Appendix F – Annual Service Volume (ASV)

Annual Service Volume

Long-term planning requires an airport to assess its ability to meet forecasted demand. Annual Service Volume (ASV) is a metric commonly used to identify deficiencies in airfield capacity. Once the ASV has been calculated and compared to the forecasts of future demand, capital improvement needs, and operational capacity enhancements can be determined.

This section estimates C29's annual operational capacity, compares it to forecasted growth, and determines whether capacity improvements are needed to accommodate forecasted growth.

Airfield capacity is defined in Federal Aviation Administration (FAA) Advisory Circular (AC) 150/5060-5, *Airport Capacity and Delay,* as the maximum number of aircraft operations that a given airport configuration can accommodate during a given time interval of continuous demand. This derived level of capacity is affected by several factors including: weather conditions, number of runways and their configuration, the placement of exit taxiways and their configuration, the number of touch-and-go operations, and the types of aircraft utilizing a facility. This section estimates and evaluates the following airfield capacity metrics:

- **Peak hourly capacity** – The maximum number of aircraft operations that can occur at an airport in an hour, given specified weather conditions.
- **Annual Service Volume (ASV)** – An estimate of an airport's annual capacity that accounts for runway use, aircraft mix, weather conditions, and other factors that would be encountered over the course of a year. The ASV also assumes an acceptable level of aircraft delay as described in FAA AC 150/5060-5, which is used in this analysis.

Runway Capacity Factors

There are several factors that can affect hourly capacity. These factors are described in the following sections:

- Ceiling and Visibility
- Runway Use Configuration
- Aircraft Mix Index
- Peak Hour
- Percent Arrivals & Percent Touch-and-Go Operations
- Exit Taxiway Locations
- Peak Hour Airfield Capacity

Ceiling and Visibility

Adverse weather conditions can impact capacity by increasing the separation needed between aircraft on arrival. Aircraft operate under two primary weather categories: Visual Flight Rules (VFR) and Instrument Flight Rules (IFR). VFR conditions exist when the cloud ceiling is 1,000 feet or greater above ground level (AGL) and visibility is at least 3 statute miles. IFR weather conditions prevail when the cloud ceiling is 500 feet AGL, or greater, but less than 1,000 feet, and visibility is less than 3 statute miles. In general, any weather conditions below VFR minimums are considered IFR weather conditions. The ability of aircraft to operate during IFR conditions is often solely dependent on the lowest available instrument approach minimums at the airport. The lowest minimums at the Airport are a 400-foot cloud ceiling and 1-mile visibility that correspond to the RNAV (GPS) and Localizer (LOC) approaches to Runway 10/28. During VFR and IFR conditions, the required separation distances between aircraft vary. In general, greater separation is required under IFR than VFR.

Information from the Dane County Regional Airport (MSN) was retrieved from the automated weather reporting station located on the field, as information at C29 has been unavailable since 2013. The frequency of weather occurrences is an important consideration as they influence the weighted capacity (Cw) variable used in the final calculation near the end of this appendix. Based on the MSN weather station data, the observed conditions for VFR and IFR conditions from 2009 to 2018 were:

- 90.7 percent of reported weather conditions were VFR.
- 9.3 percent of reported weather conditions were IFR.

Runway Use Configuration

Runway use configuration refers to the number, location, and orientation of runways. It also refers to the type and direction of operations as well as the flight rules in effect at any given time. The number, placement, and orientation of runways at an airport can affect capacity. For example, runways that intersect each other can affect the overall capacity of an airport since simultaneous use of the runways cannon occur. Likewise, parallel runways allow for simultaneous aircraft operations to occur that can increase the overall capacity of an airport. AC 150/5060-5 includes a variety of diagrams for various runway use configurations. The AC advises selecting the configuration that best represents airport use during the specified hour. C29 has 2 runways that intersect with each other. Runway 10/28 is 4,000 feet long and paved while Runway 01/19 is 1,800 feet long and turf. Given the limited length and unpaved condition of Runway 01/19 this ASV considers only the main runway, Runway 10/28.

