2014

Metropolitan Airports Commission

Noise Program Office

[MACNOMS VALIDATION STUDY]

The Metropolitan Airports Commission (MAC) owns and operates a Noise and Operations Monitoring network System (MACNOMS) that includes 39 Remote Monitoring Towers (RMTs) equipped with sound level meters/data-loggers, software that processes NextGen flight track data, and software that correlates noise events measured at the RMTs to actual flight tracks. This network is a complex system that is the backbone of the technology used by the MAC Noise Program Office for reports, maps, statistics, aircraft noise event tracking, the sound pressure level of events and the time and duration of an event reading. This study found strong correlation in noise-to-noise (0.9 dB), noise-to-track (92.1%), and operation-to-operation (97.1%) comparing field observations with the MACNOMS data outputs.

2014 MACNOMS Validation Study

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Introduction and Background

Periodically, the Metropolitan Airports Commission (MAC) conducts a validation analysis to ensure the data collected are representative of the conditions measured in the field. Prior to this report, the most recent validation study of the Metropolitan Airports Commission Noise and Operations System (MACNOMS) was done in 2006. Given community interest in airport noise issues, the Noise Oversight Committee (NOC) approved a 2014 Work Plan that included completing the MACNOMS Validation Study, as well as allowing for community representation and participation in the various steps and methods used for the analysis.

In 1992, the MAC Noise and Satellite Programs Office installed one of the most sophisticated and comprehensive Airport Noise and Operations Monitoring Systems (ANOMS) of its kind. This system became the central element of an evolving noise and airspace analysis program that has been used extensively for reporting and analyzing aircraft operations and related noise levels around Minneapolis-St. Paul International Airport (MSP).

In 1998, the Metropolitan Aircraft Sound Abatement Council (MASAC) focused on increasing the noise monitoring coverage of the Airport Noise and Monitoring System (ANOMS), predicated on existing runway geometry, existing initial system site installations, associated aircraft operational patterns, and the utilization of increased spatial analysis capabilities. At that time, 24 Remote Monitoring Towers (RMTs) had been installed and were collecting data on all sides of MSP. Following a thorough and analytical process, the RMT Location Task Force established the location of additional new sites via the use of objective data sets, which enhanced the noise monitoring system's ability to measure aircraft overflight noise impacts in residential areas surrounding MSP. As a result of analysis conducted by the RMT Location Task Force, five new RMTs were added in 1999, bringing the total number of sites to 29. Three of the five new RMT sites were located north and west of MSP.

In 2001, an additional 10 RMTs were added to coincide with development of a fourth runway (Runway 17/35) at MSP – three in Bloomington, two in Burnsville, one in Apple Valley and four in Eagan. With the addition of the 10 RMTs the former ANOMS system reached its present total configuration of 39 towers.

Limitations of ANOMS and newer technological options contributed to the MAC's interest in identifying new methods of collecting aircraft noise and flight tracking data. In 2009, the MAC moved from an off-the-shelf ANOMS product to downloading and processing flight tracks and noise data internally, which provided for increased reporting and analysis capabilities and an improved level of service to the community. The new MAC Noise and Operations Monitoring System (MACNOMS) was fully deployed by July 2009. At the time, MACNOMS was comprised of flight track data from a Multilateration (MLAT) system and 39 RMTs which provided noise data.

In November 2013, the MLAT flight tracking data source was replaced by a Next Gen data feed under a contract with the Exelis Corporation. The Next Gen data feed is the source for the flight tracking data currently used by MAC staff for noise-to-track matching, spatial analysis, monitoring aircraft operations counts, runway use percentages and to perform similarly detailed research and inquiries of the MACNOMS data. In brief, the use of Next Gen data represents the current state of the art with respect to flight tracking information provided by Exelis for activity within the National Airspace System.

