Appendix F

Lean Engineering Runway Length Assessment

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.

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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)

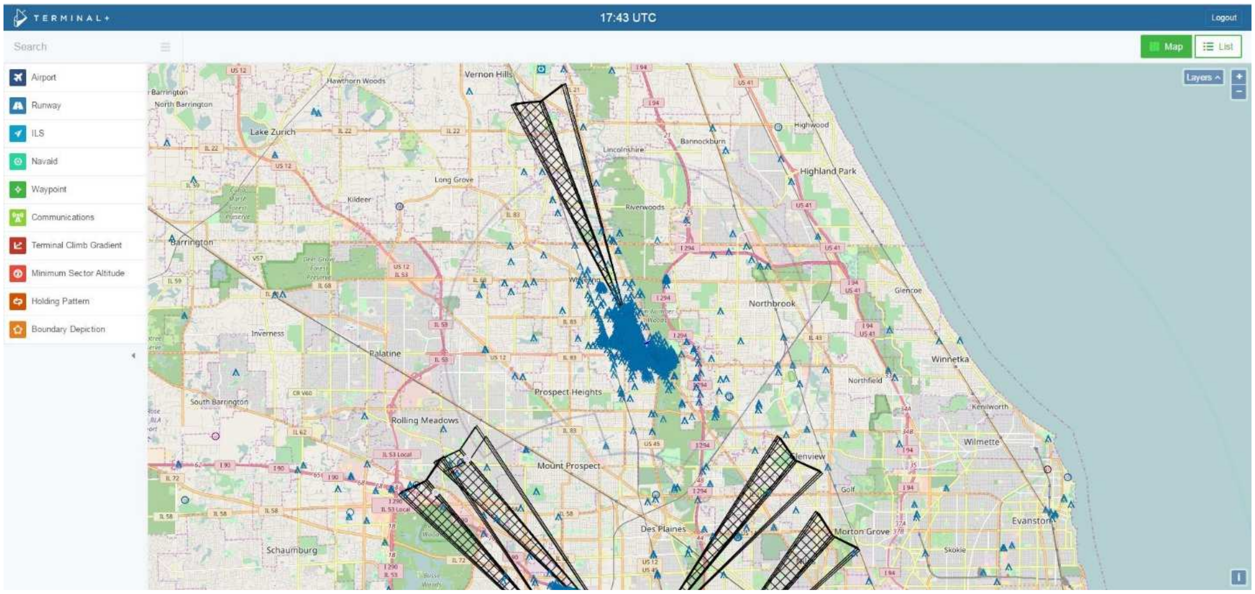


Figure 3 Image of LEAN/DragonFly Terminal+ Interface Centered on KPWK, Blue Triangles are Obstacles

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	40 or Higher	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	39 to 30; 29 to 21	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	29 to 21; 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	20 or Lower	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

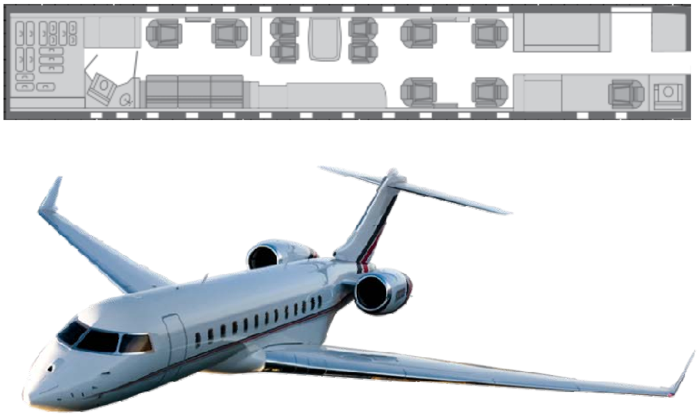


Figure 7 Bombardier Global 6000 Seating Configuration and Luggage Area Pictured Above, with Exterior Aircraft Image Below

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.

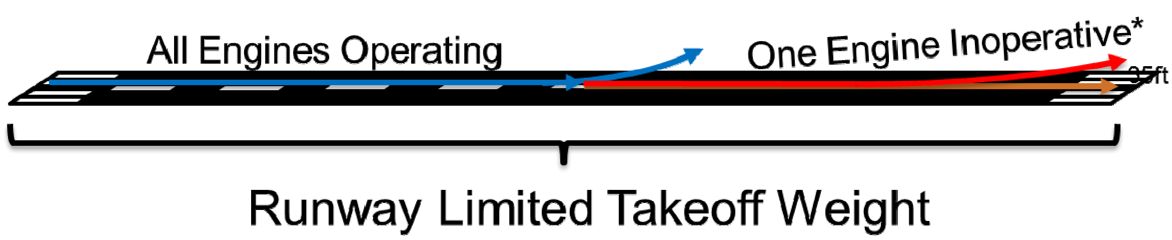


Figure 8 Consideration of Field Length in Aircraft Performance Computations

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.