Aircraft Mix Index

The aircraft mix index is based on the percentage of operations conducted by four different categories of aircraft (A, B, C, and D). Aircraft class definitions used to calculate the mix index are based on a combination of maximum certified takeoff weight, number of engines, and wake turbulence classification. The mix index can significantly impact airfield capacity. Depending on the approach speeds and the aircraft weights, airfield capacity can increase, or decrease based on the mix index.

Aircraft create wake vortices in which air turbulence trails behind aircraft because of their movement through the air. The heavier and larger the aircraft, the more significant the wake vortices which are greater of concern for aircraft on arrival to land. To mitigate the hazards of wake vortices, aircraft are spaced according to differences in approach airspeed as well as weight. In general, aircraft departures are spaced two minutes apart for larger aircraft wake vortices and at least three minutes for the largest aircraft (AC 90-23G, *Aircraft Wake Turbulence)*. The separation needed between aircraft to account for wake turbulence affects airfield capacity.

To better understand the effect aircraft mix has on runway configuration and capacity, FAA AC 150/5060-5 uses different aircraft classifications than FAA AC 150/5300-13A, *Airport Design.* When referring to the aircraft mix index categories, the categories laid out in **Table 1** coincide with the criteria used in AC 150/5060-5.

Table 1: Aircraft Mix Index Categories

Class	Maximum Takeoff Weight (pounds)	Aircraft Type	Wake Turbulence Factor
A	12,500 or less	Small Single-Engine	Small
B	12,500 or less	Small Multi-Engine	Small
C	12,500 - 300,000	Large	Large
D	300,000 or more	Heavy	Heavy

Source: FAA Advisory Circular 150/5060-5, Airport Capacity and Delay

The aircraft fleet mix for C29 was determined based on FAA operations data from the Traffic Flow Management System Counts (TFMSC) database for the year 2019. TFMSC collects information for aircraft flying under IFR flight plans and captured by FAA en route computers. Baseline 2019 operations data from Chapter 2 is also used in the airfield capacity calculations.

AC 150/5060-5 defines the aircraft mix index as the percent of Class C aircraft plus 3 times the percent of Class D aircraft, or %(C+3D), and A and B aircraft are not included in this formula. There are no Class D aircraft expected at C29 during the twenty-year planning period but the most demanding aircraft at the airfield consist of business aircraft that are Class C, such as the King Air 350, Cessna Citation CJ3 and Cessna Citation V. These aircraft have averaged between 150 to 470 operations per year at C29, equating to roughly 1 percent of the total activity. Therefore, the mix index is set at 1 percent.

Peak Hour

The number of peak hour operations can affect the total annual capacity of an airport. Due to the separation needed between aircraft, periods of congestion limit the number of aircraft that can land and takeoff on a runway. The percentage of monthly operations, compared to annual operations, from the Traffic Flow Management System Counts (TFMSC) database is shown in **Table 2**, and months with a greater number of operations have a darker shade of green for quick visual reference. The summer months have the most operations with August historically having the greatest number of operations, with an average of 10.71 percent of total annual operations.

Table 2: Historic Monthly Operations by Percentage						
Month	**2015**	**2016**	**2017**	**2018**	**2019**	**Average**
Jan	4.6%	5.1%	4.4%	5.4%	5.2%	4.94%
Feb	4.6%	5.7%	5.7%	5.4%	4.4%	5.15%
Mar	7.6%	7.2%	6.3%	6.4%	6.7%	6.81%
Apr	8.4%	8.0%	8.2%	7.2%	7.5%	7.87%
May	9.4%	8.9%	9.8%	9.5%	10.9%	9.70%
Jun	9.5%	10.2%	9.6%	9.6%	9.5%	9.68%
Jul	12.2%	10.5%	9.1%	11.5%	10.1%	10.69%
Aug	**10.1%**	**11.1%**	**9.8%**	**10.2%**	**12.3%**	**10.71%**
Sep	9.5%	10.4%	12.3%	8.8%	11.1%	10.43%
Oct	11.7%	10.2%	10.0%	10.3%	9.0%	10.26%
Nov	6.7%	6.7%	9.3%	8.9%	6.3%	7.59%
Dec	5.7%	6.0%	5.7%	6.6%	6.9%	6.18%