Purpose of the MACNOMS

The MACNOMS is used continuously in the assessment of noise reduction measures and operational procedures at the airport. The components of MACNOMS allow for sophisticated noise and operations data analysis and provide an objective tool for assessing airspace use and noise impacts. Each month, MAC staff assesses and reports the collected noise and operations information in the monthly reports that are made available to the public.

MAC staff uses the MACNOMS for such detailed analysis because of its capability to correlate data sets taken from two different sources. The Exelis data feed correlation functions match aircraft flight tracks with information specific to the operation, such as aircraft type and flight number. The MACNOMS system correlates this information with noise levels recorded by the Remote Monitoring Towers. The resulting information provides an accurate flight track displayed on a geo-referenced map with specific flight information and the noise levels generated by the aircraft around the airport at the noise monitoring sites.

The MACNOMS data are used to monitor compliance with approved noise abatement procedures at MSP as well as at the MAC's system of reliever airports. The MACNOMS was also used in the compatible land use analysis and the noise impact chapters of the MSP 2020 Improvements Environmental Assessment (EA)/Environmental Assessment Worksheet (EAW).

System Architecture

Noise Data

The noise data associated with MSP are collected by a series of 39 RMTs that have been placed strategically around MSP. Each site consists of laboratory-quality noise monitoring equipment manufactured by Larson Davis Incorporated (LD). The main components making up each RMT consist of a Type I LD 831 noise analyzer, an LD 426A12 preamplifier and an LD 2541 microphone. This equipment undergoes annual calibration and certification by an independent accredited laboratory.

The analyzer in each RMT monitors noise levels continuously, utilizing slow response with A-weighting as directed by the FAA's 14 CFR Part 150. The analyzer is set to record an event when the sound pressure level (SPL) reaches 65dBA and remains at or above this level for at least eight seconds. These recorded events are then later correlated with radar flight track data to

determine whether the noise source was a specific aircraft event or a community event. Each noise event and the associated information are stored in the individual RMT until it is transferred into the MACNOMS on a nightly basis. The analyzer also provides hourly and daily data.

Each night, the MACNOMS dials in to each RMT automatically through a modem connection. Once a connection is established, various checks are performed to ensure the monitors are functioning adequately, and the data associated with the noise events are downloaded and imported into the MACNOMS. Information about the status of the RMTs is also downloaded and imported into the MACNOMS allowing MAC staff to perform daily checks to ensure the integrity of both the monitors and the noise data they collect.

Flight Track Data

The Exelis NextGen Data are a multi-sensor based surveillance fused data feed available for the National Airspace System. The NextGen data feed contains Automatic Dependent Surveillance-Broadcast (ADS-B) data derived directly from the national ADS-B Network owned by Exelis, and U.S. government-sourced data including but not limited to: FAA en route and terminal secondary surveillance data, airport surface surveillance data from the FAA Airport Surface Detection Equipment Model X (ASDE-X), Wide Area Multilateration (WAM) from the FAA deployed WAM systems, and flight plan data from the FAA host system.

Data processing

Noise Data

Noise data are processed in a number of ways, resulting in the calculation of metrics that indicate the community- and aircraft-generated noise levels in the vicinity of an RMT. However, before these calculations can be performed, noise events generated by aircraft must be distinguished from non-aircraft events that are generated within the community. The function within the MACNOMS that makes this distinction possible is called “noise-to-track matching”.

The noise-to-track function defines the source of noise events by analyzing the aircraft activity in the vicinity of an RMT at the time the event was recorded. These two variables, time and distance from the RMT, are crucial to defining the noise source accurately.

The primary way in which the noise-to-track function matches a noise event with the noise source is by analyzing the time the event occurred. If an aircraft is operating in the vicinity of a RMT at the same time a noise event is generated, it is possible the aircraft could have been the source that generated the event. However, such a generalization would lead to noise events being attributed to aircraft operating at distances beyond the audible coverage area of an RMT. Therefore, parameters restricting the distance an aircraft can be from an RMT and still be considered to have caused the noise event must be defined.