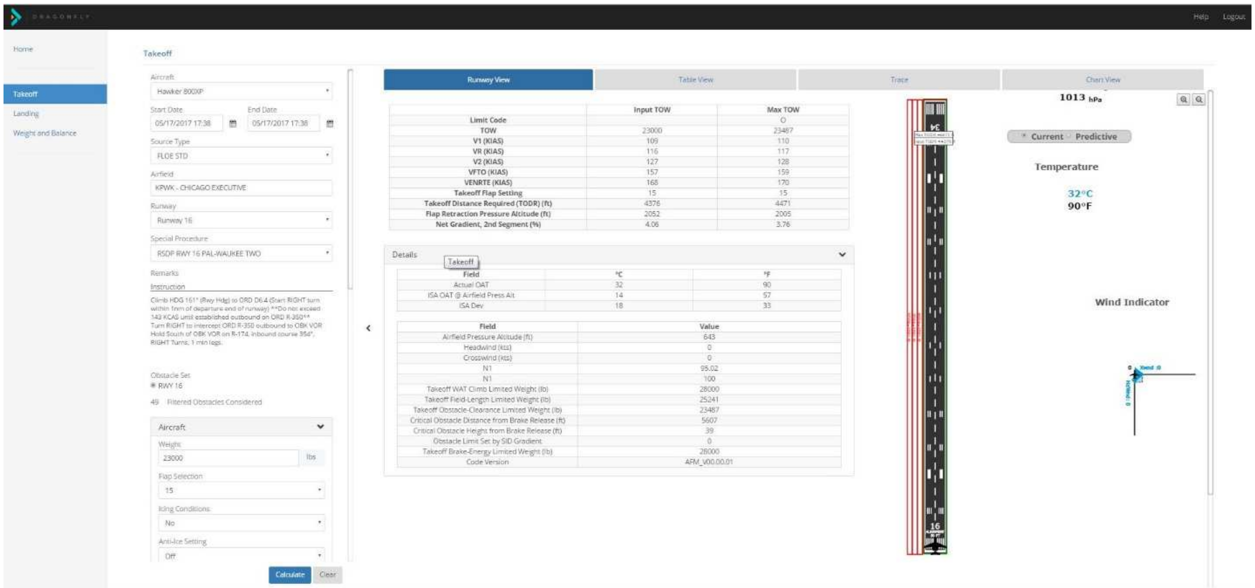


Figure 9 Screen Shot of Performance+

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.

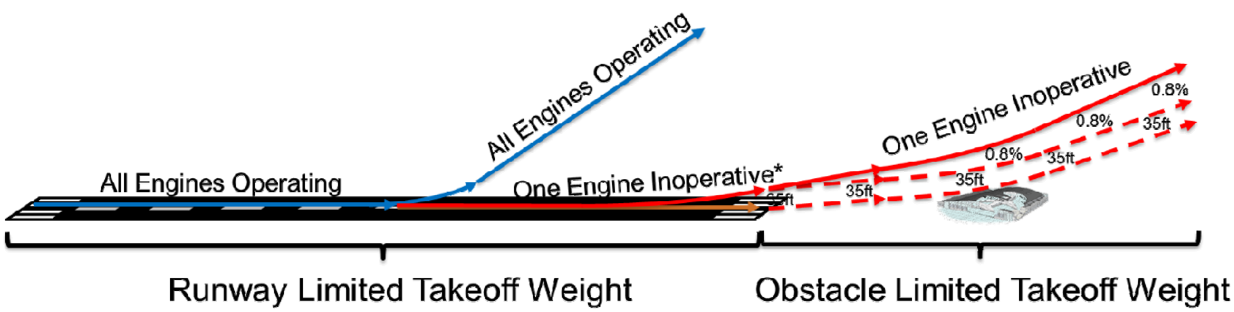


Figure 10 Runway length and obstacle clearance considerations in aircraft performance

