MINNETONKA MOBILE SOUND MONITORING REPORT

July 2021

Community Relations Office

Metropolitan Airports Commission
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Contents

1 INTRODUCTION

In 2021, the Metropolitan Airports Commission (MAC) conducted a sound study in the City of Minnetonka at the request of the Minnetonka City Council and the Minneapolis-St. Paul International Airport (MSP) Noise Oversight Committee (NOC). The study evaluated two industry standard methods for assessing aircraft sound: field-measured data and modeled data.

This study was conducted by MAC Community Relations staff, using scientific equipment and guidelines. The results of this study are intended to enhance communication about aircraft sound associated with MSP aircraft activity in the City of Minnetonka. The study captured sound data at the location of the sound monitoring equipment generated by aircraft that arrived to and/or departed from MSP or by community-related activity. Data not correlated with aircraft arriving to or departing from MSP are reported as community sound events in this report.

The sections below describe the MSP runway use, aircraft operations, weather, field-measured data collection process and analysis, AEDT modeling data and analysis, and a comparison of measured data and modeled data during the study period of May 22 – May 31, 2021.

2 BACKGROUND

The Minnetonka City Council requested that MAC conduct a mobile monitoring study within the city to assess aircraft noise levels generated from arrival activity to MSP. While this study was included on the 2020 NOC Work Plan, the study was deferred to the 2021 NOC Work Plan due to the downturn in aircraft activity following the onset of the COVID-19 pandemic.

Since 1992, the MAC has operated one of the most sophisticated and comprehensive computerized aircraft noise and flight track data collection and processing systems of its kind. The MAC Noise and Operations Monitoring System (MACNOMS) is a tool to help MAC staff analyze aircraft noise impacts around MSP and provides public access to flight tracking and detailed aircraft sound data. MAC staff utilized the MACNOMS system to assist in gathering, assembling, and correlating data in preparation of this report. A critical component of MACNOMS in an array of 39 permanent Remote Monitoring Towers (RMTs) which monitor aircraft sound events continuously in communities surrounding MSP. While there are no permanent RMTs in the City of Minnetonka, this report references data collected by the RMTs and compares them to data collected by the mobile field measurements.

It is important to note that the data collected at sound monitoring sites are not used in determining residential sound mitigation eligibility, nor are they used in the development of airport noise contours. These activities are strictly regulated by the Federal Aviation Administration (FAA), which requires the use of the Aviation Environmental Design Tool (AEDT) modeling software, which was used in preparing the modeled sound levels for this report.

3 Study Overview

3.1 Goal

The goal of this study was to collect quality field-measurement recordings and modeled measurements of sound events associated with aircraft activity arriving to MSP that occur in the City of Minnetonka, specifically the northeastern portion, in accordance with established Mobile Sound Monitoring Guidelines and provide information related to the activity.

3.2 Study Period

Mobile field-measurement equipment was deployed on May 21, 2021, and retrieved on June 1, 2021. The 10-day data collection period started at 12:00 A.M. on Saturday, May 22nd and concluded at 11:59:59 P.M. on Monday, May 31st.

3.3 Monitoring Locations

MAC Community Relations staff, in collaboration with City of Minnetonka staff, placed mobile field-measurement equipment in a single location for the duration of the study period. After consideration of various site locations, the City of Minnetonka approved use of Fire Station #2, which met the following criteria:

- The equipment was able to be secured
- The site was located on public land, owned by the City (parks, easements, out-lots, etc.)
- The site was located appropriate distances from known sources of community noises, such as major roadways, active construction, crowd assembly areas, railroad tracks, etc.
- The City and the MAC agreed that the site was located in close proximity to aircraft activity and therefore reasonable and adequate to obtain the necessary data to meet the project objectives

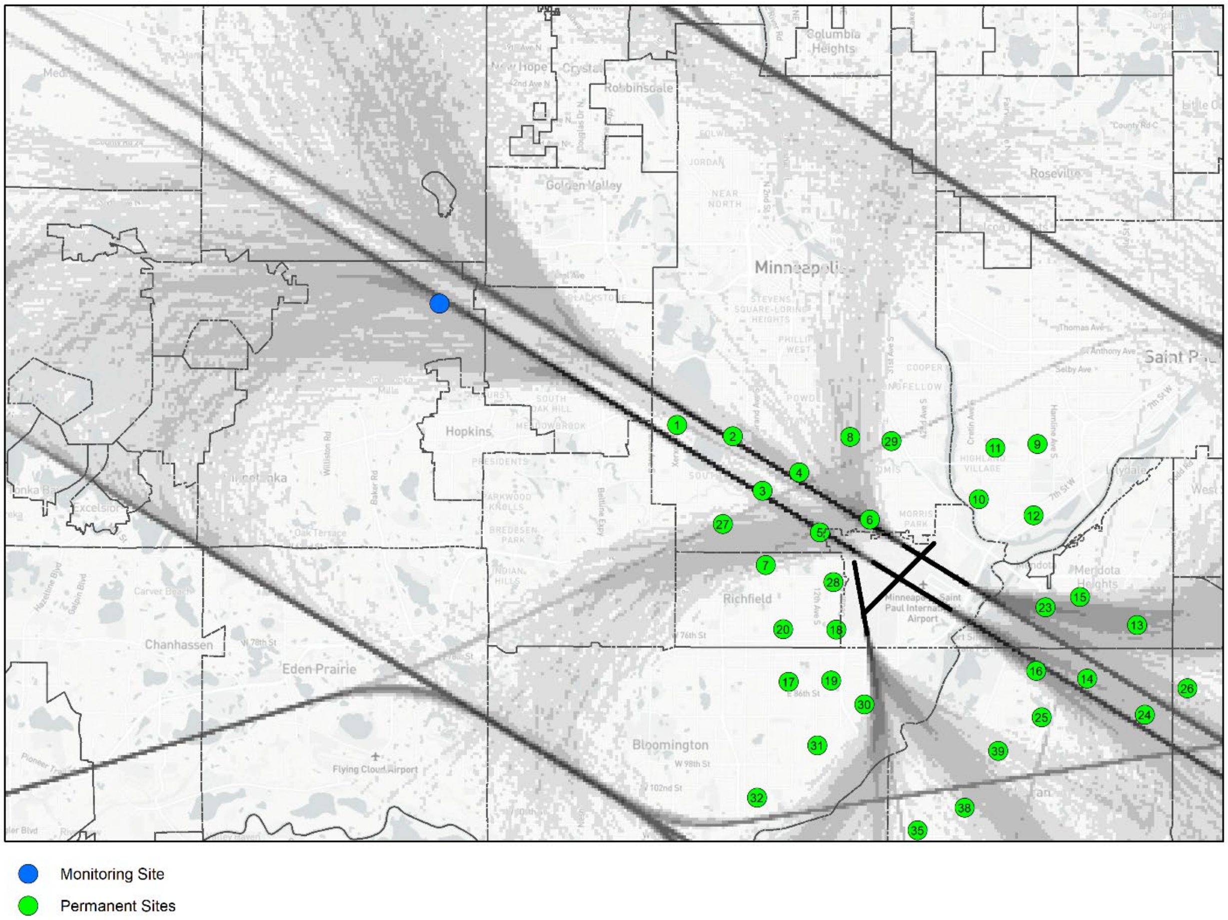
The following are the details for the mobile sound monitoring data collection site:

Minnetonka Fire Station #2

The Minnetonka Fire Station #2 site was located 1815 Hopkins Crossroad, north of the parking lot.

This location was chosen due to its proximity to MSP flight activity and position in a low community activity area while still on public property.

Monitoring Locations



3.4 Equipment and Instrumentation

A secured weatherproof enclosure was used at the mobile monitoring site to contain the measurement and recording devices. The instrumentation is manufactured by Larson Davis and consists of a laboratory quality sound level analyzer (831A class/type 1 instrument), preamplifier (PRM831), and microphone (377B02). The preamplifier and microphone were housed within environmental protection coverings to allow sound measurements during adverse weather elements. The components used at the site is the same equipment that is used at the permanent RMTs.