Source: FAA Operational Network (OPSNET) Database

The peak month percentage share of operations (10.71 percent) was applied to the total annual operations expected at C29 through 2039. As the peak month is August, this number was then divided by 31 to determine the average day operations. Finally, the types of operations vary and include corporate, flight training, and recreational operations, that are staggered throughout the day. Approximately 20 percent of daily operations are expected to occur during the peak hour. This percentage is applied to the peak month average day forecast to determine peak hour operations**.** This process can be seen for the low-growth scenario in **Table 3**, medium-growth scenario in **Table 4**, and high-growth scenario in **Table 5**.

Table 3: Low-Growth Peak Hour				
Year	**Annual**	**Monthly**	**Average Day**	**Peak Hour**
2019	41,342	4,428	143	29
2024	42,166	4,516	146	29
2029	42,856	4,590	148	30
2034	43,591	4,669	151	30
2039	44,389	4,754	153	31

Table 4: Medium-Growth Peak Hour				
Year	Annual	Monthly	Average Day	Peak Hour
2019	41,342	4,428	143	29
2024	42,514	4,553	147	29
2029	43,401	4,648	150	30
2034	44,365	4,751	153	31
2039	45,419	4,864	157	31

Table 5: High-Growth Peak Hour				
Year	Annual	Monthly	Average Day	Peak Hour
2019	41,342	4,428	143	29
2024	41,724	4,469	144	29
2029	44,379	4,753	153	31
2034	47,222	5,057	163	33
2039	50,276	5,385	174	35

Percent Arrivals & Percent Touch-and-Go Operations

Percent arrivals is the ratio of arrivals to total operations. In general, aircraft on final approach are given priority over departures, which increases percentage of arrivals during peak periods, thus reducing the ASV. Percent arrivals are computed as follows:

$$Percent\ Arrivals = \frac{A + 0.5(T)}{A + D + T}\ x\ 100$$

A = Number of arriving aircraft in the hour
D = Number of departing aircraft in the hour
T = Number of touch-and-go operations in the hour

In the section above, the current peak aircraft operations were determined to be an average of 29 peak hour operations during August, during the peak month average day. The TFMSC database does not track touch-and-go operations. Given the presence of both local and itinerant flight training at C29, and supported by information provided by local tenants, a large percentage of touch and go operations are known to occur; therefore, the touch and go operations are considered to represent 50 percent of total operations at C29. For these 29 peak operations, it is estimated that 7 were arriving aircraft, 7 departing aircraft and 15 aircraft were conducting touch-and-go operations. Arriving and departing aircraft were determined based on the assumption that for every arriving aircraft, there was also a departing aircraft. Based on the formula above as well as touch-and-go estimates, the percent arrivals during the peak hour is 50 percent.

Exit Taxiway Locations

In some cases, exit taxiway locations providing access to the parallel taxiway can affect capacity. Taxiway intersections with Runway 10/28 are, on average, 1,300 feet between each other providing a total of 4 access points between the runway and parallel taxiway. These connector taxiways provide aircraft multiple options to exit the runway as soon as their speed decreases sufficiently. Permitting aircraft to quickly exit the runway via additional exits makes the runway available for other aircraft and increases total capacity.