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

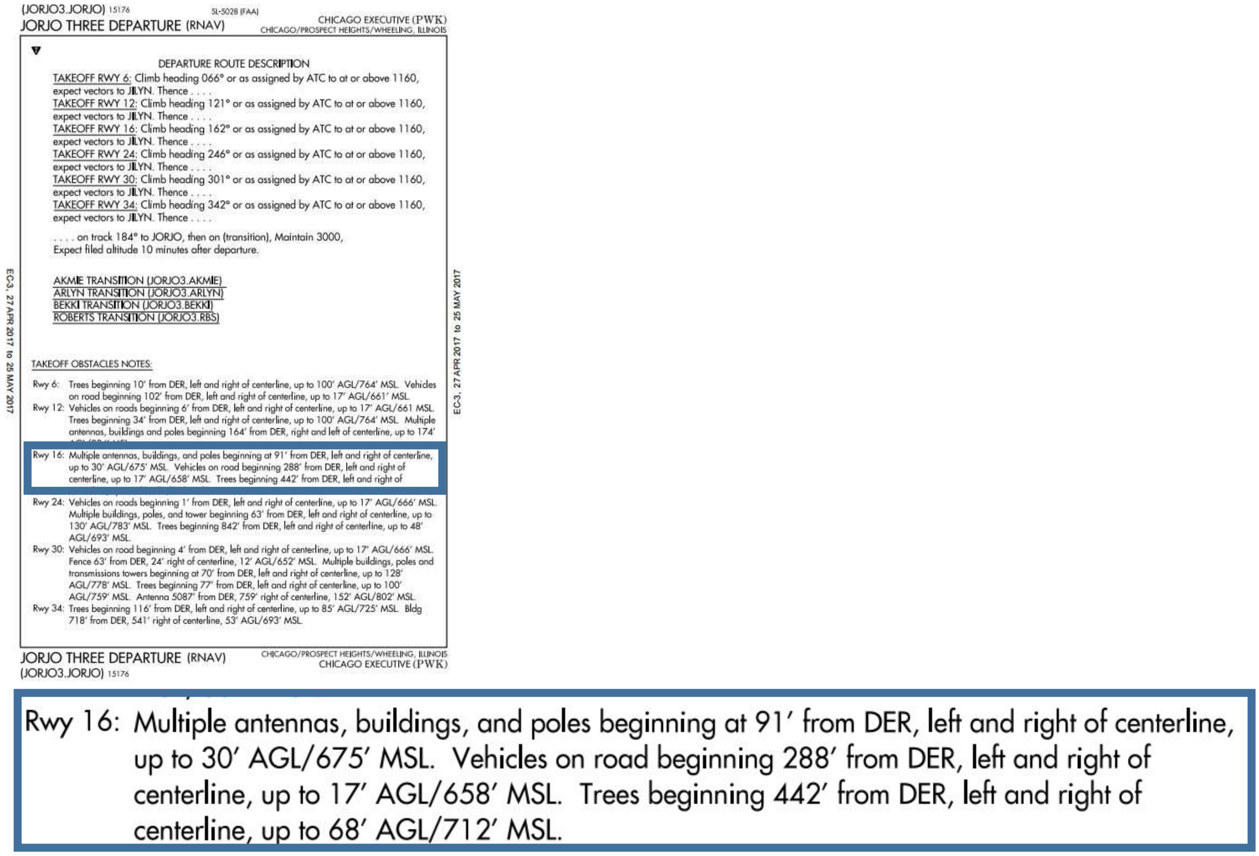
For the 800XP and 560XLS aircraft, the obstacle clearance calculations originate from information contained in the FAA approved Aircraft Flight Manual. Optimizations which balance runway consumed, obstacle clearance and runway length required are performed within a SCAP module created by LEAN/DragonFly. 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

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.

EC-3, 27 APR 2017 to 25 MAY 2017

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

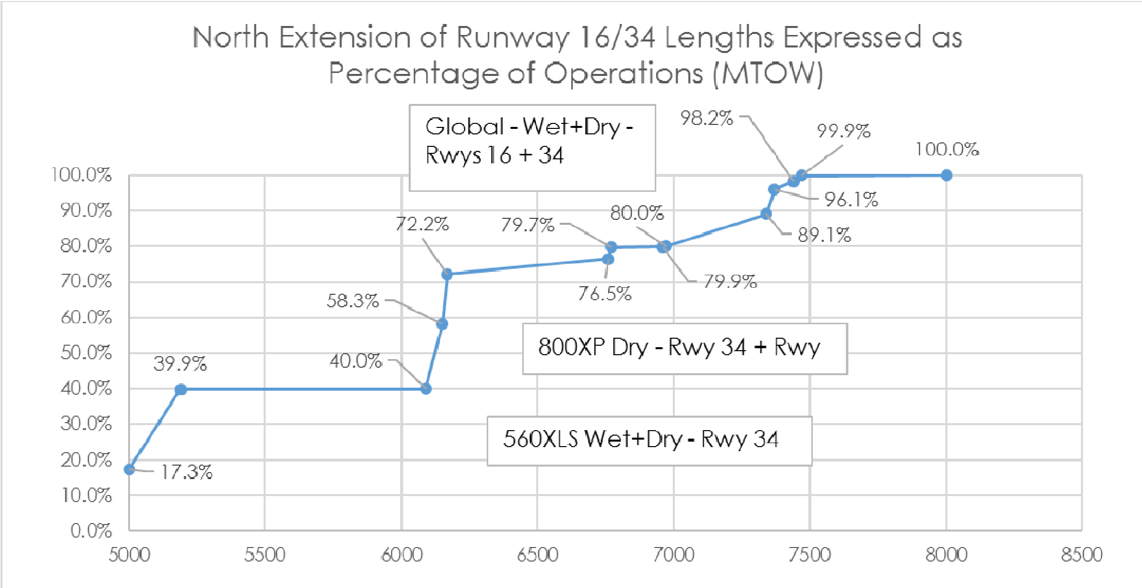
Historical weather likelihoods, runway operational likelihoods and calculated required runway lengths were combined into a discretized cumulative distribution function. The 800XP and 560XLS were each assumed to represent 40% of total jet operations that would utilize an extended runway 16/34, while the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