The instruments are certified annually, and each site was calibrated at the start of the study. Inspections were performed often throughout the study at the site to verify instruments were operating and within tolerances, and to inspect for tampering and damage. A final calibration check was performed at the end of the study and found to be within tolerance.

3.5 MEASUREMENT PARAMETERS

The sound monitoring instrumentation was configured to monitor sound continuously utilizing slow response with A-weighting, as directed by 14 Code of Federal Regulations (CFR) Part 150 and consistent with the MACNOMS data collection. Under this configuration, the analyzer uses a sound pressure level and time trigger (when the A-weighted sound pressure level exceeds 65 decibels (dBA) for a minimum period of eight seconds) to identify and document sound events. A two-second continuation period is used to extend the sound event if the sound level falls below the trigger threshold level and then exceeds it again. These parameters are consistent with the configurations employed at the permanent RMTs.

The parameters used by the sound monitoring instrumentation account for any sound level exceedance and captures both community and aircraft sounds. The equipment and tolerances are set to be sensitive so that aircraft do not have to fly directly over the measurement site to be recorded.

3.6 AIRCRAFT-EVENT CORRELATION

This study employed a process for correlating mobile site sound data with MSP flight track data; the same process is used for correlating RMT sound data with MSP flights. The process uses both temporal (time) and spatial (space) components to match a sound event with an aircraft overflight. The mobile monitoring site used the same time and space parameters as those at the permanent RMTs which include a cylindrical area of influence with a radius of 4,000 meters, a ceiling of 2,100 meters and a time window of at least one minute around an event. Sound events that could not be correlated to MSP aircraft activity were classified as “community” events.

3.7 SOUND MODELING

In addition to field-measurement data, MSP aircraft activity from May 22, 2021, through May 31, 2021, was modeled using the FAA’s modeling tool, AEDT, Version 3d.

With actual monitoring, as noted above, events are documented when the analyzer detects a sound level over 65 dBA for eight seconds or longer. Due to the nature of environmental monitoring, MACNOMS must take measures to attempt to filter out community and other ambient sounds before assigning aircraft sound events to a specific operation. The AEDT model does not have community sounds to filter out. Additionally, modeling provides sound data over a wider area compared to monitoring, which only allows data to be collected near the field-measurement site.

Conversely, AEDT must make assumptions about aircraft performance, flap configurations, engine settings, aircraft model types, weight, and weather. AEDT uses standard aircraft thrust settings, standard departure climb rates as well as standard arrival descent rates, which may not represent actual operating characteristics. Additionally, modeling requires aircraft substitutions. While many aircraft have sound data available in the model, all aircraft types operating at MSP are not represented and need to use a substitute aircraft in the model. While the goal of conducting monitoring studies and producing modeling results are similar and will often times produce the same sound metric results, the differences between actual monitoring and sound modeling will result in variances between the data due to community sound, measurement parameters, and necessary model assumptions.

The AEDT model can produce various sound metrics. Two metric options available are the Number Above Sound Level and Time Above Sound Level. For this analysis, MAC staff evaluated the number of operations at or above 65 dB and the duration of time spent above 65 dB.

This modeled sound analysis depicts aircraft sound events from actual aircraft activity at MSP for the same time period as the field-measurement site (May 22, 2021 through May 31, 2021). The model uses inputs such as runway use, aircraft fleet mix, aircraft performance and thrust settings, topography, and atmospheric conditions. Actual flight tracks for arrivals and departures were used. The location where the levels are modeled is the same location as the field-measurement site.

Quantifying aircraft-specific sound characteristics in AEDT is accomplished using a comprehensive sound database that has been developed under 14 CFR Part 36. As part of the airworthiness certification process, aircraft manufacturers are required to subject aircraft to a battery of sound measurement tests. Using federally adopted and endorsed algorithms, this aircraft-specific sound information is used in the generation of model outputs. Justification for such an approach is rooted in national standardization of sound quantification at airports. Appendix 5.1 of this report includes the fleet mix and Appendix 5.2 includes weather data utilized in the AEDT model for this analysis.

AEDT uses a grid pattern of individual noise measurement points, known as receptors, and calculates sound at each of these points. The grid pattern for this study included 24,000 unique points spaced 0.1 nautical miles apart for a grid sized 20 by 12 nautical miles to fully cover the City of Minnetonka and neighboring communities.

Additionally, AEDT uses standard weather inputs that are typically available for a study comprising a full year of data. For this study, standard weather inputs were changed to represent the average weather conditions for the study period. Section 5.2 shows a summary of the temperature and reported wind speeds during the study period. Moderate temperatures from 39° - 86° were experienced throughout the study period. Additionally, precipitation was recorded during six days of the study. A wind rose depicting all reported winds for the study period is also included in Section 5.2.

4 DISCUSSION / SUMMARY OF FINDINGS

The study time period was selected to increase the likelihood that South Flow configurations would be prevalent at MSP. As shown in the Runway Use Airport Configurations provided in Appendix 5.1, in a South flow, aircraft arrive to Runways 12L and 12R over the study area and Runways 12L, 12R and 17 are used for departures. This provides the most ideal configuration to conduct monitoring for the purpose of this study. Section 5.1 provides further data on specific runway use. For the 10 days of the study, South Flow was utilized for 27 percent of the time and Straight South Flow was used 36 percent of the time. Like South Flow, Straight South Flow uses most of the same runways but does not include departures on Runway 17. The combined 63 percent provided a reasonable amount of opportunity to collect sound data for the study at the monitoring site.

The location of monitoring sites is impacted by normal community activities. Each site within the MAC's permanent RMT system records events with sound sources that are not aircraft related. The MAC has numerous protocols in place to determine whether the sound source of events is generated by community or aircraft activity. As discussed in Section 2.6, the MAC uses an automated system to correlate events with MSP aircraft traffic using spatial and temporal data. Additionally, MAC staff reviews events and related attributes to ensure accuracy in this matching process. The MAC also has developed a noise event classification system using a convolutional neural network–generally referred to as machine learning—to further determine the likelihood that a noise event was created by an aircraft or by a community source. These current protocols and process enhancements increase the likelihood that community events will not impact the aircraft data collected at both permanent and mobile field-measurement sites.

During the study period, there were 7,719 total MSP aircraft operations. Within one mile of the monitoring site, there were 1,971 MSP operations, 92 percent of which were arrivals. The most noticeable aircraft within one mile of the site would be arrivals to Runway 12L or 12R or departures from Runway 30L or 30R. The average altitude of the 1,810 aircraft arriving to Runway 12L or 12R within one mile of the site was 2,936 feet. The average altitude of the 120 aircraft departing from Runway 30L or 30R was 6,003 feet within one mile of the monitoring site. The remaining 41 aircraft near the site were at a higher altitude because they were utilizing different runways at MSP.

There were 176 sound events recorded at the mobile field-measurement site during the study period. Of the 176 recorded events, 144 were correlated to an MSP aircraft overflight. The remaining 32 were community produced events. Sound events correlated to aircraft had an average sound exposure level (SEL) of 78.7 dB. SEL is the total sound energy expressed in one second. The SEL metric allows for the comparison of sound events of varying durations. As shown in the Aircraft Count Above table below, there were no aircraft sound events that exceeded an LA_{max} of 80 dB. The LA_{max} metric is the maximum A-weighted sound level observed for a period, event, or interval of interest.

The estimated average background sound level (utilizing the statistical LA_{90} method) was 44.5 dBA. The loudest measured sound events were identified as community-based (e.g. lawn mowers, vehicles, people, etc.).

