universally required to be applied when aircraft encounter both visible moisture and an outside air temperature of 10C or cooler.

The Likelihood of Anti-Ice Usage (Table 6) is a combination of the Likelihood of Wet or Contaminated Conditions (Table 5) and the Mean Temperature (Table 2) to create the likelihood that the anti-ice system would need to be used. An aircraft performance based color grade was selected in which green cells indicate no likelihood for anti-ice usage, yellow cells indicate some likelihood of anti-ice usage and yellow to orange cells indicated a high likelihood of anti-ice usage.

For the purposes of this assessment, anti-ice usage during periods of wet or contaminated runway operations appeared to be a likely event. Therefore, it was decided that all contaminated runway length assessments would include the use of the Anti-Ice system.

Table 6 Likelihood of Anti-Ice Usage at Chicago Executive Airport

Likelihood of Anti-Ice Usage

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0:00	5%	5%	4%	4%	2%	0%	0%	0%	0%	1%	2%	9%
1:00	5%	7%	4%	5%	3%	0%	0%	0%	0%	3%	3%	9%
2:00	4%	5%	5%	4%	2%	1%	0%	0%	0%	2%	3%	9%
3:00	4%	5%	5%	5%	3%	0%	0%	0%	0%	3%	4%	8%
4:00	3%	5%	7%	5%	3%	0%	0%	0%	0%	3%	3%	10%
5:00	4%	7%	8%	7%	4%	0%	0%	0%	1%	3%	4%	7%
6:00	4%	6%	7%	6%	4%	0%	0%	0%	0%	2%	3%	8%
7:00	4%	7%	9%	5%	4%	0%	0%	0%	0%	2%	3%	11%
8:00	5%	6%	6%	4%	2%	0%	0%	0%	0%	2%	4%	8%
9:00	5%	7%	5%	4%	3%	0%	0%	0%	0%	2%	3%	8%
10:00	5%	7%	5%	4%	1%	0%	0%	0%	0%	4%	2%	11%
11:00	8%	7%	4%	4%	1%	0%	0%	0%	0%	1%	3%	10%
12:00	6%	11%	5%	8%	1%	0%	0%	0%	0%	2%	4%	10%
13:00	6%	10%	6%	2%	1%	0%	0%	0%	0%	1%	3%	9%
14:00	5%	9%	7%	2%	2%	0%	0%	0%	0%	2%	4%	12%
15:00	6%	9%	5%	4%	1%	0%	0%	0%	0%	2%	3%	9%
16:00	7%	8%	6%	4%	2%	0%	0%	0%	0%	2%	3%	9%
17:00	5%	5%	7%	3%	1%	0%	0%	0%	0%	3%	4%	9%
18:00	5%	7%	4%	4%	1%	0%	0%	0%	0%	3%	4%	8%
19:00	5%	8%	4%	6%	2%	0%	0%	0%	0%	3%	4%	10%
20:00	5%	4%	4%	4%	1%	0%	0%	0%	0%	3%	5%	9%
21:00	7%	6%	4%	4%	2%	0%	0%	0%	0%	2%	4%	9%
22:00	5%	6%	3%	5%	2%	0%	0%	0%	0%	3%	5%	6%
23:00	5%	6%	4%	3%	2%	0%	0%	0%	1%	2%	5%	8%

4.3.5 Runway Usage Based on Winds

Historical analysis of winds for aircraft performance runway length assessments are usually best described by determining the capability of a runway to accommodate aircraft operations rather than a specific wind speed or direction that could be encountered. This is because aircraft operators are usually discouraged, and in some cases prohibited, from taking full advantage of a steady headwind component in a takeoff or landing computation. Tailwinds are typically inflated by 150% of the reported value such that operators simply increase the tailwind for performance computation purposes to the maximum certified value to operate under a conservative conclusion about runway length and/or obstacle clearance. Therefore, historical wind assessments are usually only useful to aircraft performance assessments to first determine which direction of a runway will be used for a particular hour/month and then calculate overall likelihoods of one or more runways be available for use at the same time.

In the case of Chicago Executive, the airspace challenges present a unique situation in which landing on runway 16 is a nearly mandatory consideration. In this unique situation, the historical wind data can be used to identify when the runway will likely be in a tailwind situation (most conservative length) as compared to any other outcome.

The historical wind assessment requires two data transformations to be broken into the previously discussed time weighted distribution methods. The first transformation is to convert the steady and gust wind speed units from mph to knots. This is performed purely to ensure better units matching for performance based determinations. The second transformation is to split the reported wind direction (associated with the wind intensity and time of the recording) into headwind and crosswind components. This involves a comparison of the true heading of the runway (not magnetic) with the historical wind direction in the NCEI CDO dataset, which is also stored as a true heading. For this assessment, the crosswind components were not considered as part of the runway length assessment, but in future analysis of alternatives it would be anticipated that crosswinds would be included in this analysis.

In situations in which the wind speed was recorded as variable, the maximum wind speed was considered to be a direct tailwind. This can lead to situations in which runway operations on 16 and 34 would not sum to 100%, because both runways would be experiencing a “tailwind” at the same time.

Once the headwind/tailwind components were determined, two kinds of analysis were performed: a capability analysis and a preference analysis. The capability of a runway to accommodate a historical wind value was derived solely from the time weighted observations in which the tailwind was less than or equal to the maximum certificated tailwind (for most business jets) of 10 knots. Table 7 and Table 9 show the capability of runway 16 and runway 34 respectively using a color gradation. Green cells indicate time periods where the runway is almost always capable of being used, light green indicate periods where the runway is frequently capable of being used, while yellow values indicate periods where the runway is sometimes capable of being used. From these charts, we can conclude that either runway is oriented in such a way as to permit a very high likely hood of supporting flight operations under different wind conditions.

The runway preference analysis, Table 8 and Table 10, were based on periods in which runway 16 and runway 34 respectively were not experiencing a tailwind component of any kind. This analysis, under unconstrained ATC situations, would represent periods where the indicated runway direction was likely to be the preferred direction of operations. Green cells indicated periods where the runway is likely to be preferred for use, yellow cells indicate periods where the runway is sometimes preferred for use, while orange values indicate periods where the runway is seldom preferred for use. From these charts a rather unusual situation emerged in which no particular runway seemed to have a strong preference over another one. Runway 34 had a slight preference, especially during midday in the winter months, but not enough to declare it to be the preferred direction of operations for wind purposes.

When considering both the runway wind capability and preference assessments together, it became apparent that for takeoff purposes, a direct application of the preference information would be required to obtain accurate runway length results. While the landing assessment, due to ATC constraints, would need a special application of tailwind and non-tailwind conditions.

Table 7 Runway 16 Capable of Being Used Based on Historical Winds

Runway 16 Capable of Use Based on Winds (<= 10Kt Tailwind)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0:00	90.2%	88.5%	94.0%	91.7%	95.3%	98.3%	97.9%	100.0%	97.9%	96.6%	93.8%	95.1%
1:00	91.9%	88.5%	92.0%	95.0%	94.8%	97.8%	99.0%	100.0%	97.4%	95.5%	94.0%	93.1%
2:00	93.7%	89.6%	93.8%	93.4%	96.1%	99.0%	98.2%	99.8%	94.2%	95.8%	92.7%	94.4%
3:00	93.6%	88.4%	92.9%	94.1%	96.5%	98.0%	99.3%	99.0%	96.7%	94.9%	94.1%	95.8%
4:00	92.6%	89.9%	92.9%	94.2%	97.2%	99.2%	98.8%	99.5%	97.4%	95.6%	93.9%	95.8%
5:00	92.3%	91.4%	93.3%	93.6%	96.7%	99.0%	98.9%	99.8%	97.3%	95.2%	93.2%	95.8%
6:00	92.0%	90.4%	94.5%	93.8%	93.8%	98.6%	98.5%	99.0%	96.9%	95.3%	94.4%	93.7%
7:00	90.4%	89.0%	90.7%	91.0%	94.3%	94.7%	97.4%	99.2%	94.3%	93.9%	92.7%	95.7%
8:00	88.7%	85.1%	89.7%	88.0%	89.9%	95.8%	96.2%	98.2%	94.0%	92.7%	91.2%	93.9%
9:00	86.8%	84.1%	89.4%	86.3%	91.9%	94.0%	95.6%	96.4%	93.3%	90.0%	89.0%	91.6%
10:00	85.6%	82.8%	87.8%	84.9%	88.9%	93.6%	94.6%	95.0%	91.1%	86.7%	87.2%	92.1%
11:00	86.1%	83.6%	88.7%	83.9%	89.8%	93.2%	91.3%	95.3%	90.2%	89.0%	87.9%	91.6%
12:00	85.4%	83.2%	86.1%	84.5%	87.8%	90.3%	93.2%	93.8%	89.6%	87.1%	87.0%	89.5%
13:00	85.8%	82.6%	86.7%	83.7%	90.0%	91.0%	93.4%	95.5%	88.4%	87.6%	86.1%	89.4%
14:00	87.3%	84.4%	87.3%	81.5%	88.5%	90.4%	92.4%	93.5%	91.5%	86.5%	87.3%	89.5%
15:00	91.3%	86.0%	84.2%	80.8%	90.2%	91.9%	93.2%	93.4%	91.6%	88.6%	88.3%	91.7%
16:00	92.4%	90.3%	86.9%	80.6%	91.2%	91.3%	93.6%	94.8%	90.5%	88.5%	90.6%	92.8%
17:00	89.9%	88.4%	89.1%	83.0%	90.7%	91.3%	93.3%	97.1%	91.5%	94.5%	91.5%	94.1%
18:00	91.4%	91.1%	93.4%	87.1%	90.6%	93.5%	95.0%	97.4%	94.2%	93.3%	92.2%	92.4%
19:00	89.6%	90.3%	90.4%	91.3%	93.3%	96.1%	97.5%	97.3%	96.9%	94.5%	90.9%	92.8%
20:00	86.0%	91.7%	91.6%	92.6%	93.0%	98.4%	98.3%	98.7%	98.1%	93.9%	91.9%	94.3%
21:00	85.9%	89.8%	93.7%	91.2%	95.2%	98.5%	98.9%	99.7%	96.1%	93.0%	91.5%	90.6%
22:00	90.0%	88.5%	93.4%	92.9%	94.8%	96.4%	98.3%	99.9%	96.8%	94.9%	93.2%	94.2%
23:00	91.4%	88.9%	93.3%	92.1%	95.1%	98.3%	98.1%	99.6%	96.2%	94.8%	92.7%	92.4%

Table 8 Runway 16 Preferred for Use Based on Historical Winds

Runway 16 Preferred Based on Winds (No Tailwind)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0:00	32.8%	27.5%	30.9%	33.4%	32.2%	26.1%	29.9%	26.5%	24.4%	35.7%	41.3%	40.3%
1:00	33.9%	29.5%	29.9%	32.3%	30.7%	26.3%	30.3%	26.4%	26.3%	35.2%	41.2%	39.0%
2:00	32.9%	28.5%	31.9%	31.2%	30.1%	24.1%	25.2%	27.3%	25.0%	33.1%	42.4%	38.0%
3:00	36.2%	29.8%	28.4%	30.1%	31.6%	24.0%	25.5%	24.6%	23.9%	33.7%	41.4%	38.2%
4:00	34.4%	28.8%	28.2%	33.3%	29.0%	26.2%	26.1%	24.9%	24.5%	33.5%	43.2%	38.3%
5:00	35.3%	31.8%	31.1%	32.6%	29.5%	27.7%	25.7%	25.5%	24.6%	32.8%	43.5%	39.0%
6:00	37.8%	29.6%	31.6%	36.2%	36.1%	31.1%	28.6%	29.0%	26.8%	33.5%	41.3%	38.3%
7:00	36.7%	33.9%	32.8%	38.4%	42.1%	37.9%	34.9%	35.9%	30.7%	34.9%	43.0%	40.0%
8:00	39.5%	34.5%	39.7%	40.5%	43.0%	39.9%	43.1%	41.6%	39.8%	39.6%	47.7%	40.5%
9:00	41.6%	33.3%	43.0%	41.2%	45.4%	43.1%	38.4%	42.1%	41.3%	44.6%	49.5%	44.1%
10:00	37.5%	36.5%	36.9%	41.8%	44.4%	43.9%	43.2%	41.1%	43.7%	45.2%	52.0%	45.6%
11:00	40.4%	36.3%	39.2%	38.4%	43.0%	43.2%	35.2%	40.3%	40.6%	45.6%	47.7%	45.6%
12:00	43.0%	35.4%	36.9%	34.3%	40.8%	41.0%	36.1%	37.3%	39.7%	47.5%	51.2%	44.1%
13:00	41.6%	36.7%	39.0%	37.2%	44.2%	43.0%	39.3%	41.3%	42.1%	46.3%	49.3%	45.6%
14:00	42.6%	37.9%	37.9%	40.5%	42.5%	41.4%	43.7%	44.3%	45.9%	48.8%	51.1%	46.3%
15:00	40.7%	37.5%	41.0%	38.2%	45.5%	47.6%	47.2%	43.2%	47.1%	47.8%	51.3%	45.4%
16:00	39.8%	37.2%	42.0%	40.4%	47.6%	46.2%	44.3%	48.2%	45.9%	51.3%	51.4%	45.0%
17:00	38.0%	34.2%	42.1%	36.6%	46.3%	46.9%	45.0%	48.7%	49.5%	48.9%	44.9%	43.9%
18:00	36.8%	34.2%	44.4%	41.7%	44.6%	49.5%	51.3%	51.7%	44.8%	41.5%	42.1%	44.4%
19:00	36.5%	33.6%	38.0%	43.6%	46.4%	50.7%	51.7%	43.6%	32.5%	36.1%	41.0%	42.1%
20:00	33.3%	38.9%	39.1%	39.3%	39.6%	41.9%	43.6%	34.3%	28.7%	33.7%	38.9%	43.5%
21:00	32.3%	31.5%	37.7%	37.9%	40.4%	34.8%	36.0%	25.6%	24.8%	34.5%	42.8%	43.0%
22:00	35.9%	30.0%	32.8%	34.8%	33.4%	30.3%	31.9%	25.9%	26.7%	36.6%	43.0%	42.9%
23:00	31.2%	30.9%	32.4%	33.9%	30.6%	27.7%	31.6%	24.8%	26.4%	33.7%	42.3%	41.4%

Table 9 Runway 34 Capable of Being Used Based on Historical Winds

Runway 34 Capable of Use Based on Winds (<= 10Kt Tailwind)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0:00	94.7%	97.7%	93.6%	94.0%	96.3%	96.1%	98.3%	99.7%	96.9%	93.8%	92.9%	95.0%
1:00	96.5%	97.2%	94.7%	94.4%	96.6%	96.4%	97.6%	99.4%	97.0%	94.8%	92.3%	94.6%
2:00	95.6%	96.4%	95.9%	94.4%	98.0%	97.6%	100.0%	99.6%	96.9%	95.2%	93.9%	96.1%
3:00	94.8%	96.6%	95.5%	94.2%	97.1%	96.6%	99.8%	99.9%	99.3%	96.2%	93.9%	95.5%
4:00	95.8%	96.7%	96.5%	95.2%	99.0%	96.6%	99.6%	99.6%	98.6%	97.0%	94.1%	95.2%
5:00	94.7%	96.4%	96.7%	93.4%	97.7%	97.2%	99.9%	99.0%	98.5%	97.6%	95.0%	96.7%
6:00	95.1%	95.5%	96.5%	94.6%	96.4%	97.3%	98.9%	98.6%	99.1%	97.0%	93.4%	94.5%
7:00	95.2%	96.4%	94.9%	93.8%	94.6%	97.0%	98.9%	99.2%	98.3%	95.3%	93.3%	95.0%
8:00	91.0%	93.0%	92.1%	92.0%	92.2%	94.9%	98.6%	98.6%	97.5%	94.6%	90.2%	93.9%
9:00	91.5%	92.1%	90.0%	89.1%	91.9%	91.4%	96.4%	97.1%	94.9%	91.4%	86.4%	92.4%
10:00	91.3%	90.9%	89.7%	86.6%	87.7%	91.9%	96.5%	96.7%	94.8%	90.4%	85.5%	91.8%
11:00	90.3%	91.4%	87.7%	87.1%	84.5%	90.8%	94.8%	95.4%	93.0%	89.5%	87.0%	89.6%
12:00	91.6%	90.9%	87.9%	87.6%	83.8%	91.6%	93.3%	93.0%	92.6%	88.3%	81.4%	91.6%
13:00	91.2%	90.2%	87.7%	85.8%	86.0%	88.4%	93.0%	93.3%	89.7%	87.7%	82.2%	89.5%
14:00	91.8%	88.6%	89.3%	86.2%	86.4%	90.4%	93.7%	92.7%	91.3%	87.2%	85.1%	91.2%
15:00	93.1%	91.5%	88.7%	86.0%	87.4%	89.8%	94.0%	94.0%	91.0%	88.8%	88.0%	92.9%
16:00	92.9%	93.6%	88.5%	87.6%	88.8%	90.6%	95.7%	95.3%	92.1%	90.6%	90.4%	93.2%
17:00	92.6%	94.8%	90.1%	91.0%	89.8%	91.3%	95.6%	94.5%	93.5%	93.4%	90.2%	93.3%
18:00	92.5%	93.9%	92.8%	90.9%	91.4%	93.5%	95.9%	98.2%	98.0%	95.8%	90.8%	91.6%
19:00	92.2%	95.0%	93.6%	91.5%	95.5%	94.3%	97.5%	98.4%	97.1%	94.1%	89.8%	91.1%
20:00	90.4%	95.7%	92.1%	91.5%	96.0%	94.9%	97.9%	98.3%	96.2%	94.4%	88.7%	91.4%
21:00	92.0%	96.6%	92.4%	92.4%	96.0%	97.4%	97.9%	99.0%	96.6%	91.8%	90.1%	92.8%
22:00	93.4%	96.4%	92.7%	92.5%	96.4%	97.0%	99.4%	98.7%	95.8%	93.2%	91.1%	93.6%
23:00	94.5%	96.3%	93.5%	91.1%	96.2%	96.9%	97.8%	98.7%	96.6%	92.6%	92.9%	95.2%