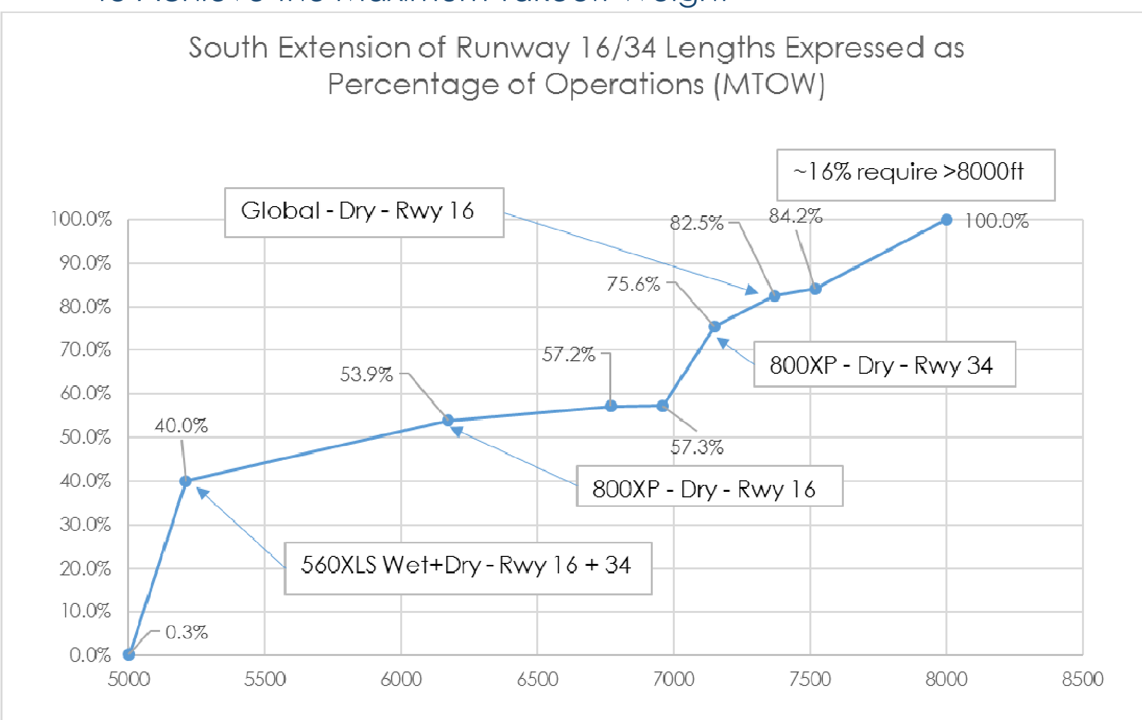
The limited data points calculated for this assessment require that the use of dry and wet performance under Hot Day conditions be considered to occur for all 12 months. For takeoff purposes, any likely occurrence of a FICON of 4 or less was considered to drive performance and runway length recommendations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