Summary of Measured Events

Date	Aircraft	Community	Total
5/22/2021	6	4	10
5/23/2021	14	1	15
5/24/2021	14	4	18
5/25/2021	2	1	3
5/26/2021	3	1	4
5/27/2021	57	3	60
5/28/2021	7	11	18
5/29/2021	16	4	20
5/30/2021	20	3	23
5/31/2021	5	0	5
Total	**144**	**32**	**176**

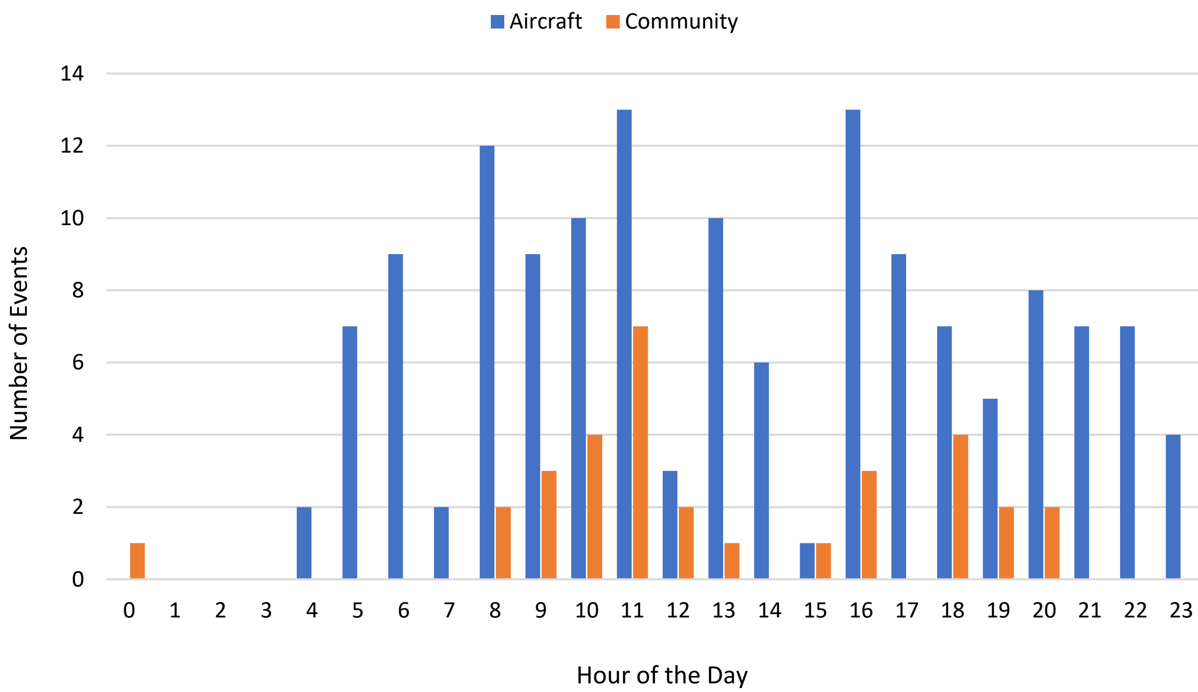
Aircraft Count Above (LA_{max}) - $N_{(level)}$

Date	N_{65}	N_{80}	N_{90}	N_{100}
5/22/2021	6	-	-	-
5/23/2021	14	-	-	-
5/24/2021	14	-	-	-
5/25/2021	2	-	-	-
5/26/2021	3	-	-	-
5/27/2021	57	-	-	-
5/28/2021	7	-	-	-
5/29/2021	16	-	-	-
5/30/2021	20	-	-	-
5/31/2021	5	-	-	-
Total	**144**	**-**	**-**	**-**

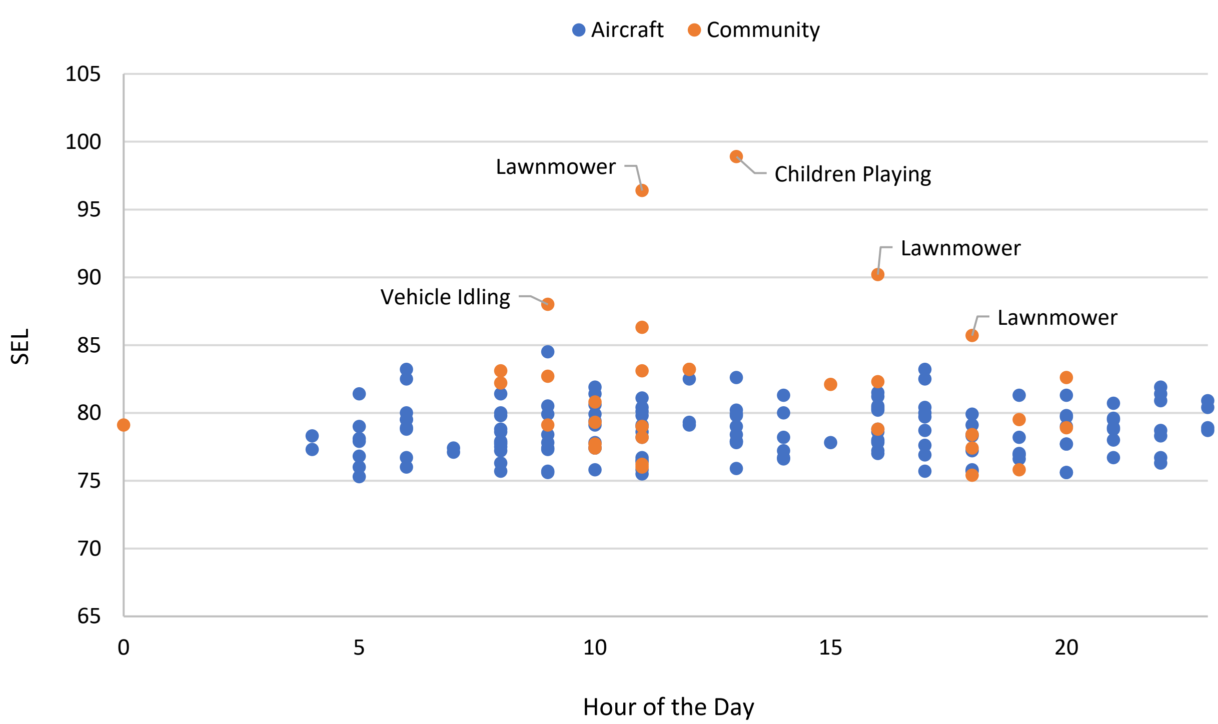
Aircraft Time Above (seconds) – $TA_{(level)}$

Date	N_{65}	N_{80}	N_{90}	N_{100}
5/22/2021	69	-	-	-
5/23/2021	180	-	-	-
5/24/2021	187	-	-	-
5/25/2021	24	-	-	-
5/26/2021	32	-	-	-
5/27/2021	819	-	-	-
5/28/2021	91	-	-	-
5/29/2021	199	-	-	-
5/30/2021	259	-	-	-
5/31/2021	59	-	-	-
Total	**1,919**	**-**	**-**	**-**

Sound Event Count by Hour



LA_{sel} vs Hour



Top 10 Measured Aircraft Events

Date/Time	Flight Number	Aircraft	Operation	Runway	LA_{max} (dB)	Duration (seconds)	3D Distance (ft)
5/27/2021 9:53	SWQ3615	B734	A	12L	76.5	18	2,015
5/27/2021 11:13	DAL2025	A220	A	12R	75.6	9	2,875
5/28/2021 6:40	DAL2114	A319	A	12L	74.3	14	2,598
5/30/2021 22:06	AAL1578	B738	A	12R	73.5	15	2,172
5/27/2021 13:37	SCX270	B738	A	12R	73.1	17	2,161
5/23/2021 17:32	UPS560	A300	A	12R	73.1	16	2,185
5/27/2021 23:53	AAL2402	B738	A	12L	73	18	3,011
5/28/2021 10:09	NKS570	A320	A	12R	72.6	11	2,750
5/27/2021 16:27	DAL654	A319	A	12R	72.5	16	2,479
5/27/2021 17:17	UPS2560	B748	A	12R	72.4	29	3,032

There were 41 modeled aircraft sound events above 65 dB at the location of the field-measurement site during the study period. The model also indicated that at the field-measurement site, the time above 65 dB was 4.88 minutes during the 10-day study period.