Table 10 Runway 34 Preferred for Use Based on Historical Winds

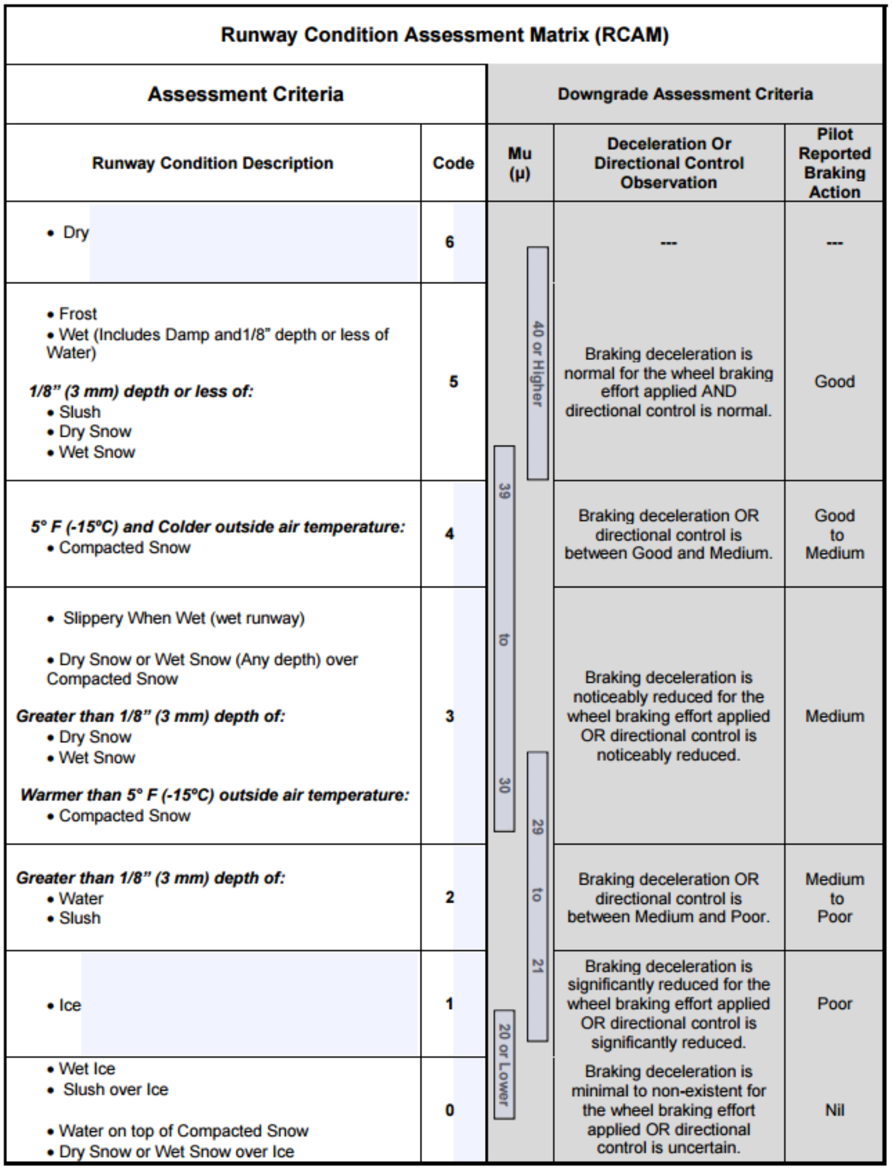
Runway 34 Preferred Based on Winds (No Tailwind)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0:00	52.8%	55.5%	46.0%	40.8%	32.5%	31.8%	26.0%	27.3%	28.6%	34.5%	37.8%	49.0%
1:00	53.7%	53.6%	45.3%	42.0%	34.5%	33.5%	26.1%	25.4%	26.5%	32.6%	39.6%	49.3%
2:00	54.1%	56.6%	45.3%	43.8%	34.9%	36.3%	30.2%	25.7%	29.5%	34.9%	36.0%	48.7%
3:00	50.9%	55.7%	47.5%	43.6%	34.9%	36.3%	30.0%	26.4%	32.3%	36.1%	37.4%	49.5%
4:00	55.7%	55.1%	47.1%	40.5%	37.1%	35.8%	30.4%	25.4%	32.6%	35.6%	35.4%	46.8%
5:00	54.2%	52.8%	47.4%	43.2%	36.0%	37.8%	31.4%	27.2%	33.8%	35.0%	37.3%	48.6%
6:00	52.6%	55.9%	47.7%	43.9%	40.5%	41.1%	40.9%	31.9%	34.2%	37.9%	38.7%	50.2%
7:00	53.5%	53.4%	50.0%	51.0%	48.3%	46.8%	46.1%	40.2%	40.0%	39.4%	40.4%	48.5%
8:00	53.6%	57.5%	49.8%	52.1%	48.3%	48.4%	47.6%	43.4%	45.0%	45.8%	43.8%	51.1%
9:00	51.9%	59.8%	52.0%	54.6%	49.1%	48.8%	51.8%	47.1%	50.3%	49.4%	44.5%	48.3%
10:00	56.0%	58.1%	58.6%	55.9%	51.9%	51.5%	53.4%	49.8%	48.6%	49.1%	44.7%	49.9%
11:00	54.6%	60.0%	54.9%	59.5%	54.2%	52.1%	60.7%	51.1%	53.8%	50.9%	48.5%	49.4%
12:00	53.2%	60.4%	57.6%	63.1%	57.1%	54.5%	58.3%	55.2%	55.7%	49.1%	46.0%	52.3%
13:00	55.6%	61.2%	56.1%	62.1%	54.0%	55.6%	56.1%	54.0%	54.7%	51.8%	48.0%	49.9%
14:00	54.1%	59.3%	58.8%	58.6%	55.7%	56.2%	53.6%	51.8%	52.9%	49.8%	46.7%	49.0%
15:00	55.1%	60.8%	57.9%	61.2%	53.1%	51.3%	50.1%	53.7%	50.4%	50.3%	46.7%	50.6%
16:00	55.6%	61.5%	56.6%	59.6%	51.0%	51.7%	52.1%	48.7%	51.1%	46.7%	43.3%	49.5%
17:00	55.2%	59.6%	56.2%	62.5%	52.2%	52.7%	53.3%	47.0%	47.6%	46.2%	41.5%	47.2%
18:00	51.1%	54.4%	50.3%	56.5%	53.1%	49.2%	46.1%	44.0%	47.4%	41.0%	41.2%	45.0%
19:00	52.0%	53.8%	50.2%	49.6%	44.8%	45.0%	42.6%	37.2%	34.3%	37.7%	38.7%	46.4%
20:00	58.2%	47.9%	44.5%	46.3%	43.2%	37.8%	31.9%	26.9%	29.6%	37.9%	39.4%	47.0%
21:00	53.1%	53.9%	41.6%	41.9%	36.1%	32.7%	24.7%	25.6%	30.3%	33.8%	36.4%	47.1%
22:00	52.3%	53.5%	42.7%	43.2%	33.8%	34.7%	25.7%	23.6%	30.1%	35.9%	38.5%	46.7%
23:00	56.0%	52.8%	43.7%	39.6%	34.5%	33.4%	25.0%	26.2%	28.7%	36.5%	37.4%	46.5%

4.4 Field Condition Data

To more accurately assess the effects of runway contamination conditions on the aircraft performance based runway length assessment, it was necessary to find a complimentary data source that could help to discern the potential conditions on runway 16/34 during winter operations. Thanks to recent changes in FAA NOTAM and field condition reporting (FICON), the Chicago Executive Airport had one complete winter period worth of historical NOTAM information available to analyze for specific time weighted contamination applications.

FICON values form a part of the Runway Condition Assessment Matrix (RCAM) shown in Figure 4 Runway Condition Assessment Matrix Including FICON Categories. For aircraft operators, many use the FICON codes in the landing distance assessments either directly, as a representation of several different contamination types, or as an additional layer to adjust a pre-takeoff landing distance assessment up or down from the one which was anticipated before the flight began.



Runway Condition Assessment Matrix (RCAM)

Assessment Criteria		Downgrade Assessment Criteria		
Runway Condition Description	**Code**	**Mu (μ)**	**Deceleration Or Directional Control Observation**	**Pilot Reported Braking Action**
• Dry	6	40 or Higher	---	---
• Frost • Wet (Includes Damp and1/8" depth or less of Water) ***1/8" (3 mm) depth or less of:*** • Slush • Dry Snow • Wet Snow	5		Braking deceleration is normal for the wheel braking effort applied AND directional control is normal.	Good
5° F (-15°C) and Colder outside air temperature: • Compacted Snow	4	39 to 30	Braking deceleration OR directional control is between Good and Medium.	Good to Medium
• Slippery When Wet (wet runway) • Dry Snow or Wet Snow (Any depth) over Compacted Snow ***Greater than 1/8" (3 mm) depth of:*** • Dry Snow • Wet Snow ***Warmer than 5° F (-15°C) outside air temperature:*** • Compacted Snow	3		Braking deceleration is noticeably reduced for the wheel braking effort applied OR directional control is noticeably reduced.	Medium
Greater than 1/8" (3 mm) depth of: • Water • Slush	2	29 to 21	Braking deceleration OR directional control is between Medium and Poor.	Medium to Poor
• Ice	1	20 or Lower	Braking deceleration is significantly reduced for the wheel braking effort applied OR directional control is significantly reduced.	Poor
• Wet Ice • Slush over Ice • Water on top of Compacted Snow • Dry Snow or Wet Snow over Ice	0		Braking deceleration is minimal to non-existent for the wheel braking effort applied OR directional control is uncertain.	Nil

Figure 4 Runway Condition Assessment Matrix Including FICON Categories

Historical NOTAM data was downloaded from the FAA FANS website starting in October of 2016 through April of 2017. A FICON NOTAM was assumed to be in effect either for its published duration, or until another NOTAM was published which replaced or created different condition than the preceding one. This would sometimes result in FICON NOTAMS which would last for an entire day, especially for wet conditions (FICON 5/5/5). The following is an example of a FICON NOTAM used in this assessment:

!PWK 01/061 PWK RWY 16 FICON 3/3/3 100 PRCT 1/8IN SLUSH OBSERVED AT 1701160950. 1701160950-1701170950

All FICON NOTAMs were collected and divided into categories where the lowest of the three values (reported in thirds of the runway) represented the condition for the entire runway. The direct FICON values 5, 4 and 3 were used to make more accurate landing distance assessments. Values less than 2 were not used as most aircraft operators will not attempt a landing when that value (or lower) is indicated in a NOTAM.

FICON values were also used to assist with takeoff distance determinations. However, most operators do not rely on a FICON to impact the takeoff performance determination instead relying on a determination of the specific type and depth of contaminant. Therefore, FICON values of less than or equal to 4 were used to indicate time periods where a typical takeoff contaminant (compacted snow) was in effect.

FICON data was summarized to match the winter period and was assumed to represent conditions which were in effect from October to April. Year-round assessments also considered the FICON data for those 7 months along with standard wet/dry results calculated from the NCEI CDO Hourly data. Table 11 represents the summary of those results.

Table 11 Likelihood of FICON Conditions for 2016/2017 on runway 16/34

FICON (Description)	Likelihood October - April	Likelihood Year Round
6 (Dry)	75%	81%
5 (Wet)	24.07%	18.84%
4 (Compacted Snow)	0.53%	0.31%
3 (Contaminant Buildup)	0.55%	0.32%
2 or Less (Significant Contamination)	0%	0%

The lack of FICON data points less than or equal to 2 is most likely caused by proactive measures taken by the Chicago Executive Airport to close the runway and restore the FICON to a higher value which was safe for continued flight operations.

Because only one winter season of data was available in this format, and 10 years of historical data had been collected under the NCEI CDO analysis, it was necessary for LEAN/DragonFly to expand the 2016/17 winter data to be applicable over the same 10-year period as the NCEI CDO data. This may lead to errors in prediction for contamination events in the future. It is therefore recommended that any future FICON NOTAMs, in subsequent winter seasons, be consulted and combined to expand the statistical population of observations.

5 Airspace and Air Traffic Limitations

5.1 Departures

The Chicago Executive Airport is currently served by several IFR departure procedures serving all runways at the airport. The purpose of this section is to examine any potential impacts or challenges addressed by the existing departure procedures that would help to inform runway utilization for takeoff and identify any takeoff performance issues resulting from the existing departure procedure routes or restrictions. No additional analysis has been performed on the integrity of the existing departures, compliance with current TERPS criteria and no consideration has been given to future departure procedures either public or private.

5.1.1 All Engines Operating

The Chicago Executive Airport is currently supported by three instrument departure procedures:

- JORJO THREE
- MONKZ THREE
- PAL-WAUKEE TWO

The JORJO and MONKZ departure procedures are both RNAV departures which support aircraft departing from each of the three runways, 6 directions, at Chicago Executive Airport. The departure procedure requires an initial required climb gradient of 500ft/nm to 1,160ft (approximately 500ft above the departure end of the runway). Both departure procedures require aircraft to depart on a heading which is identical to the runway used for departure. The climb gradient requirement for the JORJO and MONKZ departure procedures, aided by the initial straight heading, are not considered to be a performance limitation for any of the jet aircraft using the Chicago Executive Airport.

The PAL-WAUKEE TWO departure procedure, which is specific to runway 16, has no required climb gradient. The departure has a procedural limitation which requires aircraft to make a right turn, with a turn radius restriction, that is designed to help aircraft maneuver away from O'Hare Airport approach and departure procedures. The turn is specifically designed to keep aircraft east of ORD VOR R-345 and the FAA has taken the unusual step to ensure that this limitation is observed by providing speed and bank angle restrictions to aircraft. Despite these procedure requirements, the procedural instructions, bank angles, and speed restrictions are not considered to create any performance limitations for jet aircraft using the Chicago Executive Airport using the PAL-WAUKEE TWO.

Aircraft which cannot utilize any of the existing departure procedures from runway 16/34 must seek clearance from ATC and/or utilize the CABAA Visual departure procedure.

While none of the current departure procedures present a performance limitation today, any relocation of the departure ends of the runway towards the south will create a challenge for C90 TRACON as they attempt to separate aircraft departure runway 16 from class B airspace restrictions just south of the runway. The current turn initiation point for both PAL-WAUKEE TWO and the CABAA Visual departure procedure is 1 nautical mile from the DER. In the event that runway 16 departure end (34 threshold) were shifted to the south, the FAA would have to amend the PAL-WAUKEE and CABAA departure procedures to include a climb gradient or decrease departures speeds or modify the class B airspace structure. In the event that a class B airspace redesign could not be accommodated, then a lower speed restriction would be put in place which could create a performance limitation (takeoff weight reduction). Therefore, any south extension of the runway should be carefully evaluated for potential TERPS speed restrictions on the PAL-WAUKEE TWO which would cause all engines operating weight limitations.

5.1.2 One Engine Inoperative

Aircraft operators at Chicago Executive Airport utilize one of three different kinds of special departure procedures.

The first kind of one engine inoperative departure procedure are those used by FAR Part 91 operators which do not utilize FAA AC-120-91 Airport Obstacle Analysis. These operators must ensure obstacle clearance by showing compliance with the published FAA all engines operating departure procedure which for the purposes of computing aircraft performance is a combination of ensuring clearance of any published low close in obstacles along with maintaining a climb path which remains above the altitudes and climb gradients published on the procedure. For aircraft departing on any of the current departure procedures at Chicago Executive Airport, only the low close in obstacles will present a potential aircraft performance challenge.

The second kind of one-engine inoperative departure procedure are those used by FAR Part 91, FAR Part 91-K, and FAR Part 135 operators which use an AC-120-91 straight out, area analysis method for obstacle accountability. In the event of an engine failure at the takeoff safety decision speed (on the runway), these aircraft intend to follow the extended runway centerline until such time that their emergency engine failure can be brought under control. After climbing along the extended runway centerline, and reaching the minimum vectoring altitude, aircraft will begin accepting instructions from air traffic control on how to execute a safe landing.

The third kind of one-engine inoperative departure procedure are those used by only a few FAR 91-K and FAR Part 135 operators following an AC-120-91 turning procedure. These procedures would be applicable to both runway 16 and 34 departures and involve a turn from the runway heading to either avoid distant obstacles or to maintain separation from O'Hare air traffic. The procedures for runway 34 typically involve only a slight heading change away from the extended runway centerline to avoid obstacles between 2 – 3 nautical miles north of the runway. The procedures for runway 16 are more complicated, and are designed to mimic the PAL-WAUKEE TWO departure procedure.

Of the three one-engine inoperative departure procedures in use at the airport today, the overwhelming majority of business jet operators at the airport utilize either a basic FAR Part 91 assessment or an AC-120-91 straight out, area analysis method. Therefore, only one engine inoperative procedures which follow the extended runway centerline will be considered for this aircraft performance based runway length assessment.

5.1.3 Historical Takeoff Operations

Table 12 below provides some insight regarding the percentage of departures over the past five years from each of the runways at the Chicago Executive airport. The breakdown suggests that there is a significant preference for aircraft to use runway 34, followed by 16 and then 12. Other runway directions were considered by non-jet aircraft.

When comparing jet aircraft usage of runway 16 vs 34, there is a 30% increased likelihood for aircraft to utilize runway 34 over runway 16. If we were to combine runway 12 numbers into runway 16, due to presumed similarly favorable wind conditions for both runways, then we would still see an 18% preference for the use of runway 34 over the combined runway 12 and 16.

When comparing this information with the historical runway preference, Table 8 Runway 16 Preferred for Use Based on Historical Winds" and Table 10 Runway 34 Preferred for Use Based on Historical Winds", there does appear to be a relationship between wind preference and runway usage with runway 34 having a higher preference for use over runway 16 by approximately 8% of operations. Therefore, for the purposes of this study, historical takeoff runway usage will reflect a bias towards runway 34 which does not necessarily reflect the preferred wind likelihood. This will be achieved by dividing up the likelihood of a runway operation based on the preferred runway usage (taken from winds) and then any remaining likelihood not expressed by the historical weather statistics (due to variable winds) will be assumed to represent a runway 34 takeoff.

Table 12 Historical Takeoff Operations at Chicago Executive Airport, By Runway

	Percentage of Departure Operations by Runway						
Runway	Jets in This Study	Large Jets	Medium Jets	Small Jets	Light Jets	Turboprop	Piston
16	29%	27%	27%	28%	28%	30%	25%
34	59%	62%	60%	59%	57%	51%	47%
12	12%	11%	12%	13%	13%	14%	18%
30	0%	0%	0%	0%	1%	2%	4%
6	0%	0%	0%	0%	0%	2%	4%
24	0%	0%	0%	0%	0%	1%	2%

5.2 Arrivals and Approaches

The Chicago Executive Airport is currently served by several straight in instrument approach procedures to runway 16, but all other runways at the airport do not currently have any straight in public approach options. The purpose of this section is to examine any potential impacts or challenges addressed by the existing approach procedures that would help to inform runway utilization for landing and identify any landing performance issues from the existing approaches. No additional analysis has been performed on the integrity of the existing approaches, compliance with current TERPS/PBN criteria and no consideration has been given to future approaches either public or private.

5.2.1 Standard Arrivals

Chicago Executive Airport is served by 3 straight-in public instrument approach procedures to runway 16: a full ILS CAT I approach, an RNAV approach (with both LPV and LNAV minimums) and a VOR approach. Each of the three approaches support circling minimums supporting arrivals on each of the other runway directions. There are no published standard terminal arrival procedures to join the approaches, but it is presumed that aircraft operating under an IFR flight plan will receive arrival instructions via vectors from C90 TRACON.

Each of the three straight-in approaches to runway 16 involve standard glidepath angles and threshold crossing heights, presenting no unusual aircraft performance limitations that would affect the landing distance required.

It is noted that the 34:1 surfaces for runway 16, and presumably 34, are not currently clear of obstructions. Further evidence suggests that vehicle heights on the roads surrounding the airport would even present potential 20:1 penetrations. Under a strict adherence to FAR 135.361, this could create a reduced distance to be considered for landing performance. However, jet transport aircraft operators in the US have not been asked to make any adjustments to their landing distances to accommodate this regulatory requirement. Therefore, for the purposes of this aircraft performance based runway length assessment, no additional actions will be taken to mode operator compliance with FAR 135.361.

5.2.2 Missed Approach

The missed approach procedures for runway 16 follow typical TERPS guidelines with no unusual climb gradient requirements or restrictions on turning flight. All missed approach procedures to runway 16 involve aircraft executing a left turn which commences at a point very similar to the one designed for the PAL-WAUKEE TWO departure procedure, approximately 1 nautical mile south of the runway 16 DER or runway 34 threshold. Unlike the departure procedure turn point, the missed approach point uses assumed standard climb gradient distances assumed to begin at the DA/MDA for the ILS, RNAV or VOR procedures.

Because the missed approach procedures do not present any aircraft performance limitations, no additional restrictions or maneuvers will be considered for this aircraft performance based runway length assessment.

5.2.3 Balked Landing and One Engine Inoperative

Aircraft operators are currently required to create their own plan of action with respect to balked landing, rejected landing and the possibility of executing a missed approach with one engine inoperative.

At this time, none of the aircraft operators utilizing the Chicago Executive Airport utilize any customized flight procedures, or impose any aircraft performance limitations, to ensure that balked landing, or rejected landing can be accommodated under all conditions. Aircraft operators ensure that their landing can be performed within the limitations imposed by the landing climb performance certified under FAR Part 25. This requires aircraft to be at a weight that will enable the plane of executing a rejected landing, with both engines operating, in the landing configuration, that will produce a 3.2% still air climb gradient, which is equivalent to approximately 195ft/nm.

One engine inoperative missed approach accountability is handled through the typical landing performance assessments, defined by FAR Part 25 aircraft in the Aircraft Flight Manual, under approach climb considerations. This requires aircraft to be at a weight that will enable the plane of executing a missed approach, with one engine inoperative, in the approach configuration, that will produce a 2.5% still air climb gradient, which is equivalent to approximately 152ft/nm.

Both climb gradients resulting from these assessments are not intended for comparison against TERPS or PBN considerations of existing approaches, instead representing a “minimum” level of climb performance that pilots must ensure will be available should the aircraft need to execute a missed approach or balked/rejected landing maneuver.

The landing climb and approach climb weight limitations were considered as a potential limitation on the effectiveness of any landing length recommendations. No further aircraft performance restrictions were imposed in this analysis.

5.2.4 LAHSO

Runway 16 currently supports a Land and Hold Short Operations (LAHSO) which ensures that FAR Part 121, FAR Part 125, FAR Part 135 and FAR Part 129 aircraft operators, who are approved to conduct LAHSO, will come to a complete stop prior to crossing the current runway 12/30. The reported distance available for consideration is 3,700ft restricting use to aircraft of LAHSO Group 3 or smaller (per FAA N7110.118). Because there are currently no jets listed in LAHSO Group 3 aircraft, the LAHSO aspects of landing on runway 16 will not be considered in this aircraft performance based runway length assessment.

If, in the future, a runway extension to the North of the current runway 16 threshold in excess of 1,300ft were to be considered, then additional analysis should be considered for the use of VLJs and small cabin business jets under LAHSO.