Peak Hour Airfield Capacity

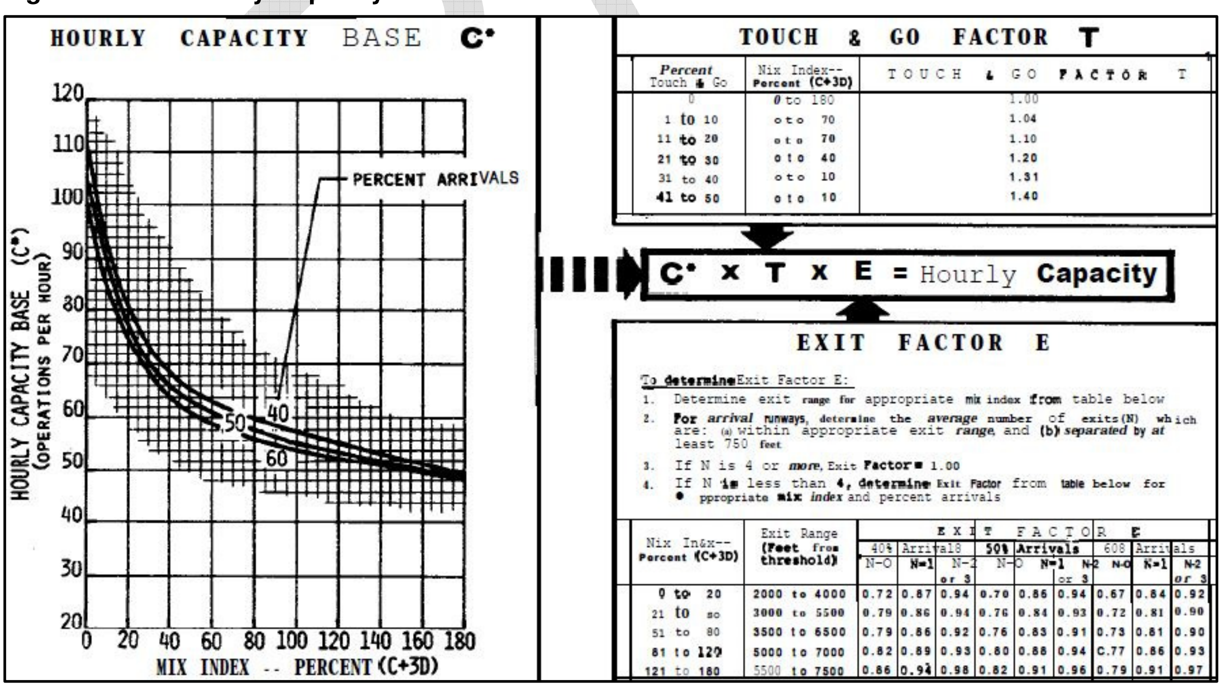
Determining the peak hour airfield capacity provides a method to review how an airfield can accommodate aircraft operational demand during the busiest time of day. Peak hour airfield capacity is calculated using the guidelines in AC 150/5060-5 under both VFR and IFR conditions. It is calculated as follows:

$$Hourly\ Capacity = C^{*} x\ T\ x\ E$$

C = Hourly capacity base*
T = Touch-and-go factor
E = Exit factor

The hourly capacity base (C*) is based on performance curves developed for the specific runway use configuration. As shown in **Figure 1** and **Figure 2** below, C* is calculated by identifying aircraft mix index and percent arrivals, which are 1 percent and 50 percent, respectively. Using these inputs, C* is 110 operations per hour in VFR conditions and 68 operations per hour in IFR conditions.

Figure 1: VFR Hourly Capacity Base



TOUCH & GO FACTOR T

Percent Touch & Go	Nix Index-- Percent (C+3D)	TOUCH & GO FACTOR T
0	0 to 180	1.00
1 to 10	o to 70	1.04
11 to 20	o to 70	1.10
21 to 30	o to 40	1.20
31 to 40	o to 10	1.31
41 to 50	o to 10	1.40