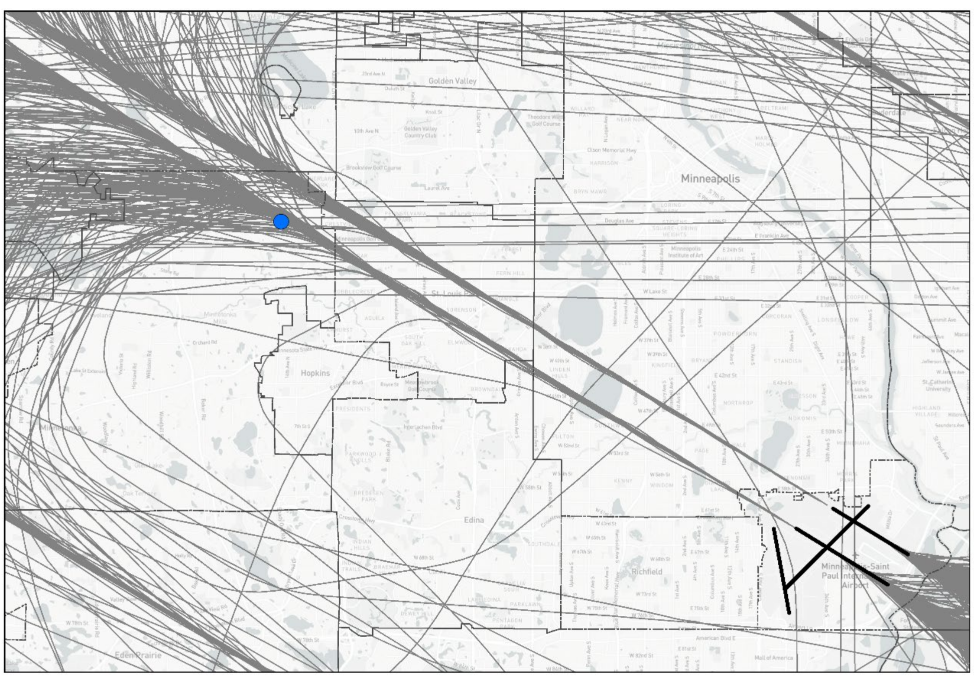
Metric	Modeled Events	Measured Events	(+/-)
Number Above	41	144	103
Time Above (seconds)	293	1,919	1,626

The field-measurement site recorded the highest number of events on May 27. Rain and wind may have contributed to the number and duration of measured aircraft events by adding to the loudness and extending the amount of time sound events exceeded the measurement threshold. On May 27th, there were 9 modeled events and 57 measured events, when rain was audible on recorded events. The use of a visual or instrument aircraft approach procedure will subtly change the area in which aircraft overfly. Instrument meteorological conditions (IMC) occur when weather conditions cause visual conditions to drop below the minimum required to operate using visual flight referencing. At MSP, Air Traffic Control (ATC) will determine whether conditions are IMC or visual meteorological conditions (VMC) using all available weather information. Conversely, per the FAA, a visual approach is an Air Traffic Control (ATC) authorization for an aircraft to proceed visually and clear of clouds to the airport. Aircraft assigned a visual approach will often overfly a different portion of the community when arriving to MSP while aircraft assigned an instrument approach, during IMC, will follow more consistent flight tracks and line up at a greater distance from the airport, as shown in the graphics below. On May 27th, MSP operated almost 17 hours in IMC and on May 29th, MSP operated for 24 hours in VMC.

Events, Operation, Time in Approach Type and Flow

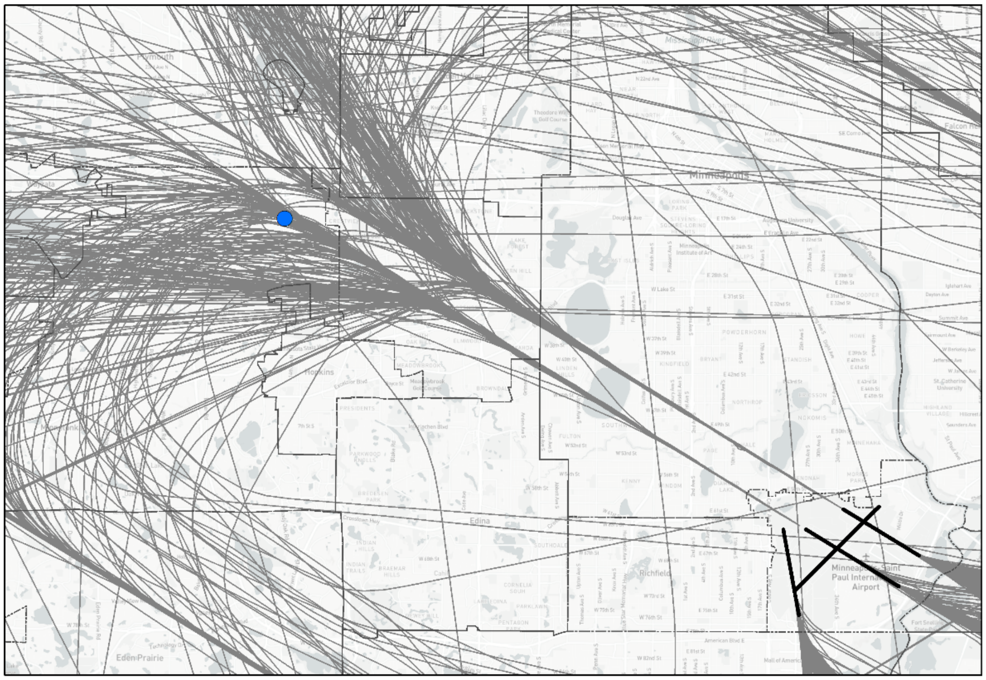
Day	Number of Aircraft Events Above 65 dB	MSP Arrivals (Within 1 Mile of Monitoring Site)	Instrument Meteorological Conditions (hours)	Visual Meteorological Conditions (hours)	North/Mixed A Flow (hours)	South Flow (hours)
22-May	6	130	9.50	14.50	5	16
23-May	14	327	10.50	13.50	-	23
24-May	14	192	9.50	14.50	6	13
25-May	2	39	3.75	20.25	15	5
26-May	3	-	-	24.00	18	-
27-May	57	414	16.75	7.25	1	19
28-May	7	207	0.75	23.25	1	20
29-May	16	148	-	24.00	3	18
30-May	20	316	14.00	10.00	-	23
31-May	5	39	4.50	19.50	16	4
Total	**144**	**1,812**	**69.00**	**171.00**	**65**	**141**

MSP Operations – May 27, 2021 (IMC)