5.2.5 Historical Landing Operations

Table 13 below provides some insight regarding the percentage of arrivals over the past five years to each of the runways at the Chicago Executive airport. The breakdown suggests that there is a near operational requirement for aircraft to land on runway 16 with 97% of all jet arrivals landing on the runway.

Landing on runway 16 is a logical operational flow given the class B airspace restrictions and necessary separation of air traffic from aircraft landing on Chicago O’Hare runways 27L, 27R, or 28R when winds in the Chicago area would support a west operation. However, the requirement for aircraft to land on runway 16, in rejection of following the preferential runway availability based on historical winds, means that most aircraft operations must consider landing in some state of tailwind operation.

For the purposes of this aircraft performance based runway length assessment, all landing distances are assumed to happen with a 10kt tailwind in the runway 16 direction. The only exceptions would be for aircraft which would need to perform a landing on a potentially contaminated runway surface that cannot land with a tailwind. For these aircraft, a small exception was permitted reflecting the extremely low percentage of operations which would land on runway 34.

Table 13 Historical Landing Operations at Chicago Executive Airport, By Runway

	Percentage of Arrival Operations by Runway						
Runway	Jets in This Study	Large Jets	Medium Jets	Small Jets	Light Jets	Turboprop	Piston
16	97%	96%	96%	97%	97%	96%	85%
34	2%	3%	2%	2%	2%	1%	5%
12	0%	0%	0%	0%	0%	1%	2%
30	0%	1%	1%	0%	0%	1%	5%
6	0%	0%	0%	0%	0%	0%	1%
24	0%	0%	1%	0%	0%	1%	2%

6 Aircraft and Performance Considerations

6.1 Aircraft

Three aircraft types were selected by the LEAN/DragonFly and CMT team to provide a representation of operations which were considered to represent:

1. Historically significant percentage of operations
2. Future operational profile of operators following a possible runway extension
3. Takeoff and landing performance characteristics of similar aircraft that were not otherwise analyzed

Of all the aircraft currently operating at the Chicago Executive airport the Cessna Citation 560XLS, Hawker 800XP and Global Express 6000 were selected to best represent these criteria.

6.1.1 Cessna Citation 560 XLS

Figure 5 Image of Cessna Citation 560XLS with Seating/Luggage Above and Aircraft Exterior Below

The Cessna Citation 560XLS is a FAR Part 25 Certificated light cabin jet which had the single highest number of operations into and out of the Chicago Executive airport in the past 5 years.

The aircraft has excellent short field takeoff characteristics which resemble the capabilities of almost all other light cabin and very light jets operating into the Chicago Executive Airport including most LearJet models, all older/prior Cessna models and most VLJs.

While the 560XLS has thrust reversers installed, not all aircraft in this category have thrust reversers. Therefore, any results in subsequent sections of this report which indicate the use of thrust reversers to obtain the required field length may under represent the required length for other aircraft in the group.

For the purposes of combining aircraft performance based runway lengths to make a presentation of total operations covered at the airport by runway length extensions, the Cessna 560XLS runway length results were assumed to represent 40% of all takeoffs and landings.

6.1.2 Hawker 800XP

Figure 6 Hawker 800XP Seating Configuration Pictured Above, with Exterior Aircraft Image Below

The Hawker 800XP is a FAR Part 25 certificated medium cabin jet which had the 3rd highest number of historical operations into and out of the Chicago Executive airport in the past 4 years.

The aircraft has good short field performance when not operating near the maximum structural weight limitations, but has been known to require runway lengths which make it a closer representative of older medium and large cabin jets including the Cessna Citation X, Cessna Citation Sovereign and Falcon 2000.

While the 800XP has thrust reversers installed, not all aircraft in this category, or even previous models within the HS-125 Family, have thrust reversers installed. Therefore, any results in subsequent sections of this report which indicate the use of thrust reversers to obtain the required field length may under represent the required length for other aircraft in the group.

For the purposes of combining aircraft performance based runway lengths to make a presentation of total operations covered at the airport by runway length extensions, the Hawker 800XP runway length results were assumed to represent 40% of all takeoffs and landings.

6.1.3 Bombardier Global 6000

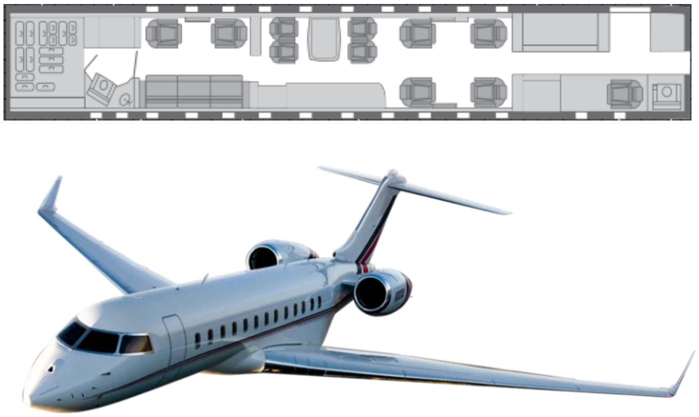


Figure 7 Bombardier Global 6000 Seating Configuration and Luggage Area Pictured Above, with Exterior Aircraft Image Below

The Global Express 6000 is a FAR Part 25 certificated large cabin jet which currently does not have a significant number of historical operations at the Chicago Executive Airport. Its older variant, the Global Express, and its shorter-range equivalent, the Global 5000, do comprise a number of historical operations at the airport.

The aircraft was selected because it is a good representative of future medium and large cabin aircraft performance needs. The G6000 also has similar, if not slightly more conservative, runway performance requirements to the Gulfstream family and is therefore a good representation of both current and future large cabin operations.

For the purposes of combining aircraft performance based runway lengths to make a presentation of total operations covered at the airport by runway length extensions, the Global 6000 runway length results were assumed to represent 20% of all takeoffs and landings.

6.2 Weight and Balance

The weight and balance information for each of the three aircraft considered in this analysis is summarized in Table 14 below.

Table 14 Weight and Balance Characteristics for Aircraft in This Assessment

Aircraft	**OEW (lbs)**	**MZFW (lbs)**	**MLW (lbs)**	**MTOW (lbs)**	**MRW (lbs)**	**Fuel Capacity (lbs)**	**Seating Capacity (PAX)**
560XLS	12,600	15,100	18,700	20,200	20,400	6,790	7
800XP	16,400	18,450	23,350	28,000	28,120	9,908	8
G6000	51,400	58,000	78,600	99,500	99,750	45,050	13

All weights listed in Table 14 were derived by DragonFly based on actual Operating Empty Weight (OEW) values from operators of the three equipment types including allowances for 2 pilots, catering and other high end business jet onboard amenities.

The structural weight limitations are those specified by the FAA Type Certification Data Sheets current as of MAY 2017. The total number of passengers and their belongings which can be loaded onto the aircraft is found by subtracting the Maximum Zero Fuel Weight (MZFW) from the OEW.

For considerations of passengers, and their baggage, an average PAX weight was used which combines the average weight of a passenger with the weight of items they are expected to bring with them onto the aircraft. The PAX weight used for this assessment was 220lbs.

6.3 Takeoff Performance

The takeoff performance assessments are one of the primary basis for the aircraft performance based runway length analysis and are intended to directly simulate the FAR Part 25 and FAR Part 91, 91-K and 135 rules that aircraft operators must follow. However, most aircraft operators utilize manufacturer provided, FAA approved, manuals and computerized software to determine a weight limitation that works within a predefined runway and obstacle environment, which is then adjusted to match ambient conditions. In the case of a runway length assessment, it is necessary to run the approved takeoff calculations in reverse by identifying a target weight to be achieved and then optimizing the calculation steps to determine the shortest possible runway length that would be required to support the target weight.

These calculations are broken into the same components of a typical aircraft operator as follows:

- Runway Limited Performance
- Obstacle Limited Performance
- Other Limitations

By following the same methods as an aircraft operator would utilize in their aircraft operation, albeit in reverse, LEAN/DragonFly can determine runway extensions that still comply with all FAA operating regulations, while providing maximum benefit to operators.

6.3.1 Runway Limited Calculations

Runway limited calculations represent the length necessary to support the possibility that an aircraft can both accelerate from a start of takeoff roll on the runway, and liftoff the runway surface passing a predetermined screen height, or abort the takeoff and come to a complete stop in the distance permitted for such an action. This is typically broken up into two, related, computations called accelerate go and accelerate stop.

The two computations are often calculated using the same algorithms that determine the takeoff decision safety speed (V1). The V1 speed is the binding factor that pilots will use to determine which actions are to be taken following any possible disruptions in the takeoff phase of flight.

6.3.1.1 Accelerate Go

The primary consideration in a runway limited aircraft performance computation is for the aircraft to accelerate from the start of the takeoff roll (after alignment distance has been taken into consideration) with all engines operating and either pass the decision speed without an issue, proceeding to an all engines operating takeoff distance, or experiencing an engine failure at or after the decision speed forcing the aircraft to continue with the takeoff phase of flight becoming airborne. Both the all engines operating distance and the one engine inoperative distance for the accelerate go consideration terminate at a predefined screen height based on the type of runway contaminant. Dry and wet surface conditions require the aircraft to pass a point which is 35ft above the height of the runway (or ground elevation underneath the clearway) at the defined takeoff distance available. For contaminated calculations, or advisory wet distances, the screen height is reduced to 15ft.

The Figure 8 below depicts the all engines operating takeoff distance, in blue, and the one engine inoperative takeoff distance in red. On very long runways, there is usually a significant difference between the two distances, meaning that real world observations of runway used during a takeoff appear to be much less than those which are often requested or considered by aircraft performance for the one engine inoperative situation. However, on shorter runways, such as the current runway 16/34 at Chicago Executive, the difference between the all engines operating and one engine inoperative length can be reduced to only a few hundred feet. In these situations, it is even possible for the all engines operating takeoff distance to be more limiting.

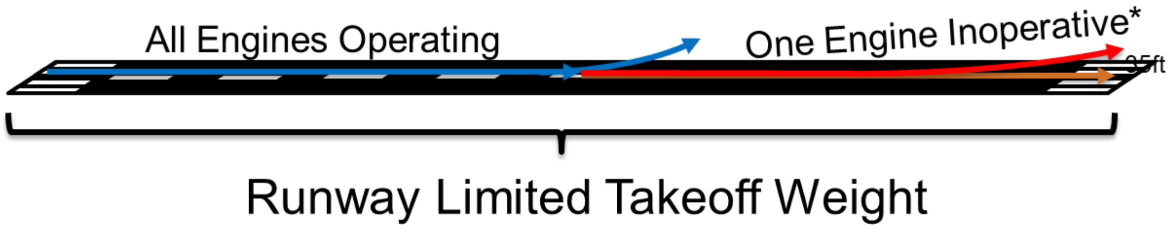


Figure 8 Consideration of Field Length in Aircraft Performance Computations

The distance required for the accelerate go phase of flight will be highly influenced by the aircraft weight, flap setting, thrust setting, runway slope and ambient surface conditions. The accelerate go situation can also be limited by runway contamination, but only when enough contaminant has built up to the point that it creates an impingement or displacement drag on the aircraft. These effects were considered in the performance considerations in this assessment.

6.3.1.2 Accelerate Stop

The secondary consideration in a runway limited aircraft performance computation is for the aircraft to accelerate from the start of the takeoff roll (after alignment distance has been taken into consideration) with all engines operating and experience a situation in which the aircraft needs to abort the takeoff maneuver just prior to passing the decision speed on the runway. In this scenario, the worst-case outcome of both engines operating or one engine operating is considered as the flight crews work to bring the airplane to a stop on the remaining runway (shown in Figure 8 in orange). It is important to note that for all dry aircraft performance computations, the use of thrust reverser credit is not permitted. For wet and contaminated performance, certain aircraft (and operators) are permitted to take credit for thrust reversers. However, credit for thrust reversers is usually limited to only one working thrust reverser. And in no situation can a dry accelerate stop calculation produce a runway length which is longer than the one necessary for wet or contaminated conditions. This limitation is imposed by a comparison of runway length performed after each of the runway surface condition results are calculated, and is not a physics based limitation.

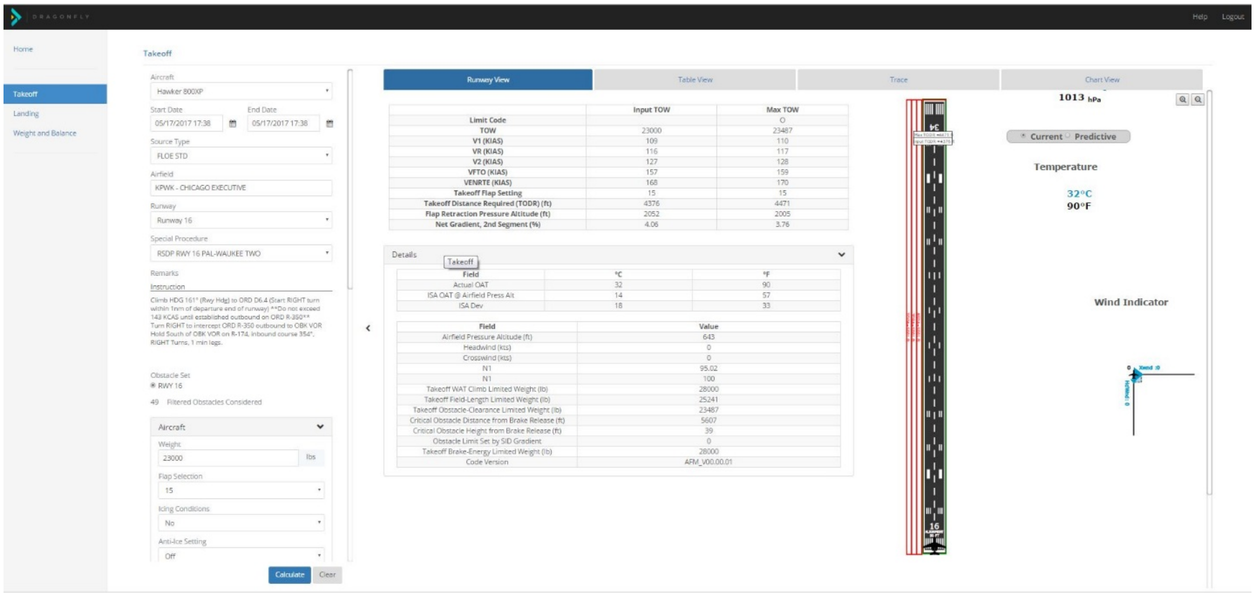
The primary variables impacting accelerate stop performance are runway length, runway slope, ambient conditions, runway surface contamination all of which are critical on a runway supporting jet operations.

6.3.1.3 Balanced Field Length

The goal of a runway limited takeoff computation is to achieve a balanced runway result that, given one takeoff decision speed, the pilots will be able to perform either the accelerate go and the accelerate stop maneuver in the amount of runway available to them. This is usually achieved by a software process called a balanced field length assessment, in which the decision speed is modulated until the two distances required are equal to one and other.

Certain aircraft flight manuals provide balanced field length results directly in table look up format for consideration in runway length assessments, like the Cessna 560XLS. More advanced aircraft, like the 800XP or the G6000 can utilize sophisticated decision speed optimization routines that still result in a balanced runway length, but require computerized software (like SCAP) to achieve the result.

LEAN/DragonFly utilize in house created aircraft performance modules run through a proprietary system called Performance+ (shown below in Figure 9) to achieve these results.



Takeoff

Aircraft: Hawker 800XP
Start Date: 05/17/2017 17:38
End Date: 05/17/2017 17:38
Source Type: FLOE STD
Airfield: KPWK - CHICAGO EXECUTIVE
Runway: Runway 16
Special Procedure: RSDP RWY 16 PAL-WAUKEE TWO
Remarks
Instruction
Climb HDG 161° (Rwy Hdg) to ORD D6.4 (Start RIGHT turn within 1nm of departure end of runway) **Do not exceed 143 KCAS until established outbound on ORD R-350** Turn RIGHT to intercept ORD R-350 outbound to OBK VOR Hold South of OBK VOR on R-174, inbound course 354°, RIGHT Turns, 1 min legs.
Obstacle Set
● RWY 16
49 Filtered Obstacles Considered

Aircraft
Weight: 23000 lbs
Flap Selection: 15
Icing Conditions: No
Anti-Ice Setting: Off

	Input TOW	Max TOW
Limit Code		O
TOW	23000	23487
V1 (KIAS)	109	110
VR (KIAS)	116	117
V2 (KIAS)	127	128
VFTO (KIAS)	157	159
VENRTE (KIAS)	168	170
Takeoff Flap Setting	15	15
Takeoff Distance Required (TODR) (ft)	4376	4471
Flap Retraction Pressure Altitude (ft)	2052	2005
Net Gradient, 2nd Segment (%)	4.06	3.76

Details

Takeoff

Field	°C	°F
Actual OAT	32	90
ISA OAT @ Airfield Press Alt	14	57
ISA Dev	18	33

Field	Value
Airfield Pressure Altitude (ft)	643
Headwind (kts)	0
Crosswind (kts)	0
N1	95.02
N1	100
Takeoff WAT Climb Limited Weight (lb)	28000
Takeoff Field-Length Limited Weight (lb)	25241
Takeoff Obstacle-Clearance Limited Weight (lb)	23487
Critical Obstacle Distance from Brake Release (ft)	5607
Critical Obstacle Height from Brake Release (ft)	39
Obstacle Limit Set by SID Gradient	0
Takeoff Brake-Energy Limited Weight (lb)	28000
Code Version	AFM_V00.00.01

Figure 9 Screen Shot of Performance+

6.3.1.4 *Unbalanced Field Length*

In situations where a balanced field length computation resulted in a runway length, for a given weight, that was higher than necessary, LEAN/DragonFly utilized an unbalanced field length computation. This enabled the 800XP and G6000 to use less runway than what would have been required by a traditional balanced assessment of runway length required. When results were calculated using an unbalanced method, they were identified in the comments section of the tabular results.

6.3.1.5 *Runway Limited Calculation Capabilities for Aircraft in This Assessment*

In the 560XLS, the ability to calculate the accelerate go and accelerate stop distances are combined into a single assessment with no insight as to which phase created the need for the runway length.

In the 800XP and G6000, certain runway limited calculations do permit the accelerate stop and accelerate go phase to be calculated independently. However, for the purposes of this runway length assessment, no records were kept with respect to whether the aircraft was limited by the stop or the go distance. In future analysis of alternatives, or in situations where risk assessments are to be performed relative to safety margins resulting from length extensions (or a lack thereof), it will be important to utilize the separation in field lengths between the two cases.

6.3.2 Obstacle Limited Calculations

All domestic and international operators must consider obstacle clearance and obstacle avoidance when calculating takeoff performance. When the overall takeoff weight must be reduced to clear, or avoid, obstacles then the resulting takeoff weight is referred to as obstacle limited.

6.3.2.1 Obstacle Clearance

Obstacle limited performance stems from the requirement for aircraft operators (of FAR Part 25 certified airplanes) to vertically clear all obstacles by both a 35ft margin plus a 0.8% net margin (for two engine aircraft) or a 0.9% net margin (for three engine aircraft). This vertical obstacle clearance begins at the end of the takeoff distance (TODA) and continues until the aircraft has reached either 1500ft above the airport or an altitude/distance at which the aircraft is no longer considered to be in the takeoff phase of flight. The initial obstacle clearance phase can be seen in Figure 10.

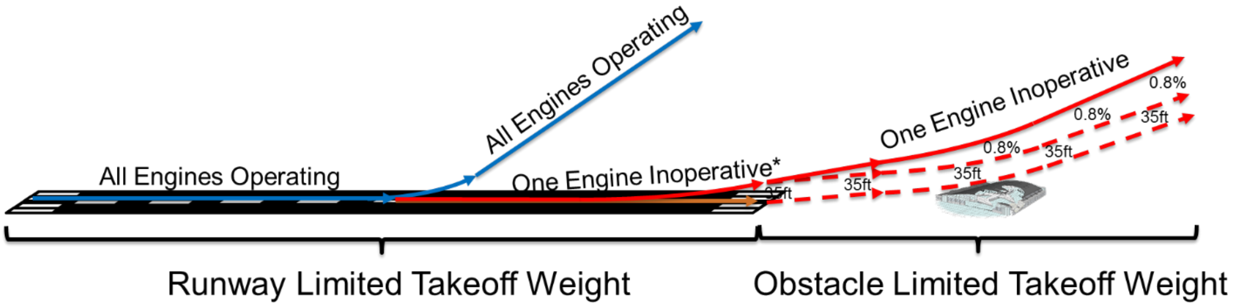


Figure 10 Runway length and obstacle clearance considerations in aircraft performance

The amount of runway length available for the aircraft to utilize will often directly influence the impact of obstacle limited takeoff weights. Longer runways, or runways with brake release points which are far away from obstacles, will potentially improve obstacle limited takeoff performance. This is because the longer runway provides aircraft an opportunity to gain more speed on the ground, which leads to a faster/steeper climb out path, and/or will enable the use of a reduced flap setting that also improves the angle of the climb out path. Shorter runways, conversely, will force aircraft to either use high flap takeoffs that consume less distance on the ground but create shallow obstacle clearance paths or they will require significant weight reductions to enable the use of low flap (steep climb) operations.