EXIT FACTOR E

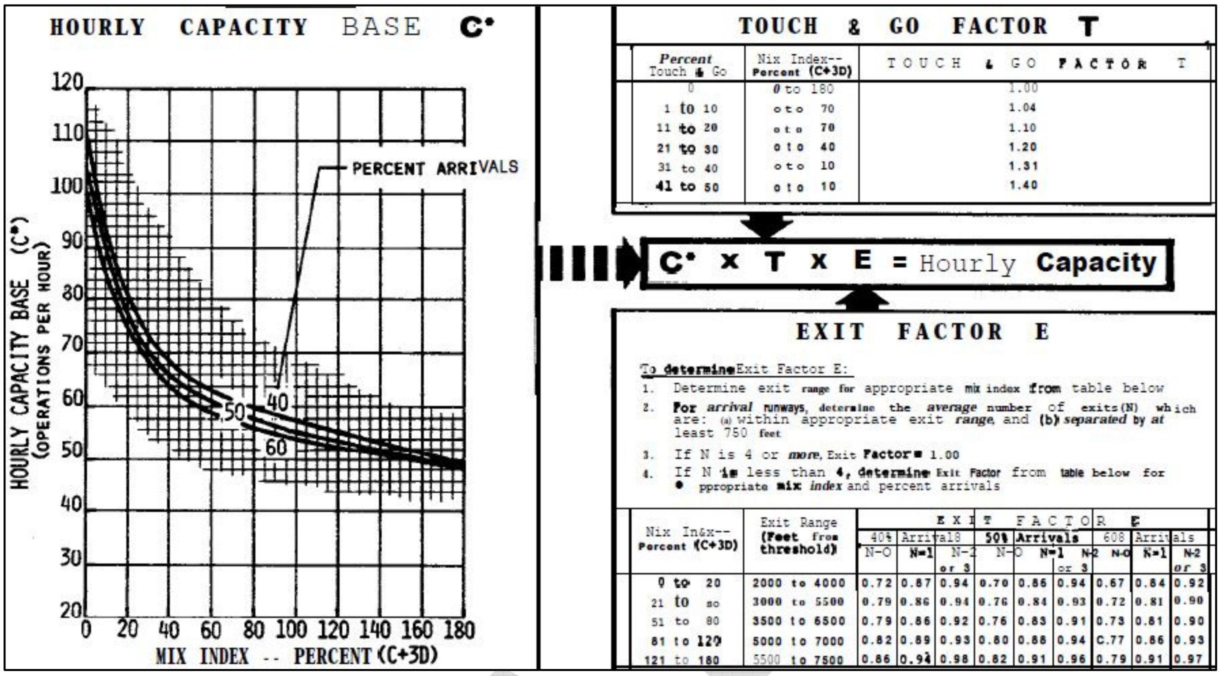
To determine Exit Factor E:

1. Determine exit range for appropriate mix index from table below
2. For arrival runways, determine the average number of exits (N) which are: (a) within appropriate exit range, and (b) separated by at least 750 feet
3. If N is 4 or more, Exit Factor = 1.00
4. If N is less than 4, determine Exit Factor from table below for appropriate mix index and percent arrivals

Nix In&x-- Percent (C+3D)	Exit Range (Feet from threshold)	EXIT FACTOR E 40% Arrivals N-O			50% Arrivals N-O			60% Arrivals N-O		
		N-O	N=1	N-2 or 3	N-O	N=1	N-2 or 3	N-O	N=1	N-2 or 3
0 to 20	2000 to 4000	0.72	0.87	0.94	0.70	0.86	0.94	0.67	0.84	0.92
21 to so	3000 to 5500	0.79	0.86	0.94	0.76	0.84	0.93	0.72	0.81	0.90
51 to 80	3500 to 6500	0.79	0.86	0.92	0.76	0.83	0.91	0.73	0.81	0.90
81 to 120	5000 to 7000	0.82	0.89	0.93	0.80	0.88	0.94	C.77	0.86	0.93
121 to 180	5500 to 7500	0.86	0.94	0.98	0.82	0.91	0.96	0.79	0.91	0.97

Source: AC 150/5060-5, Airport Capacity and Delay, Figure 3-3

Figure 2: IFR Hourly Capacity Base



Source: AC 150/5060-5, Airport Capacity and Delay, Figure 3-43

The touch-and-go factor (T) is determined based on the aircraft mix index (1 percent) and percent touch-and-go (50 percent). A table in AC 150/5060-5 specific to the runway use configuration identifies T based on pairing these two factors. At C29 with the current runway use configuration, T equals 1.4 in VFR conditions and 1 in IFR conditions.