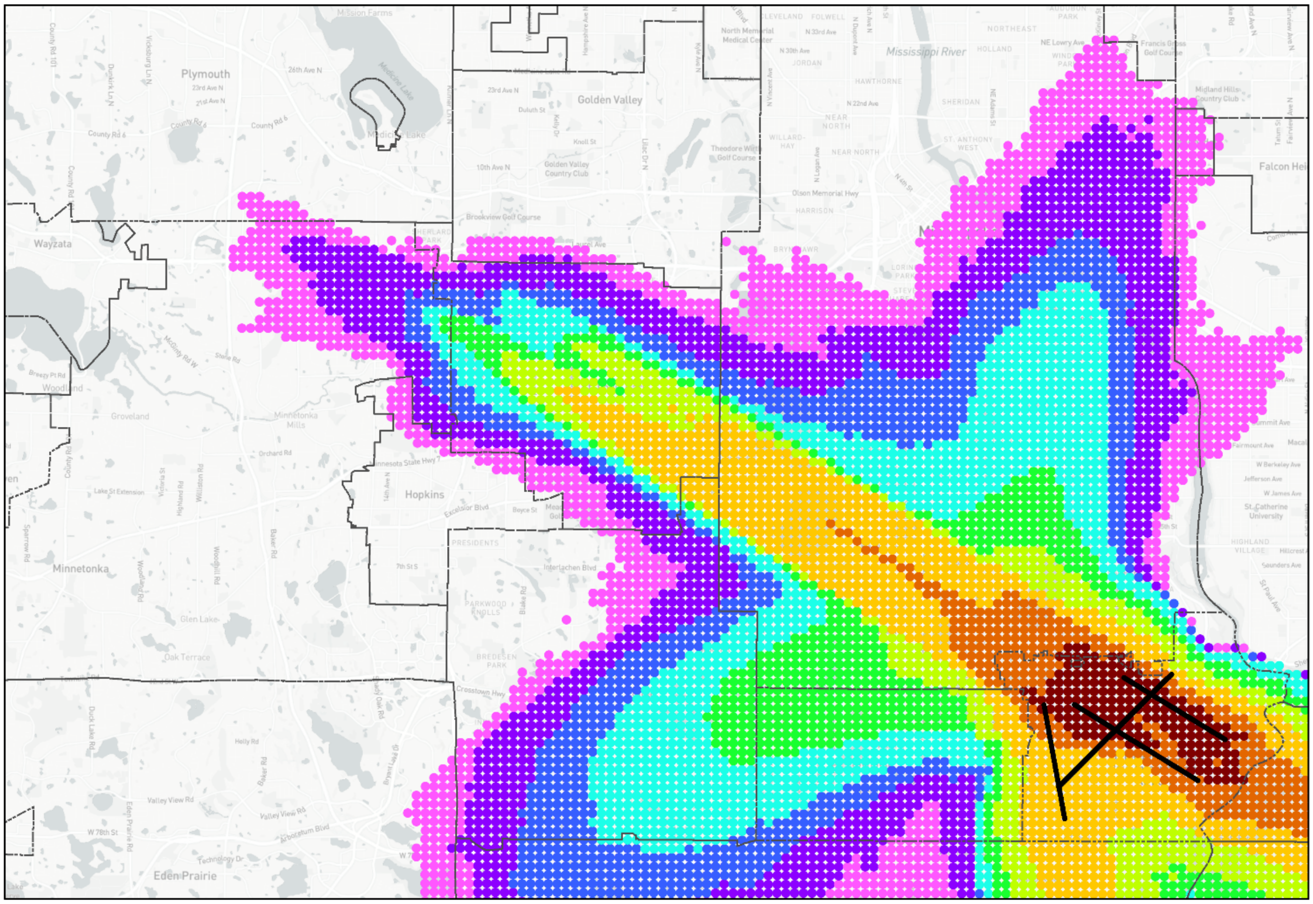
MSP Operations
May 27, 2021

MSP Operations – May 29, 2021 (VMC)



MSP Operations
May 29, 2021

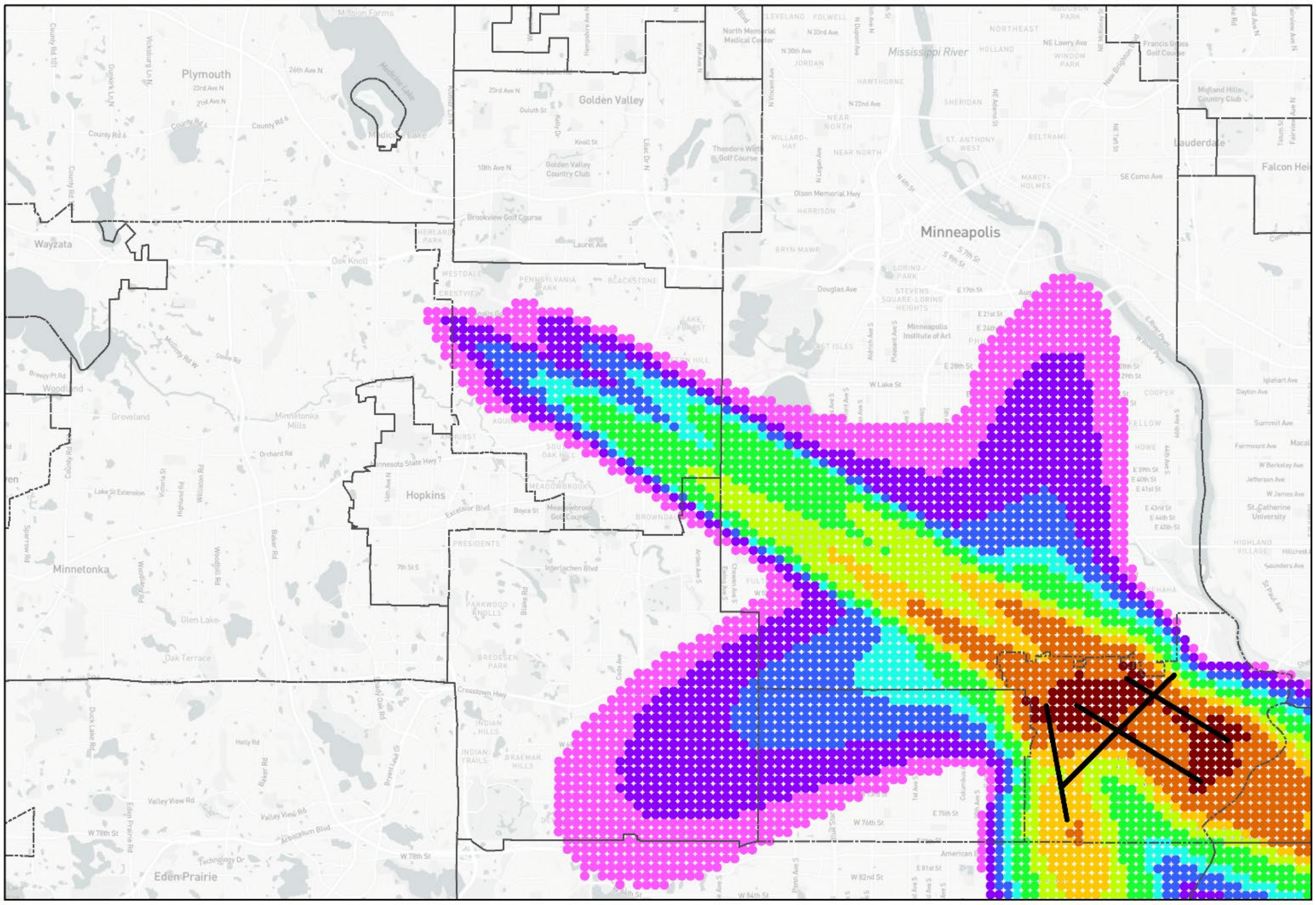
Modeled Sound Events – Number of Events Above 65dB



Modeled Events Above 65 dB

- < 1 per day
- 1 to 2 per day
- 2 to 5 per day
- 5 to 10 per day
- 10 to 25 per day
- 25 to 50 per day
- 50 to 100 per day
- 100 to 200 per day
- 200 to 300 per day
- > 300 per day