The calculation of obstacle limited takeoff weights is performed using either an FAA approved aircraft flight manuals (AFM), FAA approved computerized aircraft flight manuals (CAFM) or FAA accepted standard computerized aircraft performance module (SCAP). Obstacle limited takeoff weights optimization is directly tied into the runway limited takeoff weight optimization as the flap or speed selection which is utilized at the end of the takeoff distance is the same speed and flap that will be used, initially, to clear obstacles vertically. The main challenge for using AFMs, CAFMs or SCAP is that they are inherently centered around a fixed definition of runway lengths, declared distances and obstacles to be considered for vertical clearance. This is very useful for pilots and aircraft operations planners, but not as useful when compared to a runway length extension.

LEAN/DragonFly uses the same technology as those available to operators, but applies the technology through additional software applications and engineering expertise ability to calculate obstacle limited weights, and runway lengths which contribute to obstacle limited weights. LEAN/DragonFly converts all the sources previously described into extended capability SCAP modules which are passed information about the location of obstacles originating from the break release point on the proposed runway extension. As different runway extensions are considered, the obstacle definitions are automatically adjusted to account for changing break release points, for example a north extension of runway 16/34 with departures on runway 16. Certain extensions can also trigger automated obstruction removal based on input runway and airspace design triggers. This is particularly important for this project given the potential to eliminate obstacles located in the departure and approach RPZ.

The ability to perform highly optimized runway length determinations that account for obstacle limited takeoff weight is limited by the level of sophistication available in the FAA approved and accepted materials available to operators and LEAN/DragonFly.

6.3.2.2 Obstacle Clearance for the Aircraft in This Assessment

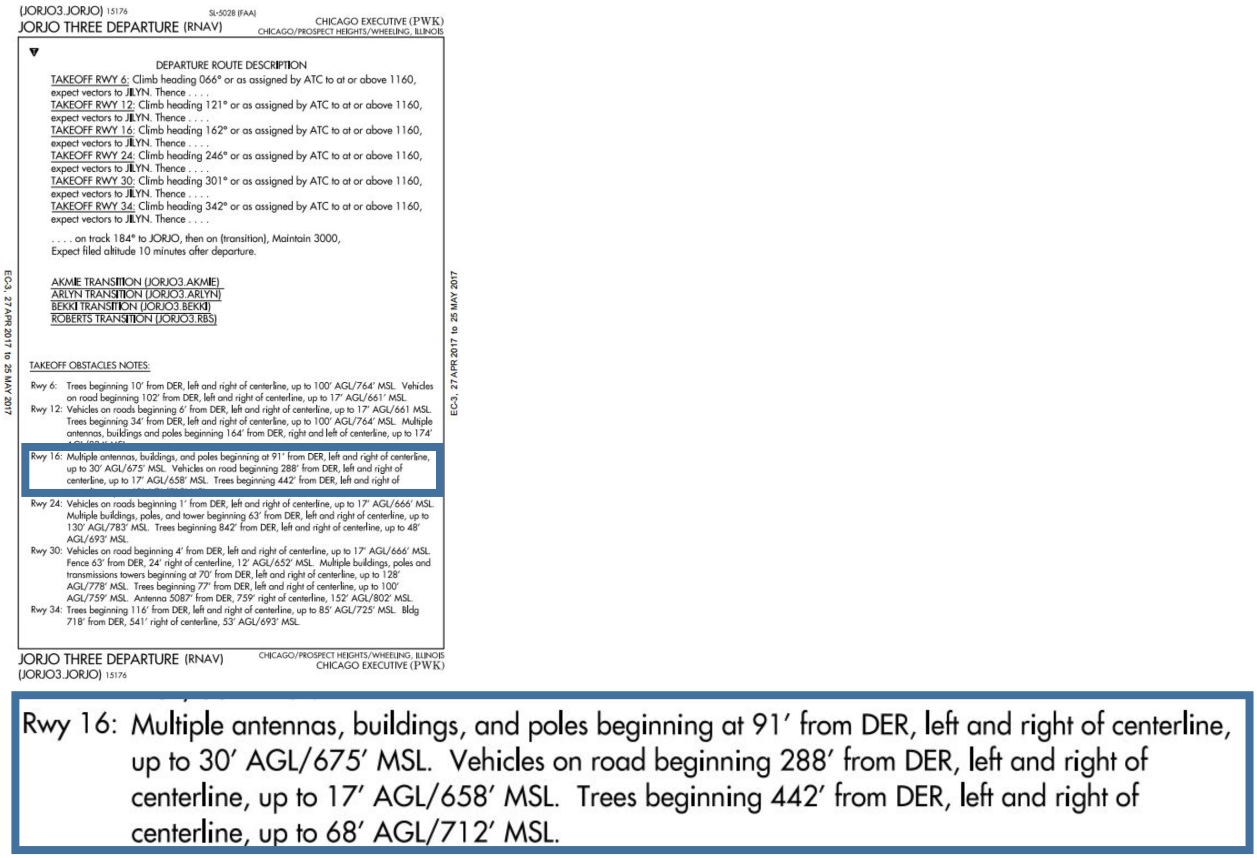
For the 800XP and 560XLS aircraft, the obstacle clearance calculations originate from information contained in the FAA approved Aircraft Flight Manual. Optimizations which balance runway consumed, obstacle clearance and runway length required are performed within a SCAP module created by LEAN/DragonFly. Neither aircraft have any improved climb techniques, gaining additional speed on the runway to clear obstacles, but both aircraft to have multiple flap settings that can be considered for enhancing obstacle limited takeoff weights with the minimum possible runway extension.

For the Global6000, a Bombardier created SCAP module handles the basic optimization and obstacle clearance functions. This SCAP module is purpose built for optimizing obstacle clearance with a “set” runway length. Therefore, LEAN/DragonFly applied an additional optimization layer on top of the module which handles the changes in runway length, obstacle clearance, flap settings and improved climb.

6.3.2.3 Obstacle Avoidance

For FAR Part 91 and 91-K operations, pilots can consider obstacle avoidance either through compliance with published FAA departure procedure guidance or with a one engine inoperative obstacle avoidance procedure which may diverge from all public FAA departure procedures.

In situations where an operator chooses to utilize the public FAA departure procedure, they must have a means to show that at the anticipated time of departure, the aircraft can both meet or exceed the climb gradient requirements as well as clear all obstacles listed as a part of the “Low Close In” takeoff obstacle notes section. The image below (Figure 11) depicts an example of the current “Low Close In” obstacles published at Chicago Executive Airport.



(JORJO3.JORJO) 15176 SL-5028 (FAA)

JORJO THREE DEPARTURE (RNAV)

CHICAGO EXECUTIVE (PWK)
CHICAGO/PROSPECT HEIGHTS/WHEELING, ILLINOIS

EC-3, 27 APR 2017 to 25 MAY 2017

DEPARTURE ROUTE DESCRIPTION

TAKEOFF RWY 6: Climb heading 066° or as assigned by ATC to at or above 1160, expect vectors to JILYN. Thence . . . .
TAKEOFF RWY 12: Climb heading 121° or as assigned by ATC to at or above 1160, expect vectors to JILYN. Thence . . . .
TAKEOFF RWY 16: Climb heading 162° or as assigned by ATC to at or above 1160, expect vectors to JILYN. Thence . . . .
TAKEOFF RWY 24: Climb heading 246° or as assigned by ATC to at or above 1160, expect vectors to JILYN. Thence . . . .
TAKEOFF RWY 30: Climb heading 301° or as assigned by ATC to at or above 1160, expect vectors to JILYN. Thence . . . .
TAKEOFF RWY 34: Climb heading 342° or as assigned by ATC to at or above 1160, expect vectors to JILYN. Thence . . . .

. . . . on track 184° to JORJO, then on (transition), Maintain 3000, Expect filed altitude 10 minutes after departure.

AKMIE TRANSITION (JORJO3.AKMIE)
ARLYN TRANSITION (JORJO3.ARLYN)
BEKKI TRANSITION (JORJO3.BEKKI)
ROBERTS TRANSITION (JORJO3.RBS)

TAKEOFF OBSTACLES NOTES:

Rwy 6: Trees beginning 10′ from DER, left and right of centerline, up to 100′ AGL/764′ MSL. Vehicles on road beginning 102′ from DER, left and right of centerline, up to 17′ AGL/661′ MSL.
Rwy 12: Vehicles on roads beginning 6′ from DER, left and right of centerline, up to 17′ AGL/661 MSL. Trees beginning 34′ from DER, left and right of centerline, up to 100′ AGL/764′ MSL. Multiple antennas, buildings and poles beginning 164′ from DER, right and left of centerline, up to 174′
Rwy 16: Multiple antennas, buildings, and poles beginning at 91′ from DER, left and right of centerline, up to 30′ AGL/675′ MSL. Vehicles on road beginning 288′ from DER, left and right of centerline, up to 17′ AGL/658′ MSL. Trees beginning 442′ from DER, left and right of
Rwy 24: Vehicles on roads beginning 1′ from DER, left and right of centerline, up to 17′ AGL/666′ MSL. Multiple buildings, poles, and tower beginning 63′ from DER, left and right of centerline, up to 130′ AGL/783′ MSL. Trees beginning 842′ from DER, left and right of centerline, up to 48′ AGL/693′ MSL.
Rwy 30: Vehicles on road beginning 4′ from DER, left and right of centerline, up to 17′ AGL/666′ MSL. Fence 63′ from DER, 24′ right of centerline, 12′ AGL/652′ MSL. Multiple buildings, poles and transmissions towers beginning at 70′ from DER, left and right of centerline, up to 128′ AGL/778′ MSL. Trees beginning 77′ from DER, left and right of centerline, up to 100′ AGL/759′ MSL. Antenna 5087′ from DER, 759′ right of centerline, 152′ AGL/802′ MSL.
Rwy 34: Trees beginning 116′ from DER, left and right of centerline, up to 85′ AGL/725′ MSL. Bldg 718′ from DER, 541′ right of centerline, 53′ AGL/693′ MSL.

JORJO THREE DEPARTURE (RNAV)
(JORJO3.JORJO) 15176

CHICAGO/PROSPECT HEIGHTS/WHEELING, ILLINOIS
CHICAGO EXECUTIVE (PWK)

Rwy 16: Multiple antennas, buildings, and poles beginning at 91′ from DER, left and right of centerline, up to 30′ AGL/675′ MSL. Vehicles on road beginning 288′ from DER, left and right of centerline, up to 17′ AGL/658′ MSL. Trees beginning 442′ from DER, left and right of centerline, up to 68′ AGL/712′ MSL.

Figure 11 Low Close-In Obstacles on Runway 16

Takeoff performance computations utilizing FAA departure procedures are typically used by aircraft that are not challenged by obstacle limited performance requirements due to low operating weights, favorable environmental conditions, or substantial excess aircraft performance capabilities.

For those FAA Part 91, FAA Part 91-K and FAA Part 135 operators that need to enhance their obstacle limited takeoff weight, they will typically choose to utilize a one engine inoperative procedure, either of their own design or purchased from a 3rd party provider. With these procedures, obstacles which are known to the operator must either be cleared vertically or avoided laterally through a combined flight path and obstacle clearance performance analysis. The lateral containment areas considered for determination of obstacle clearance vs obstacle avoidance were assumed to abide by the Area Analysis Method described in FAA AC-120-91 Airport Obstacle Analysis.

In the event that non-US operators perform takeoffs from Chicago Executive Airport, they would be required to comply with the more conservative definition between AC-120-91 and their specific host nation regulations. In most cases, the specific host-nation guidance would be more restrictive than the FAA standards. However, for the purposes of this assessment, only US operators following the FAA AC-120-91 method were considered.

The performance calculations for obstacle avoidance are more complicated than typical aircraft performance software, or AFM reviews, and require a DragonFly created aircraft performance flight path simulation. This flight path simulation is integrated with the Global Procedure Designer (GPD) mentioned in section 3 of this assessment. This combination of technology not only determines optimal flight paths for obstacle avoidance, but it also optimizes runway length and obstacle clearance over any obstacles which were detected using flight track/flight path expansion with environmentally effected true airspeed adjustments.

All obstacle clearance calculations that result from a One Engine Inoperative obstacle avoidance departure procedure will need to account for any losses in climb performance associated with turning flight. This is of importance for obstacle limited aircraft performance calculations used when departing runway 16, that might follow the ATC restricted PALWAUKEE TWO SID. The amount of climb performance lost, which occurs during turning flight, is accounted for by applying a climb gradient loss in the form of a vertical adjustment to the height of any obstacles which still must be cleared by the vertical path of the aircraft. Gradient loss is specific to each aircraft, flap setting and in some cases airspeed/weight and is accounted for with the Terminal+, GPD and Performance+ tools used by LEAN/DragonFly.

6.3.3 Takeoff Performance Settings and Configurations

The following is a list of the configurations considered for this assessment:

1. Thrust
    a. Maximum takeoff
2. Flaps
    a. Best available flap setting to achieve shortest field length with highest weight
3. Engine Bleeds
    a. Air Conditioning – On
    b. Anti-Ice – As Needed
4. Acceleration Altitude
    a. Minimum of 800ft HAR
5. Decision Speed Bias
    a. Balanced
    b. Unbalanced
6. Thrust Reversers
    a. As needed for contaminated conditions
7. Brake Application
    a. Maximum Effort

6.3.4 Other Limitations

Takeoff performance is limited by other factors which aren’t as directly related to the length of the runway or the obstacle clearance flight path. These include the brake energy limited weight, tire speed limited weight, minimum controllable airspeed limited weights and climb limited weights. These independent weight limitations were considered as a part of this runway length assessment.

In some cases, these individual limitations, which are often specific to a selected flap setting, imposed a weight limitation that prevented a target runway extension from achieving the desired weight. In that situation, a different flap setting was selected which may have had the effect of increasing the necessary runway length for the weight to increase beyond the values achieved by other flap settings. This was a particularly common occurrence on the G6000 when attempting to determine runway length extensions that could achieve the maximum structural takeoff weight.

It is also important to note that the current runway width of 150ft prevented any additional minimum controllable speed calculations from needing to be performed in conjunction with this runway length assessment. Therefore, only standard minimum controllable speed considerations, without consideration for crosswind, were utilized in the takeoff runway length assessments.

No considerations were made for inoperative or MEL items on any takeoff performance computation.

6.4 Landing Performance

Landing performance is a substantial consideration for any aircraft performance based runway length assessment. While most aircraft can typically come to a complete stop in a runway in less distance than would be necessary to execute a takeoff, the changes to landing distance assessment and the new Field Condition and Reporting system (FICON) have created situations in which business jets will experience runway length needs for landing which are in excess of the takeoff lengths.

The landing distance assessments used by pilots for pre-flight and inflight aircraft performance calculations currently consider two general types of limits: Runway Length and Missed Approach Climb Capabilities. In the very rare situations where missed approach, go around and/or balked/rejected landing operations require an operator to consider one engine inoperative obstacle clearance, separately from FAA derived missed approach paths and gradients, then an additional limitation on runway extensions would be considered relative to the location of the landing threshold and touchdown zone.

In the case of the Chicago Executive Airport, the current approach procedures do not contain any operational hazards or limitations that would force an operator to consider additional landing performance weight restrictions due to obstacle clearance. Therefore, the length of the runway necessary to accommodate the maximum landing weight will be assessed based on traditional runway limited, climb limited and other aircraft configuration limitations.

6.4.1 Runway Limited Landing Performance

Runway limited landing performance is computed at two points in a flight operation. The first calculation occurs prior to the aircraft departing the origin. The second calculation occurs at the time of arrival into the airport. Both calculations consider the amount of runway available, but the level of detail with respect to runway contamination, runway slope, temperature, pressure and the amount of the runway that can be considered for landing vary greatly.

For FAA Part 91, FAA Part 91-K and certain FAA Part 135 operations, the pre-departure runway limited performance must show that the aircraft can safely come to a stop at the destination airport (Chicago Executive) within a % of the overall length of the runway. The target percentage varies based on the operating type (91 vs 91-K and 135) and whether the operator has an approved Destination Airport Analysis Program (DAAP).

Pure FAR Part 91 operators need only show that the aircraft will come to a complete stop on the intended runway for use at the estimated time of arrival. This is to say that an FAR Part 91 operated flight can use 100% of the runway length as a pre-departure performance assessment.

FAR 91-K and FAR 135 operators with a DAAP can use 80% of the effective length of the intended runway for consideration in the pre-takeoff runway limited landing weight.

FAR Part 135 Operators without a DAAP will be required to follow FAR 135.385 basic requirement to show that, prior to departure, the aircraft can come to a stop within 60% of the effective length of the intended runway for consideration at the destination.

The intended runway for pre-departure planning purposes is usually either a dry or wet runway that may be the most favorable or the longest. If the runway is presumed to be wet at the anticipated time of arrival, then an additional 15% additive is placed on the aircraft performance calculated runway length, and this enhanced length must be shown to stop within the 100%/80%/60% determination.

Once any of these aircraft becomes airborne, enroute to Chicago Executive Airport, then the operator must calculate the actual landing distance required at the time of arrival. This will be a more sophisticated performance calculation that takes runway contamination, FICONs, and actual runway usage into consideration. This number must also be shown to have a 15% added safety margin for comparison against the landing distance available on the runway to be used. Because the pre-departure assessment did not require consideration of runway conditions other than dry or wet, the landing assessment at the time of arrival can in some cases become more conservative than the pre-takeoff determination, especially when FICONs less than 5 are in effect.

For the purposes of determining an aircraft performance based runway extension with as much importance as runway 16 it is necessary to compute all possible combinations of landing distance requirements both from the pre-departure and enroute landing distances. However, the distances used to make a recommendation regarding any possible extensions should be no less than those lengths required for the enroute landing distance assessments. This is because an operator that determines that the pre-departure runway limited landing weight to not be feasible, can overcome this deficiency by carrying enough fuel to land at an alternate destination airport. This requirement to carry additional fuel, which would potentially not be consumed in flight prior to landing, will be considered in the payload range estimations.

6.4.2 Missed Approach Climb Limitations

Landing performance for FAR Part 25 certificated aircraft must consider the possibility of conducting a missed approach or go-around. A missed approach, from the missed approach point (some distance prior to the runway threshold and at an altitude above the airfield) is simulated using the approach climb limited performance analysis which requires a two engined aircraft, operating with only one engine, to be able to maintain a 2.5% gradient while in the missed approach configuration. A Go-around, presumed to occur as the wheels contact the runway, is simulated using the landing climb limited performance analysis which requires a 3.2% gradient to be achievable with both engines operating with the aircraft in the final approach configuration.

The approach climb and landing climb gradient capabilities are not wind adjusted and are therefore usually checked prior to departure against the anticipated temperature and pressure conditions on the airfield. In unusual circumstances, some operators will use the approach climb and landing climb analysis to examine higher required gradients. This occurs when an approach procedure has a missed approach with a non-standard gradient (higher than 200ft/nm). However, at the time of this assessment no such approaches existed at Chicago Executive Airport. Therefore, the standard approach climb and landing climb limitation were considered as potential weight limits against any possible runway extension benefits on the landing distance.

6.4.3 Approach Considerations on Runway Limited Landing Performance

A typical runway limited landing weight limitation will consider the distance the aircraft will travel as it crosses from a height at least 50ft above the threshold to a touchdown point on the runway (known as the “air distance”) and from the point of touchdown to the point at which the aircraft can be brought a complete stop (referred to in this report as the “ground distance”). Few aircraft ever cross the threshold at precisely 50ft, and few aircraft also execute the beginning of the ground distance within a precise distance of the intended touchdown zone. But there are certain aspects of instrument approaches and visual glideslope indication systems which can exacerbate these issues to the point that a separate runway limited performance calculation must be performed.

Runway limited aircraft performance computations can be affected by three primary approach procedure properties:

1. Non-standard Glide Path Angles
2. Non-standard VGSI Angles
3. Autopilot required aircraft configurations

Chicago Executive Airport currently has standard glide path and VGSI angles for the straight in approaches to runway 16. If, in the future, or as a part of any runway extension, non-standard glide path angles or VGSI settings were to be introduced on runway 16 or 34, then additional landing performance assessments would need to be considered to assess the effectiveness of any runway extensions.