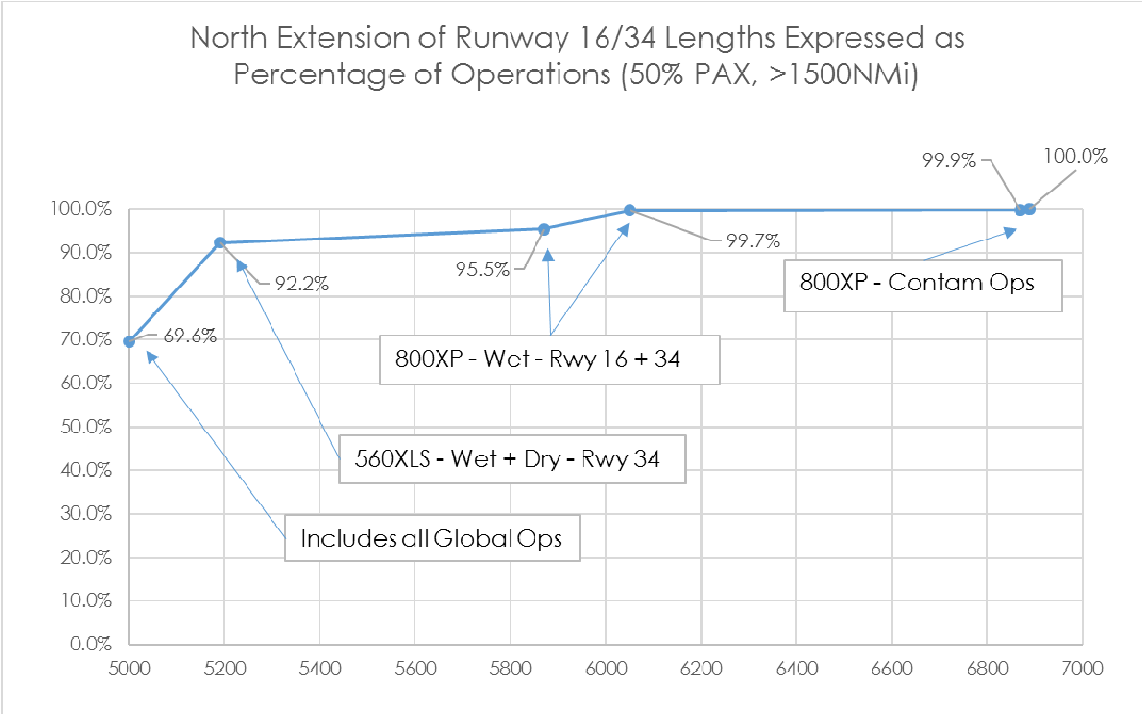
7.5.2 Percentage of Takeoff Operations Supported by North Runway Extensions to Achieve the Maximum Takeoff Weight



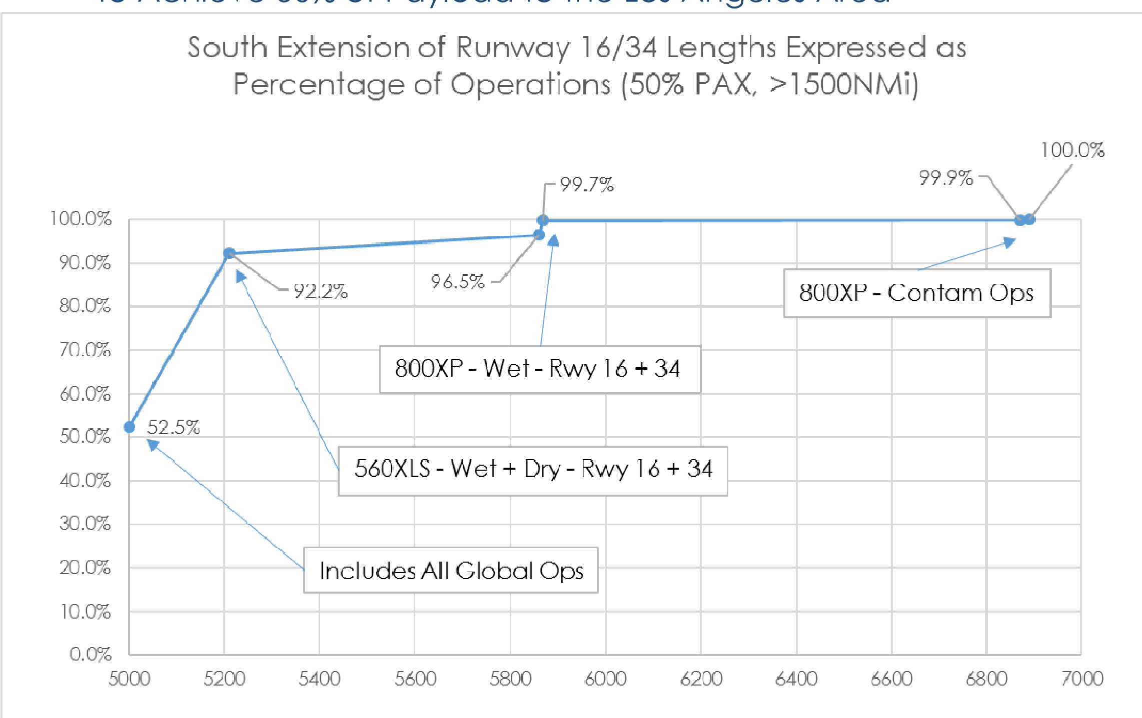
7.5.3 Percentage of Takeoff Operations Supported by South Runway Extensions to Achieve the Maximum Takeoff Weight