Modeled Sound Events – Time Above 65dB



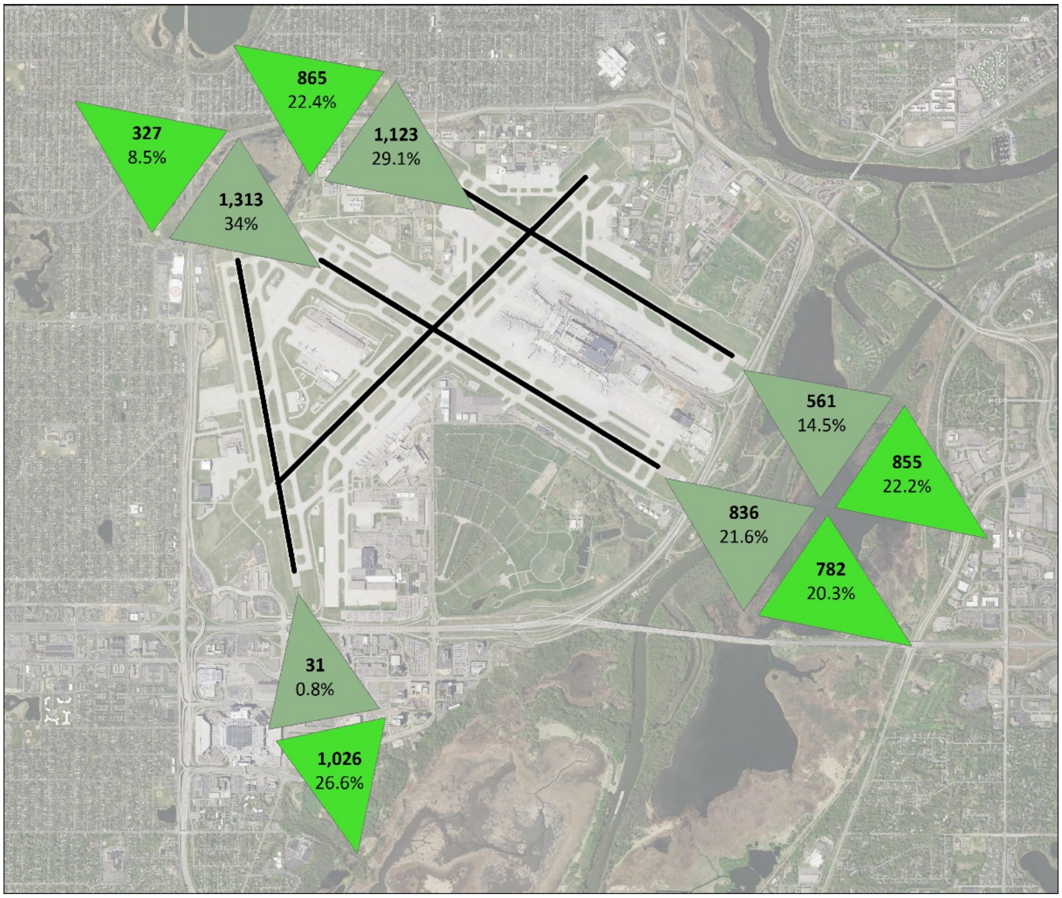
Modeled Time Above 65 dB

- < 1 min per day
- 1 to 2 min per day
- 2 to 5 min per day
- 5 to 10 min per day
- 10 to 15 min per day
- 15 to 30 min per day
- 30 to 45 min per day
- 45 to 60 min per day
- 1 to 2 hours per day
- > 2 hours per day

5 Appendix

5.1 Aircraft Operations

MSP Runway Use



Runway	Arrival Count	Arrival Percent	Departure Count	Departure Percent
4	-	-	-	-
12L	1,123	29.1%	855	22.2%
12R	1,313	34.0%	782	20.3%
17	-	-	1,026	26.6%
22	-	-	-	-
30L	836	21.6%	327	8.5%
30R	561	14.5%	865	22.4%
35	31	0.8%	-	-
Total	**3,864**	**100%**	**3,855**	**100%**

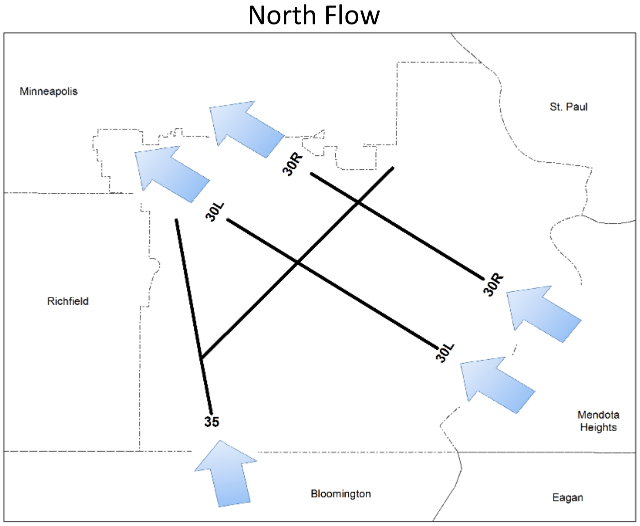
Airport Configuration (# of Hours by Day)

Day	Mixed A	Mixed B	North	Straight North	Opposite	South	Straight South	Unusual	Unlabeled	Total
22-May	2			3		6	10		1	22
23-May						8	15			23
24-May	6					7	6	1	2	22
25-May	2			13	2	1	4		1	23
26-May				18	4					22
27-May				1	1		19		1	22
28-May			1			13	7		2	23
29-May		1	3			12	6			22
30-May						13	10			23
31-May	7			9			4		1	21
Total	**17**	**1**	**4**	**44**	**7**	**60**	**81**	**1**	**8**	**223**

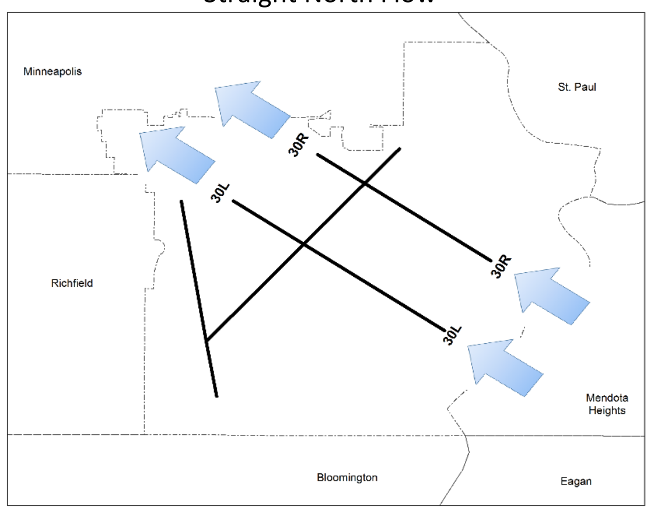
HOURS WITHOUT DATA MAY INCLUDE HOURS DURING CONFIGURATION TRANSITION OR HOURS WITHOUT OPERATIONS