The ILS approach to runway 16 is currently a CAT I ILS with a required decoupling of the autopilot at approximately 500ft HAT. If in the future, a CAT II ILS (or lower) approach were to be installed then an additional landing performance assessment would need to be made to consider aircraft that utilize reduced flap settings during ILS CAT II approaches.

6.4.4 Landing Performance Settings and Configurations

The following is a list of the configurations considered for this assessment:

8. Flaps
    a. Primary Approach
    b. Maximum Landing
9. Engine Bleeds
    a. Air Conditioning – On
    b. Anti-Ice – As Needed
10. Speed Additives
    a. As required for wind/gust conditions
11. Thrust Reversers
    a. None
12. Brake Application
    a. Maximum Effort

6.4.5 Other Limitations

Landing performance is limited by several other factors beyond runway length and missed approach capabilities including brake energy limited weight and tire speed limited weights. Both the brake energy and tire speed limitations were considered by the landing performance computations performed in this assessment.

6.5 Payload and Range

The amount of payload which an aircraft can carry is determined by adherence with the structural weight limitations and performance based weight limitations imposed by the runway, obstacle clearance and the route of flight. It is therefore important to consider the effectiveness of a runway extension not just on the ability for a runway to increase a takeoff or landing weight, but also to determine if a useful amount of payload can be carried to or from the airport with the existing or potential increased weight limitations.

For the purposes of this aircraft performance based runway length assessment, payload range analysis was included to complement individual runway length assessments. In addition, a range ring assessment was also performed to highlight the kinds of enhancements to payload range which would be experienced by the three aircraft considered in this study before and after a runway length enhancement.

6.5.1 Payload

Payload was an input to the payload range computation and was not permitted to vary based on the needs of a particular flight plan or city pair. This means that the amount of fuel necessary for achieving distance to or from the Chicago Executive airport was not allowed to compromise the target payload which was being assessed for the runway length extensions.

To provide a meaningful baseline of values for consideration, three payload assumptions were used for tabular range results:

- 100% of seats filled
- 50% of seats filled
- Empty aircraft

The most reasonable payload considered in business jet aviation would likely be a 50% seat occupancy, considered typical for operations with owners/passengers. The empty aircraft is considered typical for repositioning flights, but is not considered to represent a useful measure for runway length analysis. The empty aircraft does, however, represent a minimum length of runway necessary to possibly accommodate the aircraft.

Like the empty aircraft, a 100% full aircraft is also not considered to be a typical occurrence for a business jet, but it was considered to be an important value for consideration when comparing any potential benefits of a runway extension against future operators that may wish to consider using Chicago Executive Airport for different kinds of missions.

6.5.2 Flight Planning

LEAN/DragonFly used a performance engineering flight planning tool called PACELab Mission Suite (PLMS) to conduct realistic range assessments to be used in the determination of payload range capabilities that would accompany the aircraft performance based runway length assessments. The PLMS tool is not a traditional flight planning application, in the sense that its purpose is not to help the user file an ICAO compliant flight plan. However, PLMS is a sophisticated engineering platform that uses identical methods to other flight planning engines to calculate an accurate payload, range, fuel burn and time estimation of an aircraft capability while obeying typical flight planning and reserve fuel considerations. The primary difference between PLMS and other flight planning applications is that PLMS is more customizable for running hypothetical missions to or from a single airport (without a known destination).

6.5.2.1 Phases of Flight

All jet aircraft operations follow a relatively similar process for the estimation of payload and fuel that mirrors the anticipated phases of flight which the aircraft will follow from takeoff to landing. In the PLMS toolset, this involves the consideration of the following phases of flight and their associated durations:

- Taxi-Out – 10 min
- Takeoff – 1-2 min

- Climb – Aircraft Specific
- Cruise/Step-Climb – Aircraft Specific
- Descent – Aircraft Specific
- Approach – 5 – 10 minutes
- Landing – 5 – 10 minutes
- Taxi-In – 5 minutes

For the purposes of this initial aircraft performance based runway length assessment, the taxi, takeoff, approach and landing phases of flight were not assumed to vary significantly.

Climb, cruise/step cruise and descent were more variable and dependent upon the range of the aircraft that could be achieved.

6.5.2.2 Speed, Flight Level and Optimization

The climb, cruise/step cruise and descent calculations used in this assessment all involved an optimization of the aircraft speed and flight level to achieve a balance of minimum fuel consumption and high speed aircraft operations. This is somewhat different from typical airlines operations in which a cost index target is assigned that attempts to achieve the lowest overall operating cost of a flight by trading time for fuel efficiency. For business jet aviation, which is the primary focus of this runway length assessment, speed is critical to the operations being considered and any fuel savings were used in the extension of aircraft range at a reasonably high speed.

The climb profiles achieved this balance based on the use of manufacturer recommended climb performance in an ATC constrained environment involving a balance of climb gradient capability and time to altitude. Thus, the following climb speed profiles were considered:

- 560XLS 250KIAS/M0.65
- 800XP 250KIAS/M0.70
- G6000 250KIAS/M0.80

Maximum climb capabilities were defined at any altitude/weight combination that could not sustain a residual climb rate of 200ft/min. This means that if an aircraft were certified to fly at FL 450, but the maximum climb capability for the weight and temperature stopped at FL 410, PLMS would not permit the aircraft to climb above FL 410 until the anticipated fuel burn of the aircraft reduced the overall weight of the aircraft to enable it to climb to a higher valid flight level.

The cruise and step cruise capabilities for each aircraft were defined by typical business jet mission planning targets obtained by LEAN/DragonFly in support of FAA Part 91-K and FAA Part 135 jet operations. These speeds ranged from M0.75 up to M0.87. The target Mach for the basic payload range assessments, associated with takeoff and landing weights, was fixed at M0.75 and allowed the aircraft to climb to higher altitudes to achieve a higher true airspeed along the ground. The range ring assessments utilized M0.75 for the XLS, M0.80 for the 800XP and M0.84 for the G6000 to show a more realistic, and wind effected, range comparison between the current runway capabilities and those resulting from the range of recommended length extensions. Range ring assessments also permitted flight level optimization which took wind accountability at different flight levels into consideration.

Flight level selection was further constrained based on IFR RVSM flight planning rules. These restrictions are less apparent in the ranges presented in the tables of payload range attributed to takeoff and landing results for specific runway extensions. However, the range ring diagrams are constructed with strict adherence to the flight levels associated with FAA and ICAO conventions, coupled with RVSM limitations commonly used by business jets operating at altitudes above FL 410. This can most readily be seen by a notch in the payload range assessments where the flight level restrictions change based on direction of flight at the northern most and southern most bearings away from the airport (top and bottom of the circle).

6.5.2.3 Fuel Burn

Fuel burn information used in PLMS was compiled from Flight Planning and Performance Manuals, or Flight Operations Manuals, current for each of the three aircraft considered in this assessment. Specific fuel consumption rates were considered for the following:

- Taxi
- Climb
- Cruise/Step-Cruise
- Descent
- Holding

Fixed fuel burn assumptions were used for the following:

- Takeoff
- Approach
- Landing

All values obtained from the aircraft manufacturer provided flight manuals were not modified to reflect any potential performance degradations associated with aging aircraft.

6.5.2.4 Historical Enroute Wind

Enroute winds were considered as a factor for the range ring analysis included in this report. This information was calculated from FAA ADDS data pertaining to winds aloft tabulated at each 1,000ft pressure altitude over a distributed grid of points. A 65% confidence interval assessment was applied for each potential direction of flight to obtain an average wind encountered along the route of flight starting or terminating at the Chicago Executive airport, and emanating in radials at a 1 degree increment of true heading from 001 to 360. Each heading contained a unique historical wind value, which was based on an annual assessment of wind conditions calculated from 30 years of historical inputs.

Enroute winds were not considered in the tables pertaining to takeoff and landing weight results. This is because the table does not specify a destination, or heading, to or from the airport to be considered. Therefore, it was more appropriate to not consider enroute winds to make a consistent comparison in those tables, while using statistical wind impacts on the range assessments to demonstrate the potential enhancements specific to the target runway extension.

6.5.2.5 Reserve Fuel Planning

Aircraft operators following FAR Part 91, FAA Part 91-K and FAA Part 135 operating rules will frequently consider carrying a reserve fuel level that is either minimally specified by 91.167, or more frequently that follows NBAA recommended guidelines for IFR operations. Given that Chicago Executive is essentially surrounded by Class B airspace, requiring all departing and arriving aircraft to file for an IFR flight plan (especially for the purposes of large and medium cabin jet operations) the use of NBAA IFR reserve fuel is considered to be a reasonable quantity to be carried by aircraft for the purposes of payload range assessments.

The NBAA IFR reserve used for this assessment was calculated specifically for each aircraft payload range assessment based on the anticipated landing weight. The calculation of the reserve fuel involved the following phases of flight over a 100nm distance:

- Overshoot to 1,500ft Above the Airport: 80% of the fuel consumed in takeoff
- Holding at 5,000ft MSL: Minimum Drag Speed for 5 minutes
- Climb to FL350, or altitude defined by initial optimal step cruise: Based on standard climb profile
- Step Cruise: Based on standard cruise speed targets
- Descent to Landing: Based on standard descent profile
- Holding at 5,000ft MSL: Minimum Drag Speed for 30 Minutes
- Approach and Landing from 1,500ft

6.5.2.6 Other factors

To accurately simulate real world flight planning in PLMS, it was necessary to increase the distance an aircraft must travel to achieve a range between two points on the earth. This increase in range is a result of current inefficiencies in high altitude airspace models that require aircraft to move along predefined routes and airways that rarely overlay precisely with the great circle path. This difference between the route of flight and the great circle distance can vary from a 2% addition in required distance for long range flights to as much as 50% to 100% for very short flights.

The overall route efficiency factor applied to all range calculations in this assessment was fixed at 3%.

7 Runway Length Analysis

The following section of the report describes some of the pertinent results taken from the detailed analysis available in the LEAN/DragonFly master set of results available as a separate report.

A brief description of the runway extension assumptions which were considered is also included in this section.

Tables in this section are divided according to runway lengths which would be required to support takeoff performance and runway lengths which would be required to support landing performance. Takeoff tables are identified by the runway length, or extensions assumption, whether the conditions were a Hot Day or Winter Day, and the anticipated runway contaminant or surface from Dry to FICON 3.

The tables related to landing performance have sub section names related to the time at which the landing performance would be assessed, whether the conditions were a Hot Day or Winter Day, the runway surface conditions and the length requirements discussed in section 6. Landing tables sub-sections also include a reference to the landing distance which was presumed to be necessary for consideration as a “(XX + YY)” in the table title. The “XX” term was the percentage of runway that the aircraft could use for the landing performance assessment. The “YY” term was the percentage of additional landing performance distance that a pilot must consider to occur within the length provided by “XX” times the runway length.

The tables which highlight the current runway landing capabilities show the limiting landing weight achieved, with no payload/range consequence. Tables which highlight possible runway extensions present runway lengths necessary to achieve the maximum structural landing weight.

The tables in this section which highlight optimal runway extensions have the runway lengths highlight in bold.

7.1 Current Runway Capabilities

The current takeoff and landing performance capabilities for each of the three target aircraft are expressed in the tables below.

Summarized results stated in this section were taken from the master series of results (available as a separate excel document) which were identified as “1.b”. The series of results in the master table listed as “1.a” express the results of the current runway length if the airport were to remove all obstacles in the takeoff and approach RPZs for both runway 16 and 34. The “1.a.” results were generated as a baseline comparison for further runway extension assessments and are not considered to represent a “current” state in the same way that the “1.b.” results are.

This summary reveals that the current runway length, and obstacles, enable the 560XLS and G6000 to be capable of achieving somewhat respectable takeoff weights, and payload ranges, while the 800XP aircraft struggles to achieve any takeoff results under wet or contaminated conditions. Takeoff weights on runway 16 were considerably lower than those on runway 34 for all aircraft due to close-in obstacle limitations coupled with the existing runway length.

The current runway landing performance is more limited under non-dry conditions, which is exacerbated by the need to consider tailwinds when landing on runway 16. The 560XLS and 800XP both suffered from the existing short field length under non-dry conditions while all three aircraft are currently not likely to attempt a landing under FICON 3 conditions with the runway at its current length of 5,000ft.

7.1.1 Current Takeoff Results

7.1.1.1 Current Runway 16/34, Hot Day, Dry Conditions

Runway	Aircraft	Takeoff Weight (lbs)	OAT (C)	Wind (kts)	Length (ft)	Range with 0 PAX (Nmi)	Range with 50% PAX (Nmi)	Range with 100% PAX (Nmi)
16	560XLS	19558	32	0	5001	1724	**1478**	1240
16	800XP	24207	32	0	5001	1979	**1653**	1335
16	G6000	80833	32	0	5001	4495	**4221**	3906
34	560XLS	20144	32	0	5001	1804	**1755**	1531
34	800XP	25205	32	0	5001	2319	**1997**	1684
34	G6000	82291	32	0	5001	4717	**4443**	4128

7.1.1.2 Current Runway 16/34, Hot Day, Wet Conditions

Runway	Aircraft	Takeoff Weight (lbs)	OAT (C)	Wind (kts)	Length (ft)	Range with 0 PAX (Nmi)	Range with 50% PAX (Nmi)	Range with 100% PAX (Nmi)
16	560XLS*	19221	32	0	5001	1709	**1372**	1133
16	800XP	Not Possible	32	0	5001	0	**0**	0
16	G6000*	80398	32	0	5001	4428	**4154**	3839
34	560XLS*	20144	32	0	5001	1804	**1752**	1512
34	800XP	Not Possible	32	0	5001	0	**0**	0
34	G6000*	82291	32	0	5001	4717	**4443**	4128

* Thrust reversers required

7.1.1.3 Current Runway 16/34, Winter Day, Contaminated Conditions

Runway	Aircraft	Takeoff Weight (lbs)	OAT (C)	Wind (kts)	Length (ft)	Range with 0 PAX (Nmi)	Range with 50% PAX (Nmi)	Range with 100% PAX (Nmi)

16	560XLS*	20200	0	0	5001	1804	**1755**	1531
16	800XP	Not Possible	0	0	5001	0	**0**	0
16	G6000*	81450	0	0	5001	4589	**4315**	4000
34	560XLS*	20200	0	0	5001	1804	**1755**	1531
34	800XP	Not Possible	0	0	5001	0	**0**	0
34	G6000*	83166	0	0	5001	4849	**4575**	4260

* Thrust reversers required

7.1.2 Current Landing Results

7.1.2.1 Current Runway Under Dry Conditions, Hot Day, Using 91-K with DAAP Pre-Flight Assessment (80% + 0%)

Runway	Aircraft	Landing Weight (lbs)	OAT (C)	Wind (kts)	Length (ft)	Range with 0 PAX (Nmi)	Range with 50% PAX (Nmi)	Range with 100% PAX (Nmi)
16 or 34	560XLS	**18700**	32	-10	5001	1725	1676	1456
16 or 34	800XP	**23350**	32	-10	5001	2500	2395	2295
16 or 34	G6000	**78600**	32	-10	5001	6660	6562	6454

7.1.2.2 Current Runway 16/34 Under FICON 5 Conditions, Hot Day, with In-Flight Assessment (100% + 15%)

Runway	Aircraft	Landing Weight (lbs)	OAT (C)	Wind (kts)	Length (ft)	Range with 0 PAX (Nmi)	Range with 50% PAX (Nmi)	Range with 100% PAX (Nmi)
16 or 34	560XLS	**18700**	32	-10	5001	1725	1676	1456
16 or 34	800XP	**19433**	32	-10	5001	2500	2395	Not Possible
16 or 34	G6000	**78600**	32	-10	5001	6660	6562	6454

7.1.2.3 Current Runway 16/34 Under FICON 4 Conditions, Winter Day, with In-Flight Assessment (100% + 15%)

Runway	Aircraft	Landing Weight (lbs)	OAT (C)	Wind (kts)	Length (ft)	Range with 0 PAX (Nmi)	Range with 50% PAX (Nmi)	Range with 100% PAX (Nmi)
16 or 34	560XLS	**16072**	0	0*	5001	1725	1676	1456

16 or 34	800XP	**0**	0	-10	5001	Not Possible	Not Possible	Not Possible
16 or 34	G6000	**65451**	0	-10	5001	6660	6562	6454

*560XLS Cannot land with a tailwind below FICON 5

7.1.2.4 Current Runway 16/34 Under FICON 3 Conditions, Winter Day, with In-Flight Assessment (100% + 15%)

Only the G6000 was capable of landing under these conditions and its landing weight was not considered to be sufficient for reporting in this sub section.

7.2 Landing Length from An Extension in Any Direction

The results of a possible runway extension to 16/34 are presented in the tables below. The lengths are highlighted in bold text. Any assessment which revealed that no extension of the runway would be required to accommodate the maximum possible landing performance was noted with either a single or double asterisk.

The extension of runway 16/34 can occur in any direction to accommodate an increase in landing performance. This assumption is based on the concept that only straight in approaches to runway 16 will continue to exist following the runway extension and that any future approach will not require significant changes to any of the approach procedure designs which might affect landing performance (as discussed in section 6). If this is true, then either the runway 16 threshold will be successfully relocated north, yielding missed approach procedures which do not move closer to O’Hare traffic, or the runway 34 threshold will move south which will not affect approaches to the existing runway 16.

A possible extension of runway 16/34 to accommodate increased landing performance will have significant benefits to all three aircraft types analyzed under non-Dry operating conditions. From the conditions described in the tables below, the 560XLS requires the largest amount of additional runway length from possible extensions, growing from 5,001ft under dry conditions to 7,240ft under FICON 3. The major contributor for this increase is the lack of certified landing performance information available to the Cessna family of business jets which force contaminated landing performance assessment to consider a pre-factored landing distance based on European Operating rules. In the future, this additional conservatism may be reduced pushing the 560XLS landing performance based runway extension needs closer to alignment with the 800XP.

It is also important to point out that the 560XLS cannot land in a tailwind situation under any FICON less than 4. This means that in situations where the winds are favoring runway 34, but only runway 16 is available, the runway condition would have to be improved to a 5 or the 560XLS would be prevented from landing at the Chicago Executive Airport regardless of any potential runway extension.

7.2.1 Runway Length Resulting from an Extension in Any Direction Under Dry Conditions, Hot Day, Using 91-K with DAAP Pre-Flight Assessment (80% + 0%)

Runway	Aircraft	Landing Weight (lbs)	OAT (C)	Wind (kts)	Length (ft)	Range with 0 PAX (Nmi)	Range with 50% PAX (Nmi)	Range with 100% PAX (Nmi)
16 or 34	560XLS	18700	32	-10	**5001***	1725	1676	1456
16 or 34	800XP	23350	32	-10	**5001***	2500	2395	2295
16 or 34	G6000	78600	32	-10	**5001***	6660	6562	6454

*No extension required for this condition

7.2.2 Runway Length Resulting from an Extension in Any Direction Under FICON 5, Hot Day, Conditions with In-Flight Assessment (100% + 15%)

Runway	Aircraft	Landing Weight (lbs)	OAT (C)	Wind (kts)	Length (ft)	Range with 0 PAX (Nmi)	Range with 50% PAX (Nmi)	Range with 100% PAX (Nmi)
16 or 34	560XLS	18700	32	-10	**5200**	1725	1676	1456
16 or 34	800XP	23350	32	-10	**5730**	2500	2395	2295
16 or 34	G6000	78600	32	-10	**5001***	6660	6562	6454

*No extension required for this condition

7.2.3 Runway Length Resulting from an Extension in Any Direction Under FICON 4 Conditions, Winter Day, with In-Flight Assessment (100% + 15%)

Runway	Aircraft	Landing Weight (lbs)	OAT (C)	Wind (kts)	Length (ft)	Range with 0 PAX (Nmi)	Range with 50% PAX (Nmi)	Range with 100% PAX (Nmi)
16 or 34	560XLS	18700	0	0*	**5610**	1725	1676	1456
16 or 34	800XP	23350	0	-10	**6240**	2500	2395	2295
16 or 34	G6000	78600	0	-10	**5700**	6660	6562	6454

*560XLS Cannot land with a tailwind below FICON 5

7.2.4 Runway Length Resulting from an Extension in Any Direction Under FICON 3 Conditions, Winter Day, with In-Flight Assessment (100% + 15%)

Runway	Aircraft	Landing Weight (lbs)	OAT (C)	Wind (kts)	Length (ft)	Range with 0 PAX (Nmi)	Range with 50% PAX (Nmi)	Range with 100% PAX (Nmi)
16 or 34	560XLS	18700	0	0*	**7240**	1725	1676	1456
16 or 34	800XP	23350	0	-10	**6770**	2500	2395	2295

16 or 34	G6000	78600	0	-10	**6770**	6660	6562	6454

*560XLS Cannot land with a tailwind below FICON 5

7.3 Takeoff Performance Benefits from a North Extension of Runway 16/34

The possibility of a runway extension to the north of the existing runway 16 threshold was considered in the detailed analysis under options “2.a.”, “2.b.” and “3.a.” Any north runway extension was considered to have a clear departure and approach RPZ extending from the threshold of runway 16. Set “2.a” considered that the RPZ areas extending from the runway 34 threshold remained as they are today, while set “3.a.” were considered to have a clear departure and approach RPZ.