The exit factor (E) is determined by several factors including aircraft mix index, percent arrivals, and the average number of exits located in the appropriate exit range separated by at least 750 feet. Based on the number of taxiway exits from the runway, E is 1.0.

Lastly, using the hourly capacity bases (C*), touch-and-go factors (T), and exit factors (E) described above, the hourly capacities of C29 are as follows:

$$VFR\ Hourly\ Capacity = C^*\ x\ T\ x\ E = 110\ x\ 1.40\ x\ 1.00 = 154.0\ operations$$

$$IFR\ Hourly\ Capacity = C^*\ x\ T\ x\ E = 68\ x\ 1.00\ x\ 1.00 = 68.0\ operations$$

Annual Service Volume Calculation

Annual Service Volume (ASV) provides an estimate of an airport's annual practical capacity. It accounts for differences in runway use, aircraft mix, weather conditions, pattern of demand (peaking), and other factors that impact an airport. When calculating the ASV, three variables are considered: weighted hourly capacity (C_w), the ratio of annual demand to average daily demand during the peak month (D), and the ratio of average daily demand to average peak hour demand during the peak month (H).

The weighted hourly capacity blends several inputs to be used in the final determination of an airport's annual capacity. Both the IFR and VFR hourly capacities are used as well of the percentage of IFR and VFR weather. Using the weighted hourly capacity formula found in AC 150/5060-5, the weighted hourly capacity (C_W) of Runway 10/28 at C29 is 146.0 operations.

The Daily Demand Ratio (D) is the ratio of annual demand to average daily demand during the peak month. Using 2019 operational levels identified in Chapter 2, this ratio is calculated as follows:

$D = Annual\ Demand/Peak\ Month\ Average\ Daily\ Demand$

$D = 41{,}342/143$

$D = 289.10$

The Hourly Demand Ratio (H) is the ratio of the average daily demand to average peak hour demand during the peak month. This ratio is calculated using 201 operational levels as shown below:

$H = Peak\ Month\ Average\ Daily\ Demand/Peak\ Hour\ Demand$

$H = 143/29$

$H = 4.93$

Lastly, the ASV is calculated below and rounded to the nearest whole number:

$ASV = C_W\ x\ D\ x\ H$

$ASV = 146.0\ x\ 289.10\ x\ 4.93$

$ASV = 208{,}136$

Since AC 150/5060-5 does not provide guidance for estimating change in ASV over time, a typical airfield capacity analysis fixes ASV at a given number (such as 208,136 operations) throughout the planning period, instead of flexing with operational demand. **Table 6** shows the ASV for the planning period under all three growth scenarios from Chapter 2.

Table 6: Forecasted Operations as a Percentage of ASV

Year	ASV	Low-Growth		Medium-Growth		High-Growth	
		Operations	% of ASV	Operations	% of ASV	Operations	% of ASV
2019	208,136	41,342	20%	41,342	20%	41,342	20%
2024	208,136	42,166	20%	42,514	20%	41,724	20%
2029	208,136	42,856	21%	43,401	21%	44,379	21%
2034	208,136	43,591	21%	44,365	21%	47,222	23%
2039	208,136	44,389	21%	45,419	22%	50,276	24%

Notes: ASV = Annual Service Volume
Source: AC 150/5060-5, Airport Capacity and Delay, Mead & Hunt, Inc.

Conclusion

Current guidelines from the FAA National Plan of Integrated Airport Systems (NPIAS) direct airport sponsors to consider airfield capacity improvements when activity reaches 60 to 75 percent of the airport's ASV. This guidance is conservative and allows adequate lead time for environmental reviews, land purchases, and other necessary actions that can take up to 10 or more years to complete and could theoretically place activity at 80 percent of the ASV by the time improvements are implemented. As shown in **Table 6**, the high-growth forecast presented in Chapter 2 results in 24 percent of ASV being reached by the end of the planning period. Therefore, no airfield capacity improvements are expected to be needed during the 20-year planning period.