Runway Use Airport Configurations

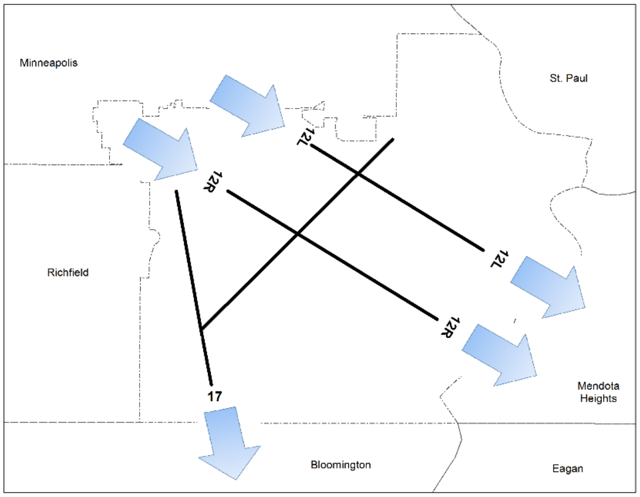
North Flow



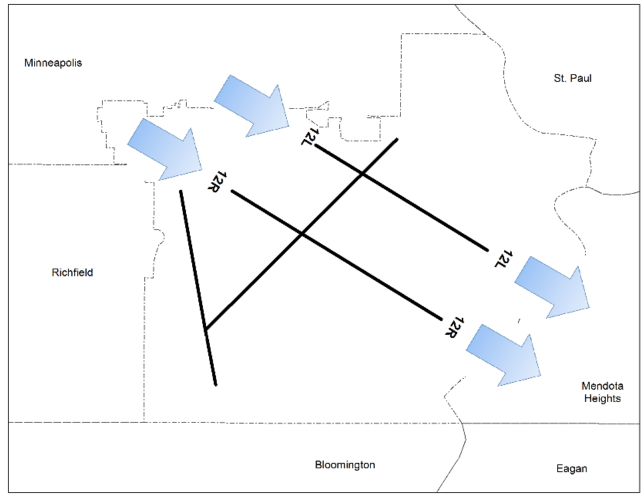
Straight North Flow



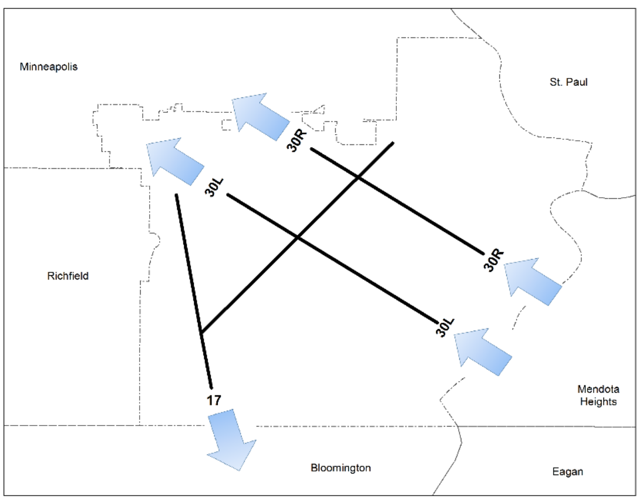
South Flow



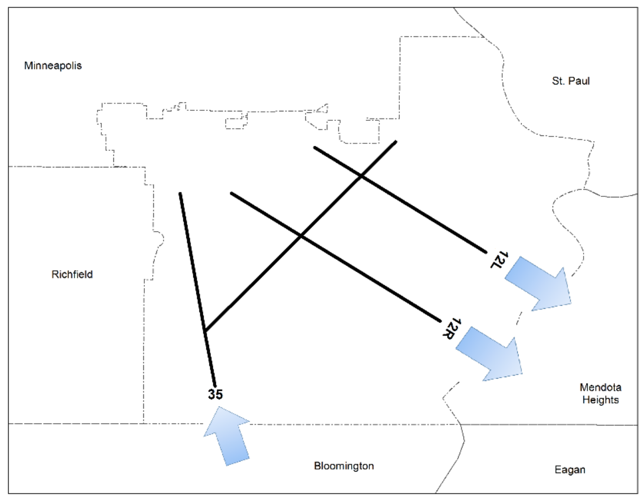
Straight South Flow



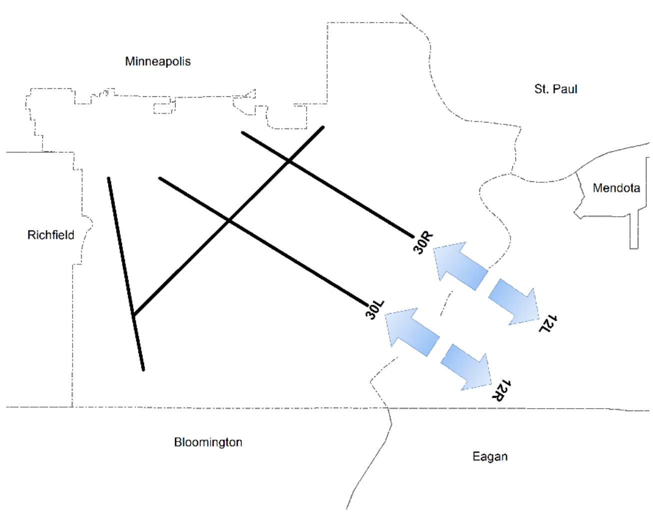
Mixed Flow A



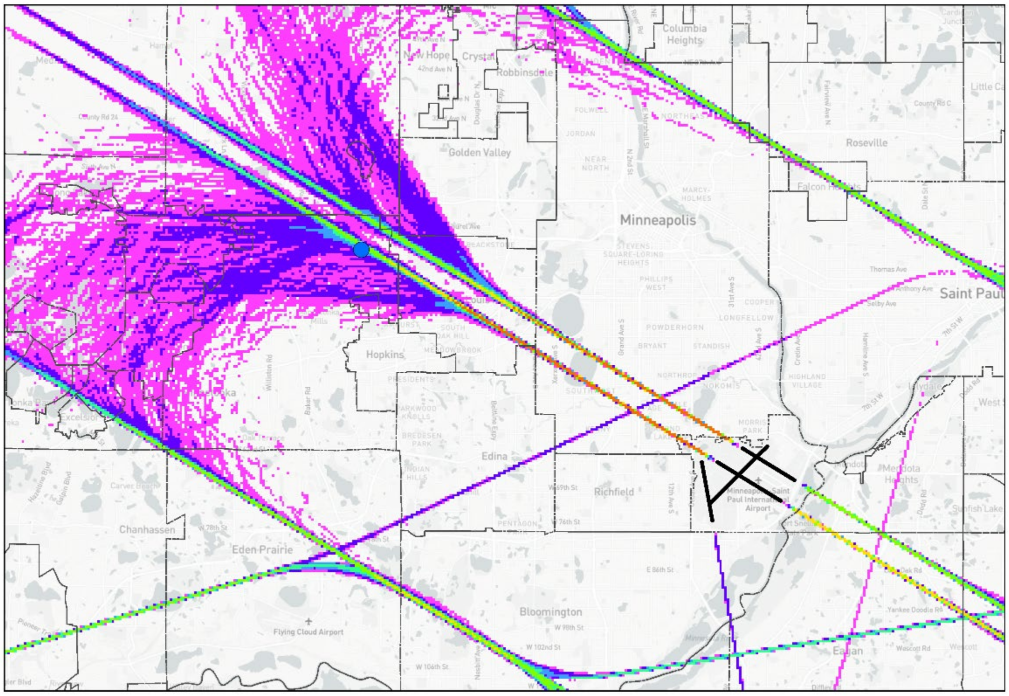
Mixed Flow B



Opposite Flow

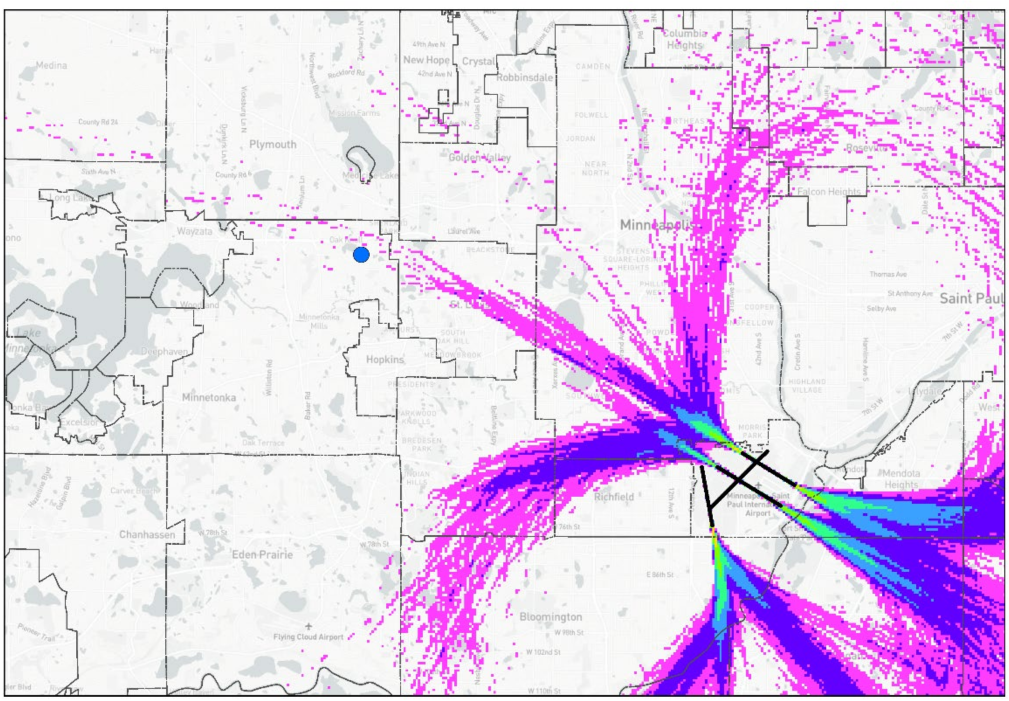


Density Maps



Low *High*

MSP Arrival Density
May 22 - May 31, 2021



Low *High*

MSP Departure Density
May 22 - May 31, 2021

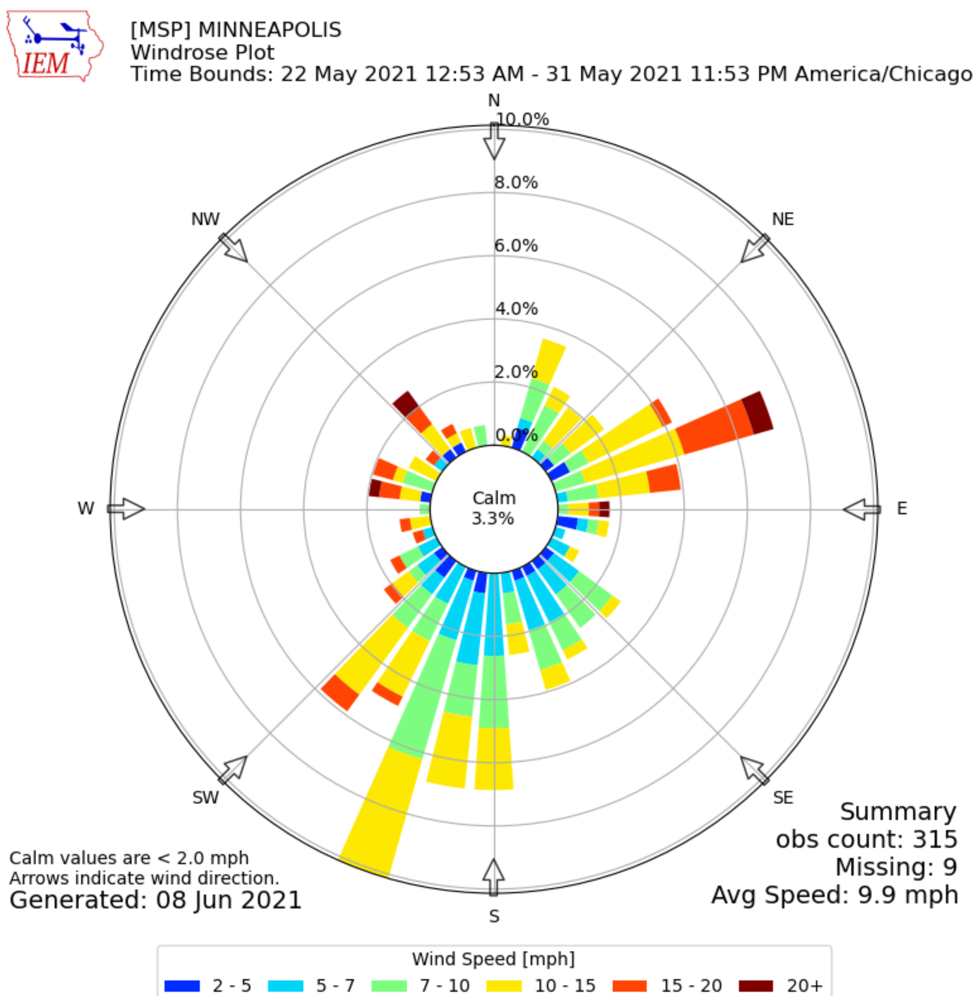
Top 10 Fleet Composition - MSP Operations During Study Period

Category	Aircraft Type	Operations
Regional Jet	Canadair CRJ-900	1,707
Regional Jet	Canadair CRJ-200	883
Narrowbody	Boeing 737-800	812
Narrowbody	Airbus A321	775
Narrowbody	Boeing 737-900	622
Narrowbody	Boeing 757-200	504
Narrowbody	Airbus A320	456
Regional Jet	Embraer E-170	347
Narrowbody	Airbus A319	343
Narrowbody	Airbus A220	223

5.2 Weather

Daily Observation – NOAA MSP Station

Date	Day	Low (f)	High (f)	Rain (in)	Max Wind Speed (mph)
5/22/2021	1	68	83	0.15	15
5/23/2021	2	66	78	-	14
5/24/2021	3	67	86	0.3	15
5/25/2021	4	64	86	0.43	22
5/26/2021	5	55	65	-	22
5/27/2021	6	42	56	0.09	23
5/28/2021	7	39	60	0.9	15
5/29/2021	8	43	65	-	13
5/30/2021	9	54	61	0.01	12
5/31/2021	10	52	77	-	13



5.3 GLOSSARY

Aircraft Operation

Aircraft arriving or departing from MSP, or an aircraft that performed both an arrival and departure.

A-Weighting

A-Weighting is a standard filter used by acoustic measurement devices and can be applied to acoustic measurements. It is frequency filter that attempts to emulate the way human hear.

Day-Night Level (DNL)

The FAA established DNL as the primary metric for aircraft noise analysis and expressing aircraft noise exposure in the United States. "DNL" is the acronym for Day-Night Average Sound Level, which represents the total accumulation of all sound energy, with a 10-decibel penalty applied for each sound event between 10:00 