For the purposes of providing a reasonable runway length for consideration as a starting point for an alternatives process, it was considered important to only utilize the results which had RPZs which were free of all performance limiting obstacles. The results in this sub-section are therefore derived from the set “2.a.” and “3.b.”

The takeoff lengths presented in this section are those necessary for the aircraft to achieve the maximum structural takeoff weight, or weight limited by other non-runway limiting factors and the weight necessary to achieve a 50% load factor mission to the Los Angeles Area. Some results revealed that the current runway length was already sufficient to support either the highest possible MTOW and/or the 50% load factor range. In these cases, no runway extension was recorded.

Other results considered a runway length which was in excess of 8,000ft long to be considered. For these situations, the takeoff performance calculations were stopped at 8,000ft and a value was entered into the master data set of “> 8000”. The reason for truncating the runway length analysis at this length was because the CMT team indicated that potential runway extension of 16/34 in excess of 8000ft are not in the scope of the current planning initiative and should therefore be set aside from further analysis.

The overall results between the maximum takeoff weight runway lengths and the lengths necessary for 50% payload to the Los Angeles Area reveal a significant difference. Maximum takeoff weight lengths all benefited from extensions to the runway ranging from 5190ft (with the 560XLS) and up to > 8000ft for the G6000. Most maximum takeoff weight runway lengths seemed to suggest that at least a 1,000 – 1,900ft extension would be beneficial.

The 50% payload lengths revealed that only the Hawker 800XP, and similar aircraft, would benefit from an increase in takeoff field length available to achieve flights to the Los Angeles Area.

7.3.1 Takeoff Runway Lengths Required for MTOW Under a North Extension

7.3.1.1 Length of Runway 16/34 Extended to the North, Under Dry Conditions, Hot Day, to Achieve MTOW

Runway	Aircraft	Takeoff Weight (lbs)	OAT (C)	Wind (kts)	Length (ft)	Range with 0 PAX (Nmi)	Range with 50% PAX (Nmi)	Range with 100% PAX (Nmi)
16	560XLS	20200	32	0	**5210**	1804	1755	1531
16	800XP	28000	32	0	**6170**	2500	2395	2295
16	G6000	99500	32	0	**7340**	6728	6641	6532
34	560XLS	20200	32	0	**5190**	1804	1752	1512
34	800XP	28000	32	0	**6150**	2500	2395	2295
34	G6000	99500	32	0	**7370**	6728	6641	6532

7.3.1.2 Length of Runway 16/34 Extended to the North, Under Wet Conditions, Hot Day, to Achieve MTOW

Runway	Aircraft	Takeoff Weight (lbs)	OAT (C)	Wind (kts)	Length (ft)	Range with 0 PAX (Nmi)	Range with 50% PAX (Nmi)	Range with 100% PAX (Nmi)
16	560XLS*	20200	32	0	**5210**	1804	1755	1531
16	800XP	28000	32	0	**6770**	2500	2395	2295
16	G6000	99500	32	0	**7440**	6728	6641	6532
34	560XLS*	20200	32	0	**5190**	1804	1752	1512
34	800XP	28000	32	0	**6760**	2500	2395	2295
34	G6000	99500	32	0	**7470**	6728	6641	6532

*Thrust Reversers Required

7.3.1.3 Length of Runway 16/34 Extended to the North, Under Compacted Snow conditions, Winter Day, to Achieve MTOW

Runway	Aircraft	Takeoff Weight (lbs)	OAT (C)	Wind (kts)	Length (ft)	Range with 0 PAX (Nmi)	Range with 50% PAX (Nmi)	Range with 100% PAX (Nmi)
16	560XLS**	20200	0	0	**5001***	1804	1755	1531
16	800XP	28000	0	0	**6960**	2500	2395	2295
16	G6000	99500	0	0	**> 8000**	N/A	N/A	N/A
34	560XLS**	20200	0	0	**5001***	1804	1752	1512
34	800XP	28000	0	0	**6970**	2500	2395	2295
34	G6000	99500	0	0	**> 8000**	N/A	N/A	N/A

*No change in current runway length, **Thrust Reversers Required

7.3.2 Takeoff Lengths Required for 50% PAX to the Los Angeles Area, North Extension

7.3.2.1 Length of Runway 16/34 Extended to the North, Under Dry Conditions, Hot Day, to Achieve 50% PAX to LAX

Runway	Aircraft	Takeoff Weight (lbs)	OAT (C)	Wind (kts)	Length (ft)	Range with 0 PAX (Nmi)	Range with 50% PAX (Nmi)	Range with 100% PAX (Nmi)
16	560XLS	20200	32	0	**5001***	1804	1755	1531
16	800XP	24100	32	0	**5001***	1948	1623	1305
16	G6000	65000	32	0	**5001***	1842	1568	1253
34	560XLS	20144	32	0	**5001***	1804	1752	1512
34	800XP	24100	32	0	**5001***	1948	1623	1305
34	G6000	65000	32	0	**5001***	1842	1568	1253

*No change in current runway length

7.3.2.2 Length of Runway 16/34 Extended to the North, Under Wet Conditions, Hot Day, to Achieve 50% PAX to LAX

Runway	Aircraft	Takeoff Weight (lbs)	OAT (C)	Wind (kts)	Length (ft)	Range with 0 PAX (Nmi)	Range with 50% PAX (Nmi)	Range with 100% PAX (Nmi)
16	560XLS**	20200	32	0	**5001***	1804	1755	1531
16	800XP	24100	32	0	**6050**	1948	1623	1305
16	G6000	65000	32	0	**5001***	1842	1568	1253
34	560XLS**	20144	32	0	**5001***	1804	1752	1512
34	800XP	24100	32	0	**5870**	1948	1623	1305
34	G6000	65000	32	0	**5001***	1842	1568	1253

*No change in current runway length, **Thrust Reversers Required

7.3.2.3 Length of Runway 16/34 Extended to the North, Under Compacted Snow Conditions, Winter Day, to Achieve 50% PAX to LAX

Runway	Aircraft	Takeoff Weight (lbs)	OAT (C)	Wind (kts)	Length (ft)	Range with 0 PAX (Nmi)	Range with 50% PAX (Nmi)	Range with 100% PAX (Nmi)
16	560XLS**	20200	0	0	**5001***	1804	1755	1531
16	800XP	24100	0	0	**6870**	1948	1623	1305
16	G6000	65000	0	0	**5001***	1842	1568	1253
34	560XLS**	20144	0	0	**5001***	1804	1752	1512
34	800XP	24100	0	0	**6890**	1948	1623	1305
34	G6000	65000	0	0	**5001***	1842	1568	1253

*No change in current runway length, **Thrust Reversers Required

7.4 Takeoff Performance Benefits from a South Extension of Runway 16/34

The possibility of a runway extension to the south of the existing runway 34 threshold was considered in the detailed analysis under options 4.a., 4.b. and 5.b. Any south runway extension was considered to have a clear departure and approach RPZ extending from the threshold of runway 34. Set 4.b considered that the RPZ areas extending from the runway 16 threshold remained as they are today, while set 4.a. were considered to have a clear departure and approach RPZ. For the purposes of providing a reasonable runway length for consideration as a starting point for an alternatives process, it was considered important to only utilize the results which had RPZs which were free of all performance limiting obstacles. The results in this sub-section are therefore derived from the set 4.a. and 5.b.

The takeoff lengths presented in this section are those necessary for the aircraft to achieve the maximum structural takeoff weight, or weight limited by other non-runway limiting factors and the weight necessary to achieve a 50% load factor mission to the Los Angeles Area. Some results revealed that the current runway length was already sufficient to support either the highest possible MTOW and/or the 50% load factor range. In these cases, no runway extension was recorded.

Other results considered a runway length which was in excess of 8,000ft long to be considered. For these situations, the takeoff performance calculations were stopped at 8,000ft and a value was entered into the master data set of “> 8000”. The reason for truncating the runway length analysis at this length was because the CMT team indicated that potential runway extension of 16/34 in excess of 8000ft are not in the scope of the current planning initiative and should therefore be set aside from further analysis.

The overall results between the maximum takeoff weight runway lengths and the lengths necessary for 50% payload to the Los Angeles Area reveal a significant difference. Maximum takeoff weight lengths mostly benefited from extensions to the runway ranging from 5210ft (with the 560XLS) and up to > 8000ft for the G6000. Most maximum takeoff weight runway lengths seemed to suggest that at least a 1,000 – 1,900ft extension would be beneficial.

The 50% payload lengths revealed that only the Hawker 800XP, and similar aircraft, would benefit from an increase in takeoff field length available to achieve flights to the Los Angeles Area.

7.4.1 Takeoff Lengths Required for MTOW Under a South Extension

7.4.1.1 Length of Runway 16/34 Extended to the South, Under Dry Conditions, Hot Day, to Achieve MTOW

Runway	Aircraft	Takeoff Weight (lbs)	OAT (C)	Wind (kts)	Length (ft)	Range with 0 PAX (Nmi)	Range with 50%	Range with 100%

							PAX (Nmi)	PAX (Nmi)
16	560XLS	20200	32	0	**5210**	1804	1755	1531
16	800XP	28000	32	0	**6170**	2500	2395	2295
16	G6000	99500	32	0	**7370**	6728	6641	6532
34	560XLS	20200	32	0	**5001***	1804	1755	1531
34	800XP	28000	32	0	**7150**	2500	2395	2295
34	G6000	99500	32	0	**> 8000**	N/A	N/A	N/A

*No change in current runway length

7.4.1.2 Length of Runway 16/34 Extended to the South, Under Wet Conditions, Hot Day, to Achieve MTOW

Runway	Aircraft	Takeoff Weight (lbs)	OAT (C)	Wind (kts)	Length (ft)	Range with 0 PAX (Nmi)	Range with 50% PAX (Nmi)	Range with 100% PAX (Nmi)
16	560XLS**	20200	32	0	**5210**	1804	1755	1531
16	800XP	28000	32	0	**6770**	2500	2395	2295
16	G6000	99500	32	0	**7520**	6728	6641	6532
34	560XLS**	20200	32	0	**5001***	1804	1755	1531
34	800XP	28000	32	0	**> 8000**	N/A	N/A	N/A
34	G6000	99500	32	0	**> 8000**	N/A	N/A	N/A

*No change in current runway length, **Thrust Reversers Required

7.4.1.3 Length of Runway 16/34 Extended to the South, Under Contaminated Conditions, Winter Day, to Achieve MTOW

Runway	Aircraft	Takeoff Weight (lbs)	OAT (C)	Wind (kts)	Length (ft)	Range with 0 PAX (Nmi)	Range with 50% PAX (Nmi)	Range with 100% PAX (Nmi)
16	560XLS**	20200	0	0	**5001***	1804	1755	1531
16	800XP	28000	0	0	**6960**	2500	2395	2295
16	G6000	99500	0	0	**> 8000**	N/A	N/A	N/A
34	560XLS**	20200	0	0	**5001***	1804	1755	1531
34	800XP	28000	0	0	**> 8000**	N/A	N/A	N/A
34	G6000	99500	0	0	**> 8000**	N/A	N/A	N/A

*No change in current runway length, **Thrust Reversers Required

7.4.2 Takeoff Lengths Required for 50% PAX to the Los Angeles Area, South Extension

7.4.2.1 Length of Runway 16/34 Extended to the South, Under Dry Conditions, Hot Day, to Achieve 50% PAX to LAX

Runway	Aircraft	Takeoff Weight (lbs)	OAT (C)	Wind (kts)	Length (ft)	Range with 0 PAX (Nmi)	Range with 50% PAX (Nmi)	Range with 100% PAX (Nmi)
16	560XLS	20144	32	0	**5001***	1804	1752	1512
16	800XP	24100	32	0	**5001***	1948	1623	1305
16	G6000	65000	32	0	**5001***	1842	1568	1253
34	560XLS	20144	32	0	**5001***	1804	1752	1512
34	800XP	24100	32	0	**5001***	1948	1623	1305
34	G6000	65000	32	0	**5001***	1842	1568	1253

*No change in current runway length

7.4.2.2 Length of Runway 16/34 Extended to the South, Under Wet Conditions, Hot Day, to Achieve 50% PAX to LAX

Runway	Aircraft	Takeoff Weight (lbs)	OAT (C)	Wind (kts)	Length (ft)	Range with 0 PAX (Nmi)	Range with 50% PAX (Nmi)	Range with 100% PAX (Nmi)
16	560XLS**	20200	32	0	**5001***	1804	1755	1531
16	800XP	24100	32	0	**5870**	1948	1623	1305
16	G6000	65000	32	0	**5001***	1842	1568	1253
34	560XLS**	20144	32	0	**5001***	1804	1752	1512
34	800XP	24100	32	0	**5860**	1948	1623	1305
34	G6000	65000	32	0	**5001***	1842	1568	1253

*No change in current runway length, **Thrust Reversers Required

7.4.2.3 Length of Runway 16/34 Extended to the South, Under Compacted Snow Conditions, Winter Day, to Achieve 50% PAX to LAX

Runway	Aircraft	Takeoff Weight (lbs)	OAT (C)	Wind (kts)	Length (ft)	Range with 0 PAX (Nmi)	Range with 50% PAX (Nmi)	Range with 100% PAX (Nmi)
16	560XLS**	20200	0	0	**5001***	1804	1755	1531
16	800XP	24100	0	0	**6870**	1948	1623	1305
16	G6000	65000	0	0	**5001***	1842	1568	1253
34	560XLS**	20144	0	0	**5001***	1804	1752	1512
34	800XP	24100	0	0	**6890**	1948	1623	1305
34	G6000	65000	0	0	**5001***	1842	1568	1253

*No change in current runway length, **Thrust Reversers Required

7.5 Combining Field Length Requirements with Historical Weather and Operational Likelihood

LEAN/DragonFly generated an additional analysis using the takeoff and landing runway length recommendations, combined with the historical weather observations and runway availability, to create a series of tables that express the total percentage of operations which would benefit from increasing the length of runway 16/34 at Chicago Executive Airport.

The first 4 tables in this subsection summarize the effects of a north extension and a south extension on takeoff performance to achieve 50% payload from the airport to the Los Angeles Area. The final table presents the non-direction sensitive landing distance extension benefits relative to aircraft obtaining the maximum structural landing weight.

7.5.1 Methods for Combining Likelihoods and Length Requirements

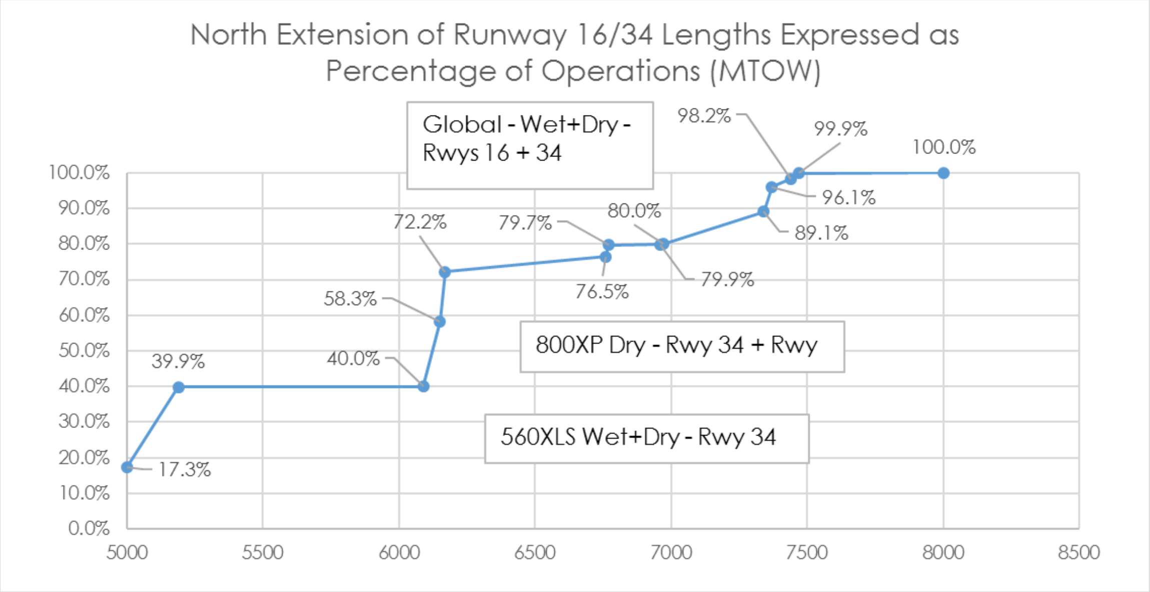
Historical weather likelihoods, runway operational likelihoods and calculated required runway lengths were combined into a discretized cumulative distribution function. The 800XP and 560XLS were each assumed to represent 40% of total jet operations that would utilize an extended runway 16/34, while the G6000 was considered to represent 20% of jets using an extended runway 16/34.

Takeoff calculations considered the prevailing direction of departure based on previously described preferred runway likelihoods with any residual likelihood (resulting from variable wind conditions) being assigned based on historical operational preference.

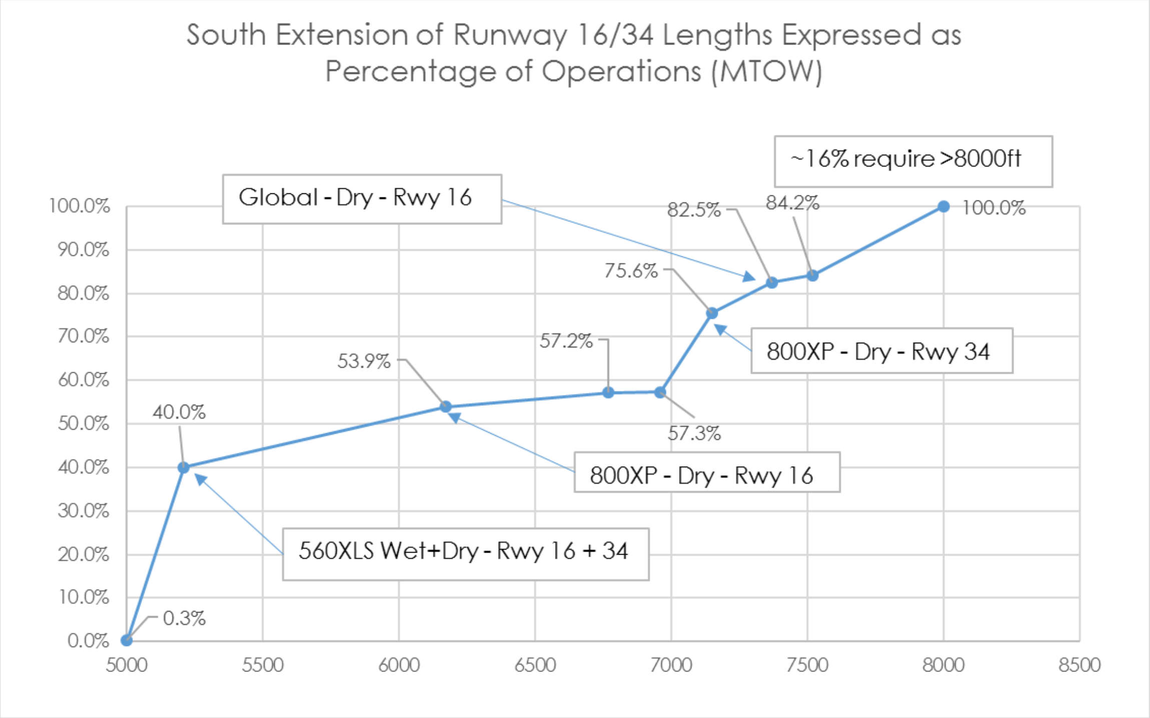
The limited data points calculated for this assessment require that the use of dry and wet performance under Hot Day conditions be considered to occur for all 12 months. For takeoff purposes, any likely occurrence of a FICON of 4 or less was considered to drive performance and runway length recommendations towards a Winter Day.