Within the MACNOMS each RMT is assigned a coverage area that is a function of the capabilities of the monitor, the geometric nature of flight tracks in the area, and the geography of the surrounding land. This area is referred to as the Area of Influence, and is used in the filtering of aircraft operating at the same time a noise event is generated. The Area of Influence filter provides the noise-to-track function with the capability to determine whether an aircraft could be responsible for the noise that caused a noise event.

In the event the noise source is determined to be an aircraft, the noise data recorded by the RMT are matched to that aircraft and calculated to determine noise values and metrics relative to aircraft operations. There are instances, however, when the noise data matched to the aircraft have been influenced by one or more other noise sources. Such instances occur when multiple aircraft are operating in the vicinity of an RMT and contributing to the same noise event, or when a community noise source is contributing to or causing a noise event when an aircraft is operating within an RMT's Area of Influence.

Because scenarios such as the ones described above exist, parameters within the noise-to-track function and the RMTs are defined to minimize the probability that noise data are matched to an incorrect noise source. The simplest restriction that prevents the matching of incorrect data is that of the noise event parameter within the RMT itself. For a noise event to be considered a prospective aircraft noise event the level at a specific RMT site must reach 65 dB and remain at or above 65 dB for at least eight seconds. The significance of the 65 dB threshold is that normal urban areas surrounding major airports such as MSP have community noise events that reach an L_{Max} of 65 dB regularly, affecting normal speech communication. As such, aircraft noise events do not begin to affect metropolitan urban life significantly below 65 dB. The threshold provides a necessary function to filter erroneous community noise.

The situation becomes more complicated, however, when a noise source does generate a noise event while one or more aircraft are flying through an RMT's Area of Influence. In the event that two aircraft are flying through the Area of Influence at the same time a noise event is generated, the noise-to-track function is programmed to refer to a static database[1] of predetermined aircraft noise values to determine which aircraft most likely generated the event.

However, it is possible the noise source generating the event was not an aircraft, but rather a source in the community. When a noise event is generated from a source in the community and there are no aircraft operating in an RMT's Area of Influence, the noise data associated with the event are attributed to a source within the community. In some cases, when an aircraft is operating in the Area of Influence at the time of the community-generated event, the noise data associated with the event can be attributed to the aircraft.

[1] The database referred to contains average noise values of aircraft that have been determined and published under the auspices of Federal Aviation Regulation Part 36.

Flight Track Data

Flight Track Data are the four-dimensional positional information of an aircraft (X/Y/Z and a time value for where the point is along the track line). The Exelis Next Gen data feed used by the MACNOMS flight track data processing includes, enroute radar, terminal secondary surveillance data, Airport Surface Detection Equipment Model X (ASDE-X), and Automatic Dependent Surveillance-Broadcast (ADS-B) data. The ASDE-X data are a new feature of the Next Gen data and are used to track movements of aircraft and vehicles on the airport surface movement area and from aircraft transponders. The ADS-B is a satellite-based geographical positioning system (GPS) that is intended to replace radar-based positioning systems within the National Airspace System in the future.

Next Gen data used by the MACNOMS are considered "near" real-time. There is a 20-minute delay of actual aircraft operations loaded into the data feed for public applications. The Next Gen data feed includes the unique flight identifier, a time stamp, a message type (flight start, amended, flight end), the flight ID number, the aircraft's call sign, aircraft type, latitude, longitude, altitude, heading, airspeed, secondary surveillance radar Mode3/A (aircraft within the range of the radar signal), the particular radar/satellite tracking source used, the aircraft category (unknown, light, small, large, heavy, rotorcraft or other), the filed flight route, the departure fix, and alerts (such as radio failure or emergency).