P.M. and 7:00 A.M. DNL has been widely accepted as the best available method to describe aircraft noise exposure and is the industry standard for use in aircraft noise exposure analyses and noise compatibility planning. It also has been identified by the U.S. Environmental Protection Agency as the principal metric for airport noise analyses.

Decibel (dB/dBA)

Sound levels are measured in Decibels, a logarithmic scale of energy referenced to human hearing. Sound levels are reported in dB; dBA is the Decibel value after the A-Weighting filter is applied.

LA_{eq} (Equivalent Sound Level) Equivalent sound level

The representation of a time-varying sound as an equivalent steady state A-weighted sound level for the period or interval of interest.

LA_{max} (Maximum A-weighted Sound Level)

This is maximum A-Weighted Sound Level observed for the period, event, or interval of interest.

LA_{90} (Sound Level Exceeded 90 Percent of the Time)

The LA90 is a common and typical method to estimate the background sound levels or sound levels seen most of the time. It is a statistical based metric which provides us with which A-Weighted sound level that is exceeded 90 percent of the time.

Number Above

The "Number Above", also referred to as N-level sound metric or Count Above, is the total number of aircraft sound events that exceeded a specified sound level threshold (LA_{max}). This report contains a count of departure events and arrival events recorded with field-measurement equipment when the maximum sound level of those events exceeds 65, 80, 90, and 100 dB levels.

SEL (Sound Exposure Level)

Sound Exposure Level is the total sound energy expressed in one second. Numerically, the energy is equivalent but allows for the comparison of sound events with varying durations.

Time Above Metric

The "Time Above" noise metric measures the total time or percentage of time that the A-weighted aircraft noise level exceeds an indicated level. Time Above data are summarized for arrival and departure events based on one-second intervals.