Landing calculations considered the requirement to utilize runway 16 under tailwind conditions throughout the year. Dry or wet likelihoods were used for all non-winter months, while specific FICON likelihoods were taken from the 2016/17 winter season to simulate the limited time periods when FICON 4 or 3 conditions would drive the required runway length up.

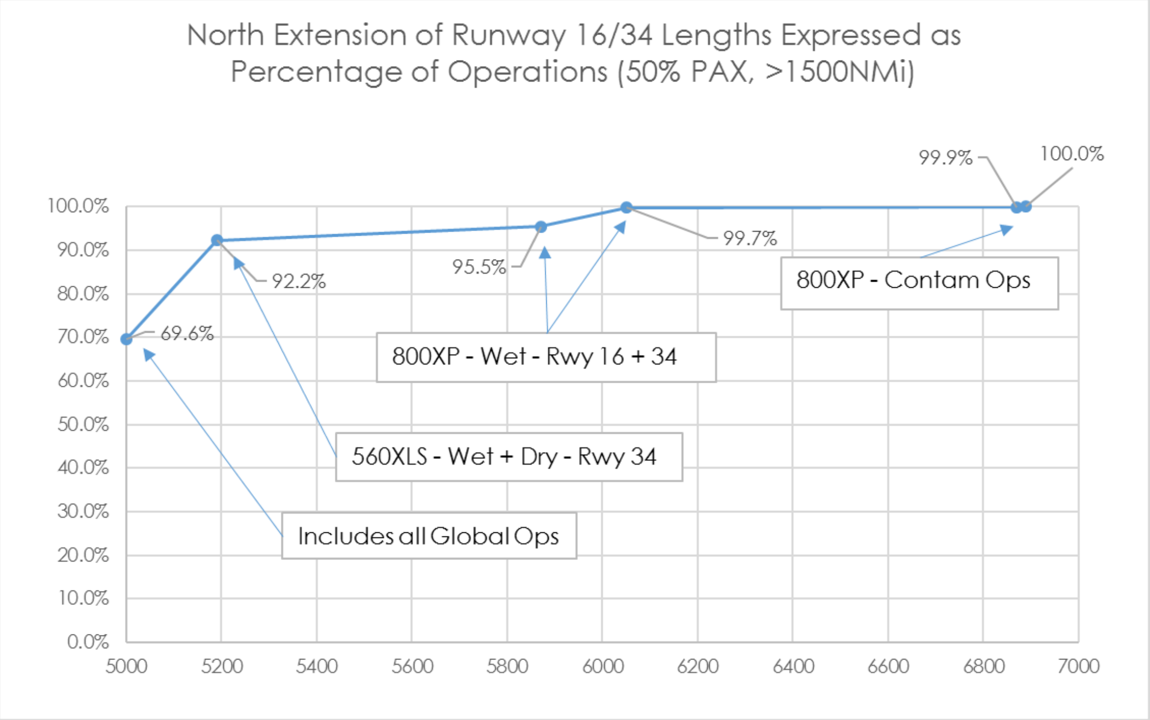
7.5.2 Percentage of Takeoff Operations Supported by North Runway Extensions to Achieve the Maximum Takeoff Weight



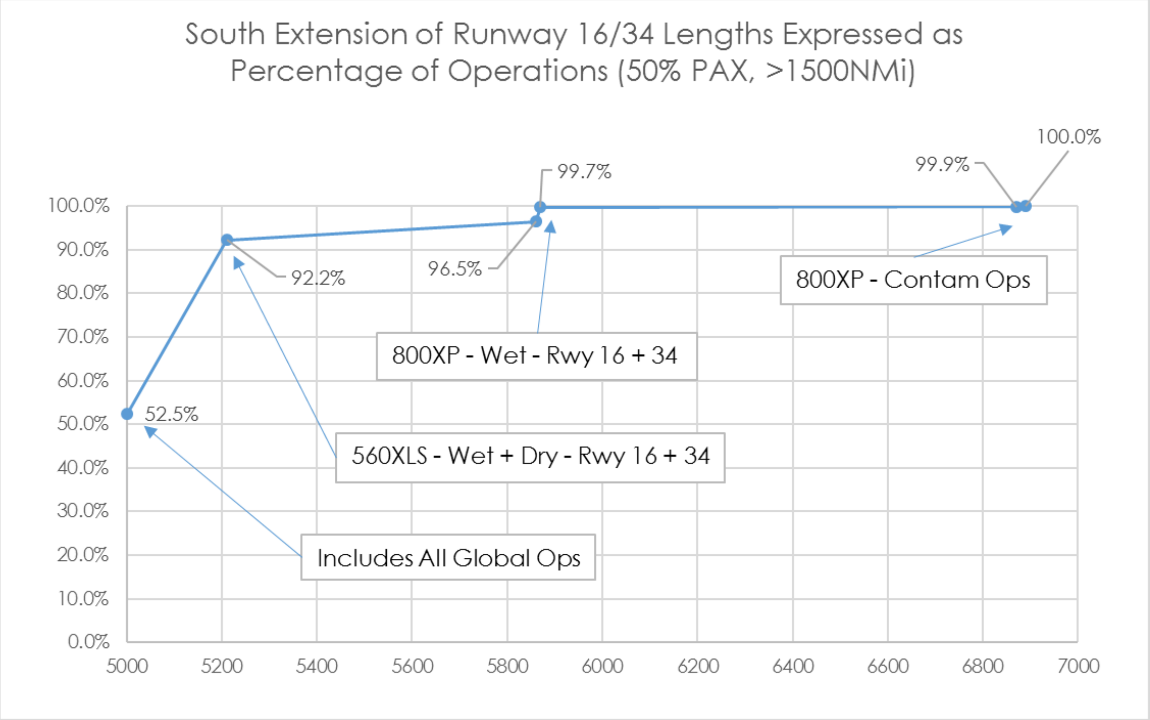
7.5.3 Percentage of Takeoff Operations Supported by South Runway Extensions to Achieve the Maximum Takeoff Weight



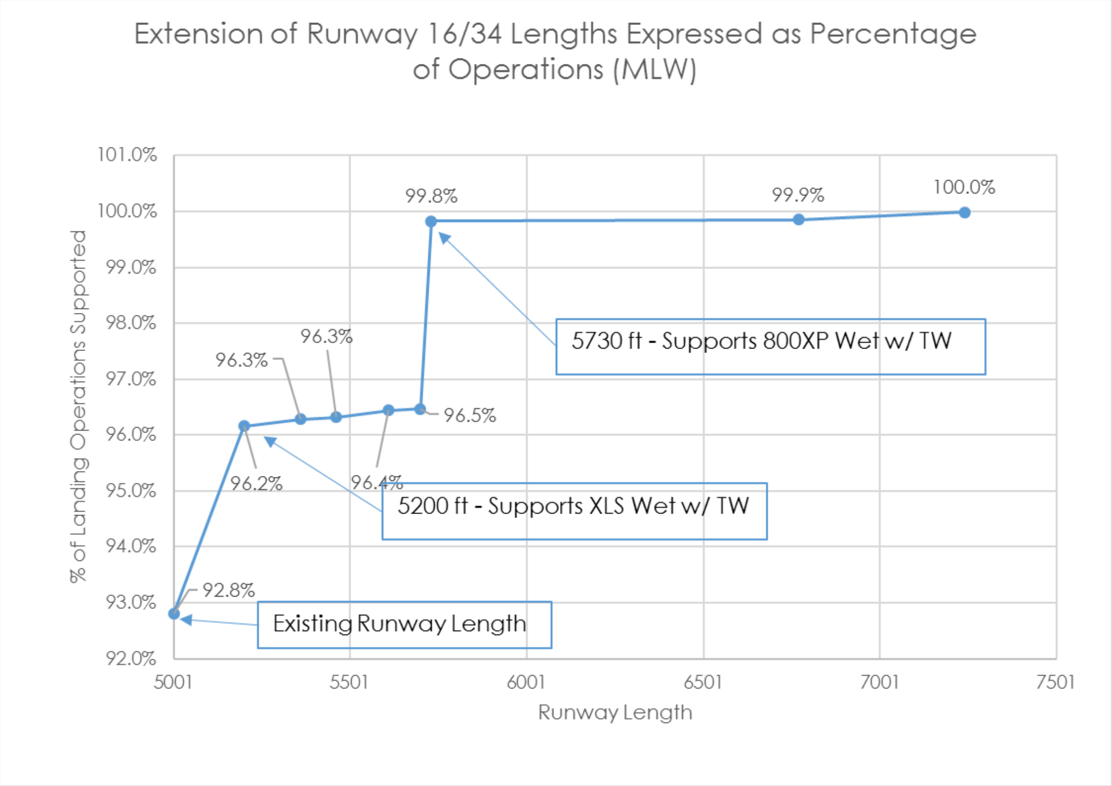
7.5.4 Percentage of Takeoff Operations Supported by North Runway Extensions to Achieve 50% of Payload to the Los Angeles Area



7.5.5 Percentage of Takeoff Operations Supported by South Runway Extensions to Achieve 50% of Payload to the Los Angeles Area



7.5.6 Percentage of Landing Operations Supported by A Runway Extension in Any Direction to Achieve the Maximum Landing Weight



*TW refers to lengths that were based on a tailwind assessment

7.6 Limitations on This Analysis

7.6.1 Limited FICON Data

The FAA only recently implemented the use of Field Condition (FICON) Reporting NOTAMs in advance of the winter of 2016/2017 yielding one winter period of historical information for use in this assessment. Aircraft operator, and LEAN/DragonFly, perform historical weather data analysis that utilizes a minimum of 10 years' worth of information to ensure that cyclical weather variations do not inadvertently effect statistical analysis that are intended to describe longer periods of applicability.

Unfortunately, the winter of 2016/2017 in Chicago was described by WGN/Chicago Tribune's Tom Skilling as, "The Winter That Wasn't". This meant that the FICON data available for the 2016/2017 period may potentially under represent the kinds of contamination, pilot braking action reports, and duration of contaminated conditions which the airport must contend with. Therefore, when utilizing the single winter period as an extrapolative example of a 10-year period, it is important to keep in mind that some of the more significant takeoff and landing distances required under contaminated conditions may represent higher overall likelihoods than what is depicted in the previous figures shown in this section. This would have the effect of shifting all the curves to the "right" meaning that longer amounts of runway lengths (longer extensions) may be required to cover the same percentage of operations.

But it is also important to mention that, at least based on historical FICON data, the Chicago Executive Airport spends a great deal of time and attention on keeping runway 16/34 clean during the winter. This was observed during situations in which other runways at the airport could accumulate contaminants (snow/ice) while 16/34 FICON had only wet or slightly worse than wet conditions.

Without having additional winter seasons worth of FICON data available, and without knowing the precise capability of Chicago Executive's Operations group ability to keep 16/34 clean, further analysis would be required to ensure that any additional runway length extensions, beyond those already recommended, are appropriate to the long-term weather expectations of a more typical winter in Chicago.

7.6.2 Pre-Departure Landing Length Assessments and Operator Experience Versus Pure Performance Assessments

Landing length assessments that utilize a combination of statistical likelihoods can under represent the length of runway necessary for operators when the existing runway is less than 6,000ft in length. This happens for two reasons which are both related to the difference between landing length considerations prior to departure and landing length considerations once the aircraft is airborne.

Charter/fractional aircraft operators will utilize runway length performance assessments to analyze the feasibility of using an airport days to months in advance of operating a flight. This can be triggered by a specific request from a client to fly to a specific location near the airport, or from a regular analysis of airports which receive high volumes of requests. For most operators, this pre-schedule flight assessment can involve a simple comparison between a generic runway length requirement and a requested aircraft type. A very common value used in for landing length assessments amongst current FAR 91-K and FAR 135 operators in that scenario was found to be 6,000ft, but that number can be less for smaller cabin jets and VLJs.

When an airport has no runways longer than 6,000ft jet operators will typically look more closely at aircraft selection or simply search for alternative airports with more runway available that can still accommodate the owner/customer request. Therefore, runway extensions that don't minimally extend the landing distances available beyond the initial cutoff for consideration, will create a kind of pseudo aircraft performance limitation that would prevent many charter operators from even considering the airport as a primary solution for their client needs.

In addition to the pre-schedule check, operators of aircraft that experience one or more events where he/she might have been unable to successfully land, especially on runway 16 with the high likelihood for tailwind operations, user experience will often override independent performance assessments. This can be modeled by considering higher than standard combinations of statistical likelihoods.

For instance, at the Chicago Executive Airport, 96.5% of arrival operations could be covered by a 700ft extension of runway 16/34 to 5,700ft. However, unless the runway is extended 1,700ft to 6,700ft, the experience of pilots who attempt to land during periods of lower FICONs may continue to force them to consider other airports in the Chicago Land Area.

7.6.3 Runway Extensions for Additional Aircraft or Specific Payload Range

The use of three representative aircraft, and a single payload range target, with a combined operational assessment of required runway extensions is a good starting point for future alternative considerations. However, adding additional aircraft or additional payload range considerations which are inline may have significant impacts on the recommended runway length.

For future assessments, it is recommended that the planning or design team consider at least two additional aircraft types in the medium to large cabin aircraft size categories and one additional small cabin aircraft. It is also recommended to consider the addition of 2 payload-range target weights to be used as a target for takeoff length enhancement with any future alternatives.

7.6.4 Extending Runway 16/34 in Both Directions

The takeoff runway length assessments presented in this report assumed that one end of the runway remained fixed in its current location, while the other end was extended. While this may be a practical consideration for future runway extension designs, it is very likely that the optimal runway length extension will involve some combination of extension both north and south of the existing threshold locations. Due to the impact of obstacles on the takeoff length recommendations, any bi-directional expansion runway design(s) should be considered separately from any length recommendations made in this report.

7.6.5 Thrust Reverser Usage

LEAN/DragonFly performed takeoff length analysis with consideration for thrust reverser credit when and where it was possible for takeoff calculations. This resulted in certain runway length recommendations which are potentially shorter than those which could be obtained by aircraft which do not have thrust reversers installed, operational or for operators that have not purchased the supplements from the OEM. Therefore, for any takeoff length results indicated in this section to have been achieved via the use of thrust reverses, a longer runway length will be required to accommodate those aircraft operators that do not have thrust reversers.

For landing performance calculations, the use of thrust reverses is typically not considered except under exceptional circumstances, and not thrust reverse was considered for this assessment regardless of whether the aircraft type had them installed.

7.6.6 EOSID Considerations

Runway extensions to the south may incur an additional performance penalty which is difficult to determine without a more comprehensive airspace analysis and review with C90 and Tower representatives. This is because any increase in runway length that pushes the runway 16 TODA further south could create situations in which additional performance limitations (both all engines operating and one engine inoperative) will need to be observed. Therefore, further analysis of potential EOSID restrictions should be performed on any south runway extensions for runway 16 departures.

8 Recommended Runway Length

8.1 Runway Length and Location

Based on the percentage of operations which would benefit from runway length extensions presented in section 7, the LEAN/DragonFly team recommends that the planning, and future design, teams consider a minimal possible runway extension of 700ft (yielding a runway length of 5,700ft) and an ideal runway extension closer to 1,700ft (yielding a runway length of 6,700ft).

The minimum recommended runway length comes from a combination of landing distance enhancements and minimal takeoff length enhancements necessary to accommodate a 50% payload being carried to the Los Angeles Area under NBAA IFR flight planning considerations. 5,700ft of runway available for landing would cover 96.5% of aircraft performance based predicted landings and approximately 95% of aircraft performance based predicted takeoffs.

The ideal recommended runway length of 6,700ft would cover 99.9% of aircraft performance based predicted landings and 99.8% of aircraft performance based predicted takeoffs.

If the team is focused on an extension of the minimum recommended 5,700ft, it is the current opinion of the LEAN/DragonFly team that this extension could be made in any direction to achieve the stated benefits in this report. However, if the team is considering runway lengths in excess of 5,700ft, it is highly recommended that extensions to the north be considered for some or all the length enhancement.

8.2 Payload Range Improvement

The follow graphics are provided as a sample of the potential improvements in real world payload range which could be achieved by pursuing the mean recommended value of runway extension at 6,200ft.

The graphics below are based on dry takeoff conditions departing runway 16 from Chicago Executive Airport at an outside air temperature of 32C. The range is calculated from a 50% passenger load and 65% confidence interval enroute winds (based on 30 years' worth of annual statistics).

The inside range ring in each of the graphics represents the range that aircraft operators could expect from the current runway. The outside range ring in each graphic represents the extended range capability that a mean extension could achieve.

8.2.1 Cessna Citation 560XLS 50% Payload Range Improvement

Figure 12 Payload Range Enhancement for 560XLS Between Current Runway and 6,200ft Length Runway

As seen in

Figure 12, the payload range increase from a 6200ft runway extension provides increased access for small cabin and VLJ aircraft to gain access to West Coast destinations, as well as several other Caribbean and Central American Destinations.

8.2.2 Hawker 800XP 50% Payload Range Improvement

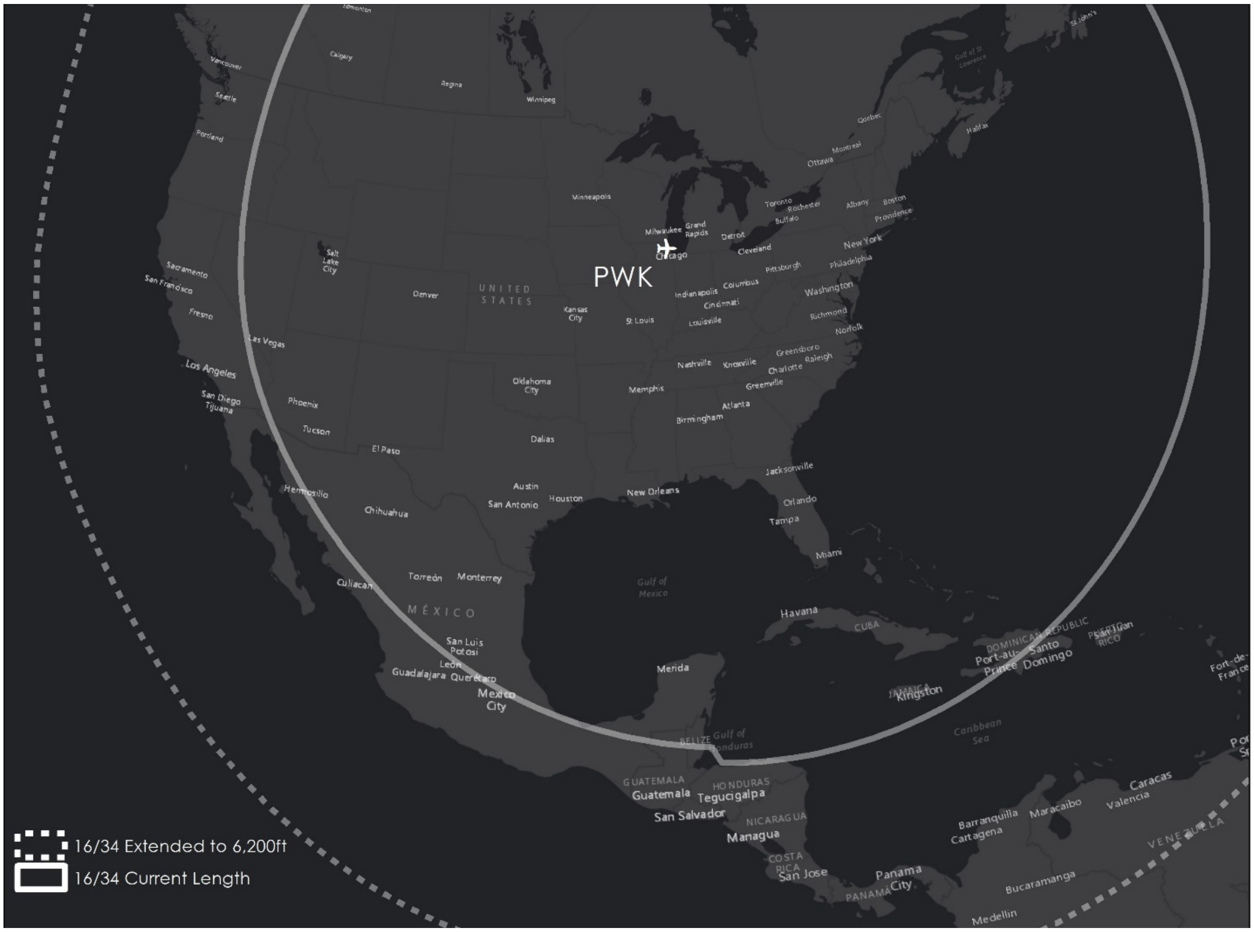


Figure 13 Payload Range Enhancement for 800XP Between Current Runway and 6,200ft Length Runway