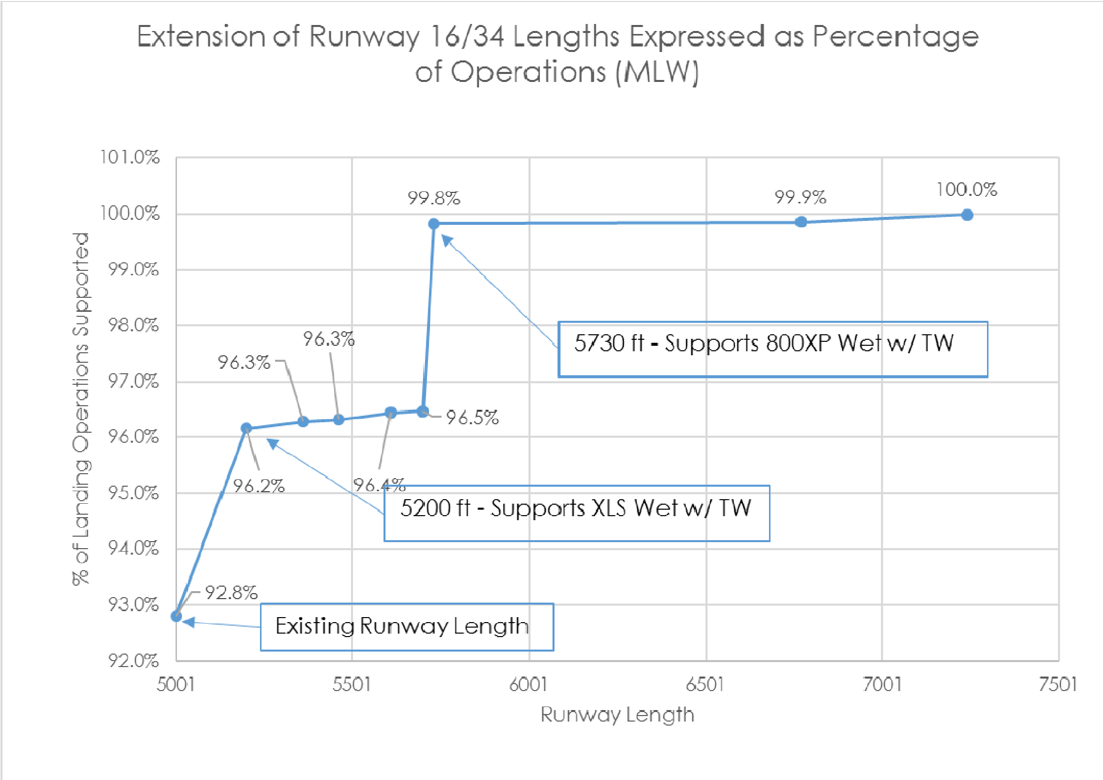
7.5.4 Percentage of Takeoff Operations Supported by North Runway Extensions to Achieve 50% of Payload to the Los Angeles Area