As seen in

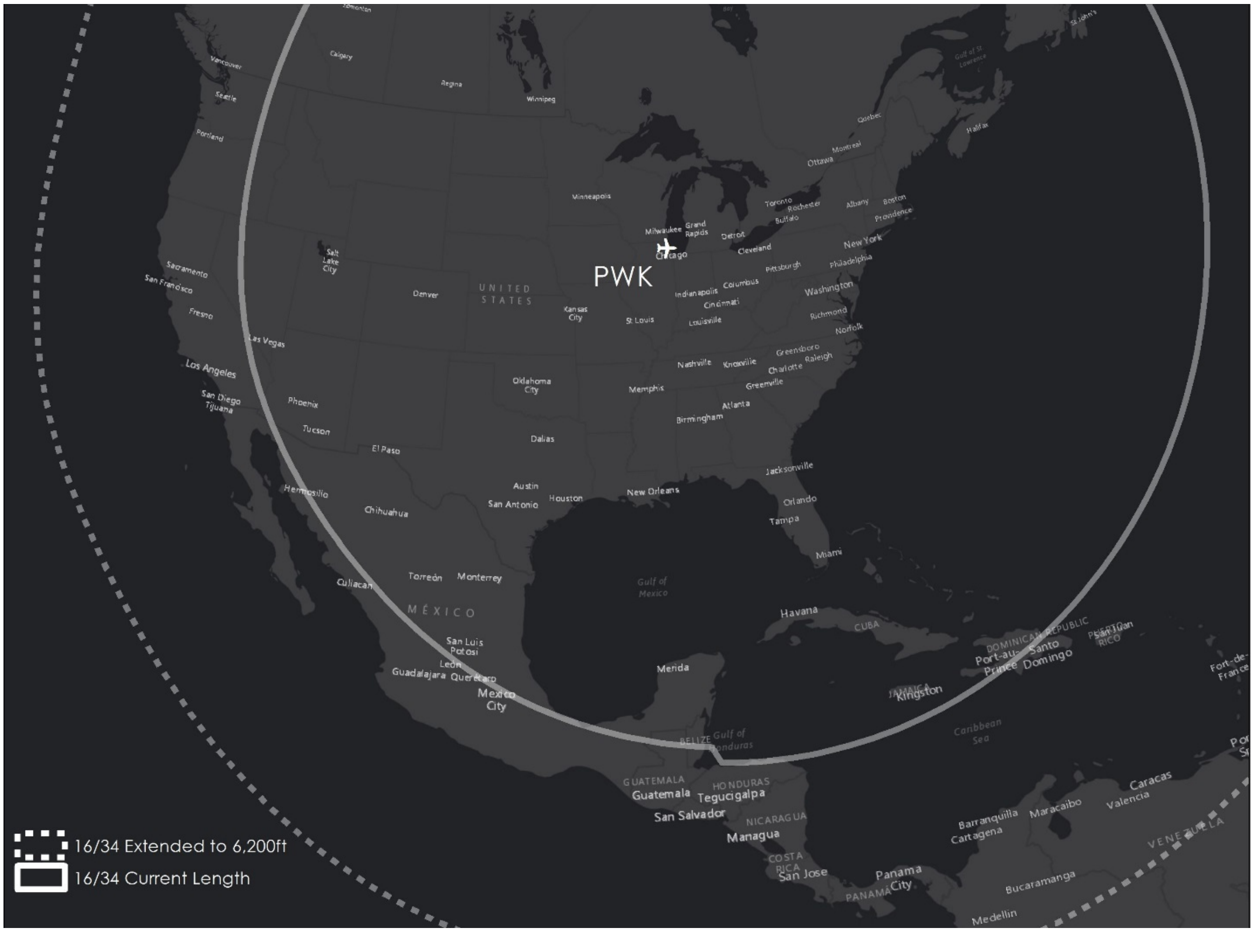


Figure 13, the payload range increase from a 6200ft runway extension with an 800XP provides significantly increased access for medium and small cabin aircraft to gain access to West Coast destinations, as well as several other Caribbean and Central American Destinations.

8.2.3 Global 6000 50% Payload Range Improvement

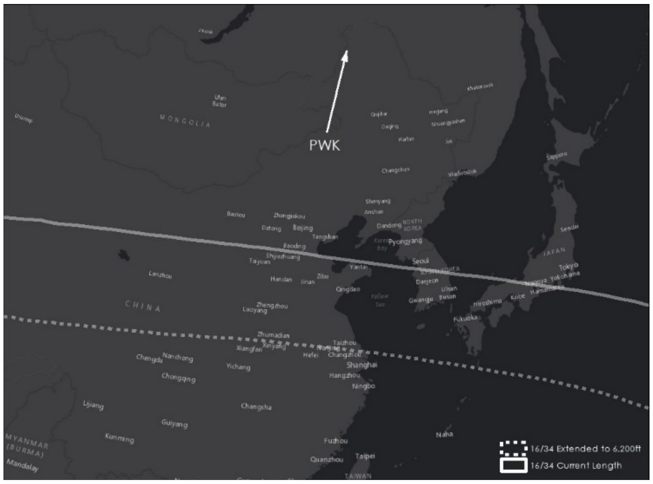


Figure 14 Payload Range Enhancement for G6000 Between Current Runway and 6,200ft Length Runway (Japan, Korea and China)

Figure 15 Payload Range Enhancement for G6000 Between Current Runway and 6,200ft Length Runway (Middle East)

As seen in Figure 14 and Figure 15, the payload range increase from a 6200ft runway extension with a Global 6000 provides increased access for large cabin aircraft operating to markets in the Middle East, India, Japan and China.

9 Glossary

- **3DEP** - A United Stated Geological Survey produced three dimensional elevation program which combines light detection and ranging (lidar) and interferometric synthetic aperture radar (IfSAR) data into a digital elevation model of the United States.

- **AC-120-91** - FAA Advisory Circular on the subject of Airport Obstacle Analysis, which is intended for assisting aircraft operators with the design and implementation of one engine inoperative takeoff and missed approach procedures
- **AC-150-5300-18, VGA Survey** - FAA Advisory Circular regarding the general guidance and specifications for submission of aeronuatical surveys to the national geodetic survey with a specific emphasis on field data collection and geographic information system (GIS) standards. "VGA" refers to a collection area required for runways which are served by vertically guided approach procedures that was hisotrically similar to the Precision Instrument Runway (PIR) definition.
- **ADDS** - National Oceanic and Atmospheric Administration Aviation Digital Data Service which provides access to current, forecast and historical terminal and enroute weather information.
- **AFM** - Aircraft Flight Manual required by FAA Part 25 certificated aircraft to expresses limitations, operational procedures and aircraft performance information.
- **AIRAC** - Aeronautical Information Regulation and Control, which identifies the distribution format and calendar cycle to be followed by host nations and aeronautical data providers.
- **ASDA** - Accelerate Stop Distance Available represents the amount of runway that an operator can consider for the accelerate stop performance calculation that begins at the physical runway threshold (or intersection) and terminates at the physical runway end, or start of the runway end safety area, whichever is shorter
- **ASOS** - Automated Surface Observation System used to collect weather information pertinent to aircraft and airport operations and report it back out to other weather data services and providers
- **ATC** - Air Traffic Control
- **AVNIS** - Aviation System Standards Information System, which is a database used primarily by FAA Flight Procedure Design teams
- **C90** - FAA Identified for the Chicago Area TRACON
- **CAFM** - Computerized Aircraft Flight Manual, which can supplement or replace a standard Aircraft Flight Manual (AFM)
- **CDO** - Climate Data Online which provides access to the US National Climactic Data Center archive of historical weather data
- **CIFP** - Coded Instrument Flight Procedure file which contains all of the FAA maintained information on instrument departures, arrivals and approaches related to waypoints, fixes, NAVAIDs, runways and procedure leg types. The CIFP is distributed every 28 days in the ARINC 424 format version 13, 15 and 18
- **Compacted Snow** - A type of surface contaminant identified as snow that has been compressed and consolidated into a solid form that resists further compression such that an airplane will remain on its surface without displacing any of it.
- **Contaminated Conditions** - Any conditions experienced on a runway in which precipitation, water, snow or ice have accumulated to the point that the runway is no longer described as dry or wet.

- **DAAP** - Destination Airport Analysis Program is FAA authorization for aircraft operators utilizing FAA Part 91-K or FAA Part 135 which reduces the effecetive runway length requirements for turbine engine-powered large transport category airplanes that must be met prior to a flight's release.
- **DDOF** - FAA Daily Digital Obstacle File containing a publication of all currently known obstructions to airspace as defined by Part 77 surfaces.
- **DER** - Departure End of Runway
- **EMAS** - Engineering Material Arresting System
- **eNASR** - FAA Electronic National Airspace Systems Resources is the electronic portal to access the FAA's aeronautical information publication data in compliance with ICAO standards.
- **EOSID** - Engine Out Special Instrument Departure is a procedure created and/or maintained by an aircraft operator, or 3rd party/non-FAA provider. that describes an route which an aircraft will take following the event of an engine failure at or after the takeoff decision safety speed.
- **ETOD** - Electronic Terrain and Obstacle Database.
- **FAA Part 135** - See FAR Part 135
- **FAA Part 91** - See FAR Part 91
- **FAA Part 91-K** - See FAR Part 91-K
- **FANS** - Future Air Navigation Service which, for the purposes of this report, describes an aspect of the FAA portal which contains several information data services including access to the latest graphical NOTAM service from the FAA
- **FAR 135** - See FAR Part 135
- **FAR 135.361** - An FAA aircraft operating regulation pertaining to FAR Part 135 which describes a fundamental starting point for the landing performance computation. The reference to 135.361 is specific to sub-paragraph (c) which states the following: " For the purpose of this subpart, obstruction clearance plane means a plane sloping upward from the runway at a slope of 1:20 to the horizontal, and tangent to or clearing all obstructions within a specified area surrounding the runway as shown in a profile view of that area. In the plan view, the centerline of the specified area coincides with the centerline of the runway, beginning at the point where the obstruction clearance plane intersects the centerline of the runway and proceeding to a point at least 1,500 feet from the beginning point. After that the centerline coincides with the takeoff path over the ground for the runway (in the case of takeoffs) or with the instrument approach counterpart (for landings), or, where the applicable one of these paths has not been established, it proceeds consistent with turns of at least 4,000-foot radius until a point is reached beyond which the obstruction clearance plane clears all obstructions. This area extends laterally 200 feet on each side of the centerline at the point where the obstruction clearance plane intersects the runway and continues at this width to the end of the runway; then it increases uniformly to 500 feet on each side of the centerline at a point 1,500 feet from the intersection of the obstruction clearance plane with the runway; after that it extends laterally 500 feet on each side of the centerline. "
- **FAR 91-K** - See FAR part 91-K
- **FAR Part 121** - FAA Aircraft Operating regulations, or aircraft operations, which pertain to scheduled aircraft operations like major airlines, regional airlines and most aircraft engaged in common carriage of passengers/freight.

- **FAR Part 125** - FAA Aircraft Operating regulations, or aircraft operations, which pertain to scheduled operations of large aircraft, 20 or more passengers and/or over 6,000lbs of payload, who are not engaged in common carriage.
- **FAR Part 129** - FAA Aircraft Operating regulations, or aircraft operations, of scheduled aircraft operators which are based outside of the United Stated and who engage in scheduled commercial avaiation within the United Stated under the oversight of an FAA Principal Operations Inspector. All foreign airlines operating into the US are required to operate under this part.
- **FAR Part 135** - FAA Aircraft Operating regulations, or aircraft operations, of scheduled or on-demand operators including aircraft with 30 or more passenger seats when holding out seats for public availability and 20 seats or less when not holding out seats for public availability. This operating part can include chart jet operations, air taxi, air medical and air tour operations.
- **FAR Part 25** - FAA Airworthiness standards for transport category airplanes.
- **FAR Part 91** - FAA Aircraft Operating Regulations, or aircraft operations, of non-scheduled aircraft operations and any other general aviation regulations which are not already covered under other FAR Parts. This part can cover general avaition, wholly owned business jet transport, and repositioning flights operated by FAR Part 91-K, 125, 121 and 135.
- **FAR Part 91-K** - FAA Aircraft Operating Regulations, or aircraft operations, specifically focussed on fractional ownership, non-scheduled, operations.
- **FICON** - Field Condition Report issued by an airport to describe the current condition of a runway in terms of surface condition (dry, wet, contamination), pilot braking action and friction tests. A FICON is issues as a NOTAM which describes the runways in 1/3 increments and displays a numerical equivalent of the runway conditions over a user specified duration.
- **FL** - Flight Level
- **GPD** - Global Procedure Development System, currently used by USAF, National Geospatial Intelligence Agency, Army, Navy, Marines and NATO.
- **ICAO** - International Civil Aviation Organization
- **IFR** - Instrument Flight Rules which refers to any flight which cannot be operated solely by means of visual references.
- **ILS** - Instrument Landing System, consisting of a vertical guidance array (usually a glideslope) installed perpendicular to the runway threshold/centerline (left or right) and a horizontal guidance array (usually a localizer) installed beyond the end of the runway.
- **KORD** - ICAO identifier for Chicago O'Hare International Airport
- **KPWK** - ICAO identifier for Chicago Executive Airport
- **LAHSO** - Land and Hold Short Operations, indicating the existence predetermined point on a runway that aircraft can be cleared to land prior to, which will facilitate other airfield operations to cross the extended centerline of the landing aircraft.
- **LDA** - Landing Distance Available, or the distance available for pilots to compute a landing performance computation against which usually begins at the landing threshold and terminates either at the physical end of the runway, or the beginning of the runway end safety area.

- **LNAV** - Lateral Navigation, which refers to using satelite based navigation methods for horizontal guidance when departing, arriving or approach a runway.
- **LPV** - Localizer Performance with Vertical Guidance, is a kind of instrument approach procedure which utilizes a space based augmentation system (like WAAS) that enhances a primary satelite based navigation system (GPS) to provide greater horizontal and vertical positional accuracy which is similar to what can be achieved from a traditional ILS installation without the need for ground based installations.
- **MDW** - FAA Airport Identified for Chicago Midway Airport
- **MEL** - Minimum Equipment List, which refers to the minimum number of working items onboard an aircraft in order to safely operate the airplane. The MEL also identifies certain aircraft performance penalties which must be considered for the absence of removal of certain items.
- **MLW** - Maximum Landing Weight, is the maximum weight which the aircraft has been certified to execute a safe landing under standard descent rates, touchdown rates and brake applications. This weight can be exceeded in emergency situations, but requires a safety/maintenance inspection after such an event occurs.
- **MRW** - Maximum Ramp Weight, is the maximum weight which the aircraft can possiblly weight while operating on the ground. This is typically the most that an aircraft can ever weigh.
- **MSL** - Mean Sea Level Elevation, as referenced from WGS-84/NAVD-88
- **MTOW** - Maximum Takeoff Weight, is the maximum weight which the aircraft has been certified to execute a safe takeoff.
- **MZFW** - Maximum Zero Fuel Weight is the heaviest weight that an aircraft can achieve without fuel onboard. This certified weight limit is meant to prevent excess loads from building up on the wing root and wing box, and to prevent certain flutter situations which could lead to unstable or unsafe flight conditions.
- **NAVAID** - Navigational Aid, usually considered to be a physical array installed on the earth which sends out an electro-magnetic, low or high frequency signale intended to be received by equipment onboard an aircraft.
- **NBAA** - National Business Aviation Association, which is a non-partisan, non-profit, group which advocates for business aviation in the US.
- **NBAA IFR** - National Buseinss Aviation Association Instrument Flight Rules reserve fuel policy which is recommended for consideration by NBAA members which are not otherwise required to consider reserve fuel requirements (FAR Part 91, 91-K)
- **NCEI** - National Centers for Environmental Information
- **NFDC** - National Flight Data Center
- **NOAA 405 Specification** - National Oceanic and Atmospheric Administration airport and obstacle surveying standard which predated the current AC-150-5300-18 standards.
- **NOTAM** - Notice to Airmen, is a means of communicating information to pilots outside of the typical AIRAC and direct pilot/controller communication. NOTAMs are considered an official means of aeronautical, procedural and obstacle information dissemination and must be reviewed by pilots prior and during flight.

- **OEM** - Original Equipment Manufacturer, which can refer to the maker of an aircraft, engine or avionics produce like Boeing, Rolls Royce or Garmin
- **OEW** - Operating Empty Weight, which refers to the weight of the aircraft, seating, flight crew, and any items onboard the aircraft which are assumed to be present for the intended flight operation (food, magazines, water, etc)
- **ORD** - FAA Identified for Chicago O'Hare International Airport
- **Part 77** - Refers to FAA Part 77 imaginary surfaces for the safe, efficient use, and preservation of the navigable airspace which are defined in Subpart C. Part 77 surfaces do not constitute a survey area, like AC-150-5300-18, but they do represent an area of space around and above an airport that is surveiled on a semi-regular basis.
- **PAX** - A single reference value for payload planning purposes which represents a combination of a passenger and their anticipated baggage. For the purposes of this report a PAX weight of 240lbs.
- **PBN** - Performance Based Navigation refers to a method of space based aircraft navigation (GPS) in which the aircraft uses multiple, redundant, sensors to determine its vertical and horizontal position over the earth resulting in tighter levels of positional precision can be ensured when compared to general navigation using a single GPS sensor. PBN can also refer to a set of instrument procedure desgin standards which are intended for approach and departure procedures with aircraft that have performance based navigation capabilities. One typical example of a PBN instrument procedure would be an RNP (Required Navigational Performance) approach.
- **PIR** - Precision Instrument Runway, which refers to a specific kind of obstacle survey conducted for runways that had an ILS
- **PLMS** - PaceLab Mission Suite, a software tool used to create engineering assessments of aircraft payload, range and economic effects for specific aircraft and city-pairs.
- **PWK** - FAA Identifier for the Chicago Executive Airport
- **RCAM** - Runway Condition Assessment Matrix, refers to a reference table of runway contamination conditions, pilot braking action reports, and runway friction readings which are all related to a numerical system of measurement from 6 (dry conditions) down to 0 (wet ice). Pilots, airports, and air traffic representatives use the RCAM to interpret information presented in a FICON, or reported by other sources to determine which actions to take for a flight or snow removal program.
- **RNAV** - Area Navigation, referring generically to any form of aeronautical navigation which utilized space based positioning satelites as the primary means of operation.
- **RPZ** - Runway Protection Zone
- **RVSM** - Reduced Vertical Separation Minimums refers to the amount of vertical airspace which must separate aircraft flying in opposite directions between 29,000ft and 41,000ft. Aircraft which are approved to operate in RVSM are allowed to manuever within 1,000ft vertically of each other, as opposed to the typical 2,000ft separation.
- **SCAP** - Standard Computerized Aircraft Performance refers to a program or "module" provided by a manufacturer (MM) or a 3rd party (NMM) that

automatically calculates takeoff and landing aircraft performance based on information contained in the AFM or taken from flight test.

- **TERPS** - FAA Terminal Instrument Procedures refers to FAA Order 8260.3C (and follow on Notices/Orders) that define how instrument approach, arrival and departure procedures are to be designed and maintained.
- **TODA** - Takeoff Distance Available, refers to the length of runway and clearway available for accelerate go takeoff performance computations originating from the beginning of the physical runway (or intersection) and terminating at the end of the physical runway or clearway if one is defined.
- **TORA** - Takeoff Run Available, refers to the length of runway availalble for accelerate go takeoff perofmance computations originating from the beginning of the physical runway (or intersection) and terminating at the end of the physical runway, unless reduced to a point prior to the physical end due to runway design constraints.
- **TRACON** - Traffic Control Unit which combines approach and departure control responsibilities for several airports in an area.
- **UGN** - FAA Identified for the Waukegan Regional Airport
- **USGS** - United States Geological Survey
- **VGSI** - Visual Glide Slope Indicator usually installed abeam the runway threshold, is a multi-light array which provides a visual reference to pilots about the relative slope which the aircraft is approach the runway at. Typical VGSI examples are a PAPI or VASI.
- **VLJ** - Very Light Jet, which is usually an FAA Part 23 or FAA Part 25 certificated aircraft with seating for 6 or fewer passengers.
- **VOR** - Very high frequency omnidirectional radio range device. A VOR is considered to be a conventional NAVAID, and is not considered to be an aid to RNAV, LNAV, PBN or LPV procedures.
- **Wet** - A runway surface which is neither dry, nor contaminated by standing water. A wet runway is usually identified as glossy in appearance, but without the presence of puddles/ponds or standing water. A grooved runway, which is shiny in appearance, may be considered as a dry runway for OEMs which allow operators to consider that interpretation. The typical FICON for a wet runway is 5/5/5.