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

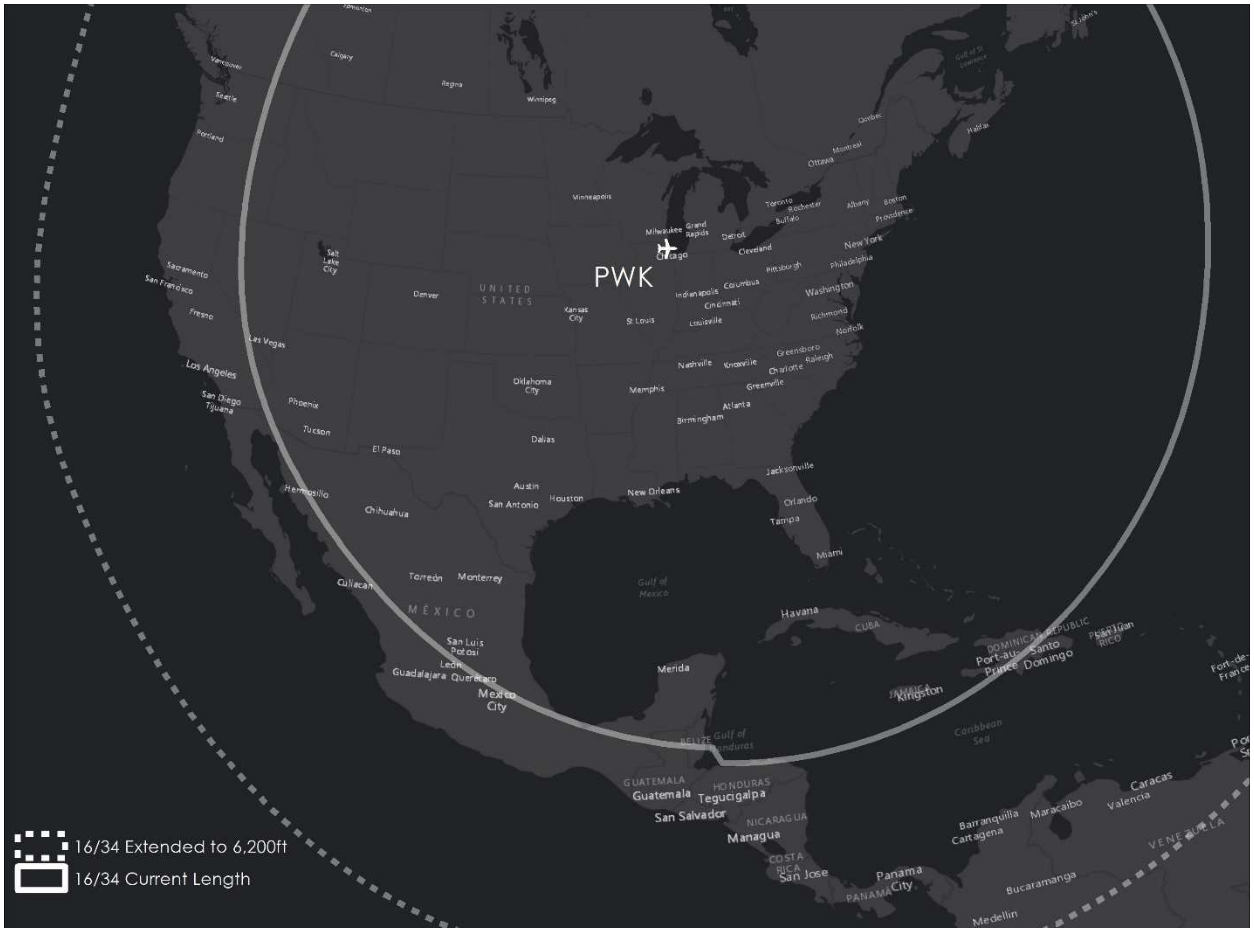


Figure 13 Payload Range Enhancement for 800XP Between Current Runway and 6,200ft Length Runway

As seen in

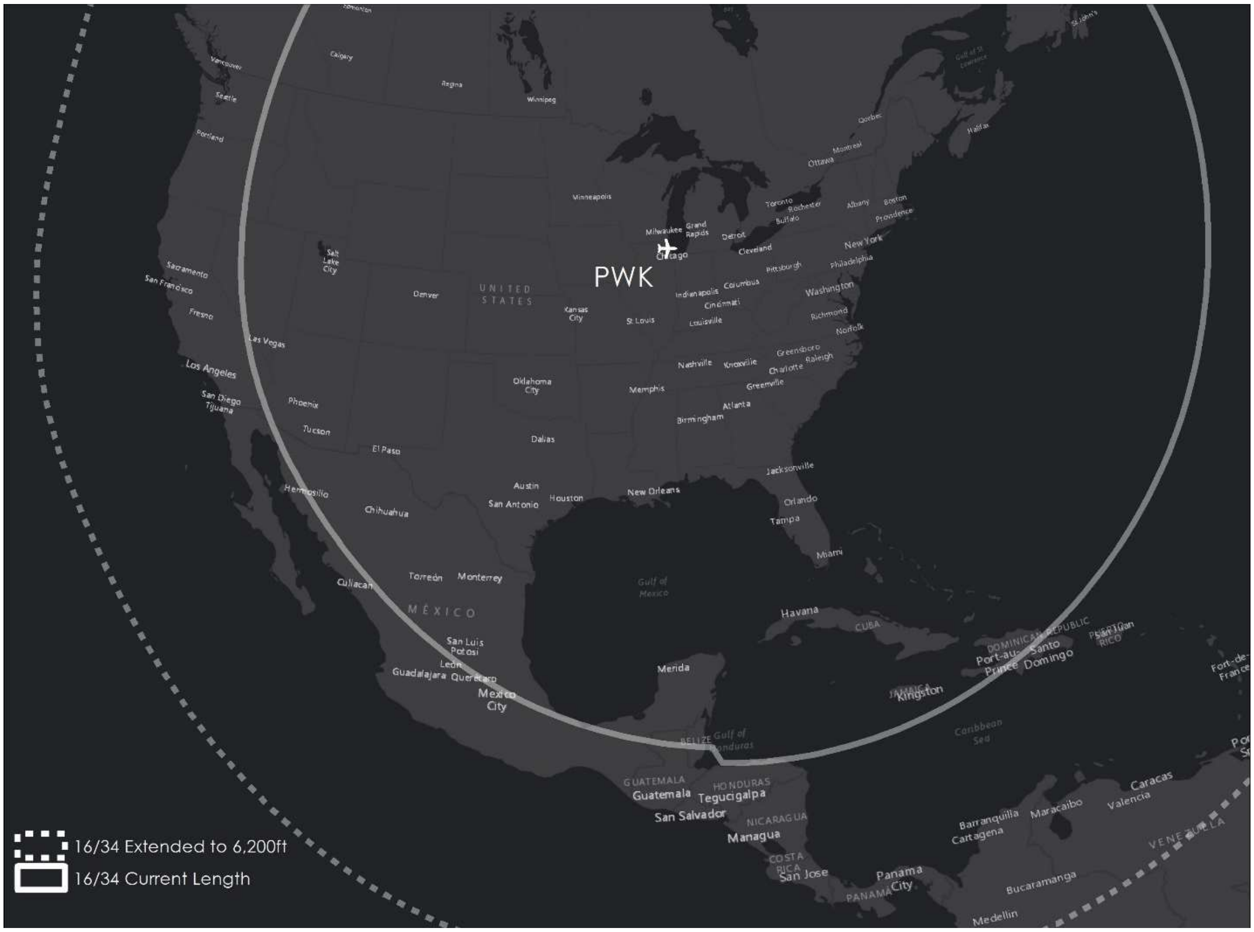


Figure 13, the payload range increase from a 6200ft runway extension with an 800XP provides significantly increased access for medium and small cabin aircraft to gain access to West Coast destinations, as well as several other Caribbean and Central American Destinations.

8.2.3 Global 6000 50% Payload Range Improvement

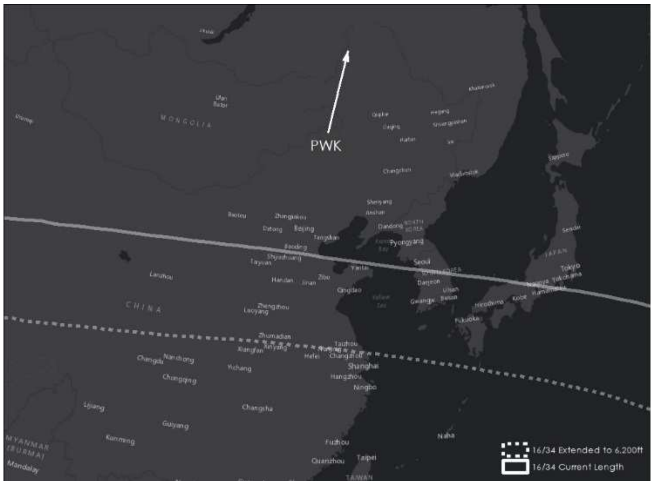


Figure 14 Payload Range Enhancement for G6000 Between Current Runway and 6,200ft Length Runway (Japan, Korea and China)

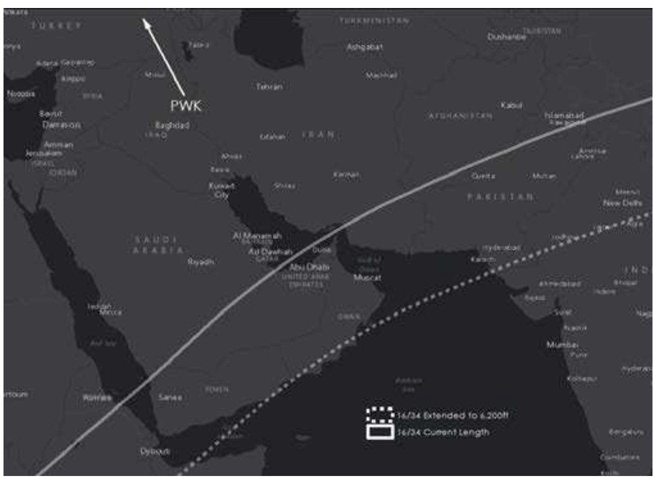


Figure 15 Payload Range Enhancement for G6000 Between Current Runway and 6,200ft Length Runway (Middle East)

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.