The data coming from the Exelis NextGen data feed consist of the real-time data feed and a nightly file download. The real-time data are broadcast from external servers at Exelis over a secure connection fed into the database and displayed on the macnoise.com website FlightTracker application with a 20-minute delay. The nightly file download provides complete flight track data from the previous 24 hours, delivered through a secure file transfer protocol and imported into the MACNOMS database each morning. The flight tracks from the nightly data file are then correlated with noise data downloaded from the MAC's system of RMTs located in the communities surrounding MSP.

Data Checks

Following the nightly import of the aircraft noise data from the RMTs a check of the data completeness and accuracy is conducted by MAC staff. On occasion, an interruption of the RMT data collection due to hardware and connection outages can occur, as was the case in May 2014 when an RMT was struck by lightning and a phone modem had to be replaced. It is rare for RMT data to be unrecoverable, as each meter stores the noise data measured, which can be downloaded manually.

MACNOMS Functionality

MACNOMS data are the backbone of many of the Noise Program Office's mission-critical functions such as interactive flight tracking, RMT noise levels for a single flight track, and customized user-defined data retrieval inquiries under the "Reports on the Fly" link at

www.macnoise.com. The MACNOMS data can be queried to provide: counts of all aircraft and carrier jet operations by runway and runway percentage of use, nighttime counts of all aircraft and jet carrier operations by runway and runway percentage of use, aircraft type counts, aircraft noise events summaries by aircraft type, and the daily noise event summary for a specific RMT. Many of these inquiries can be retrieved from the MACNOMS data base going back to the year 2001.

Data Publishing

Other MACNOMS data processes tag aircraft events to specific airports and runways, record runway use, determine compliance with noise abatement procedures, and calculate noise impacts with various metrics such as Day-Night Average Sound Level (DNL), Time Above, and Number of Events Above.

The MACNOMS data and tools have proven to be valuable for investigating specific aircraft operations and associated noise. MAC Noise Program Office staff are able to analyze flight data and aircraft noise to identify trends, view activity for specific locations, research runway use and fleet mix information, and to conduct sophisticated modeling and analyses associated with environmental assessments, planning studies, and aircraft flight procedure monitoring and development.

Many of the MACNOMS data described above are published in the Monthly Technical Advisor's Report, the Eagan-Mendota Heights Corridor Report, the Runway 17 Departure Analysis Report and the Crossing in the Corridor Analysis. These reports are posted under the "Tools and Reports" drop down menu at www.macnoise.com.

Tools

MAC Noise Program Office staff are able to retrieve and investigate noise complaints, and track aircraft noise complaint trends through a specialized web-based application called Aircraft Noise Complaint and Communications Record System (ANCCRS). ANCCRS provides MAC staff with a comprehensive suite of internally-used noise complaint investigation tools. Complaint details and communication records are stored for each address recorded. The ANCCRS mapping function integrates spatial flight track and geographical complaint location information and displays weather, flight activity, aircraft noise events and documented aircraft maintenance run-ups that occurred during the reported complaint date and time. ANCCRS will also display other complaint locations if there are any that were filed during the reported time period. ANCCRS uses the MACNOMS data as the primary source for these analytical, mapping, and technical outputs.

Supplemental MACNOMS Technology, Software, and Infrastructure

The MACNOMS system incorporates a wide variety of software technology and applications in the processing of the RMT and Exelis Next Gen data. Programming languages include: Python,

Structured Query Language (SQL), JavaScript, PHP, R-Programming Language, Shell Script, JavaScript Object Notation (JSON), and Comma Separated Variables (CSV).

Software includes: Apache Web Server, MapServer, GeoServer, ESRI ArcGIS, the CRON scheduling utility, Github, pgAdmin, Putty, and "NextGen" (a series of related Python scripts developed by the MAC for processing data provided by Exelis).

Additional computer infrastructure includes: Data Base Servers, Linux Operating Systems and a Storage Area Network.

The technology, software, and infrastructure of the MACNOMS are supported by up to 10 computer servers.

Previous MACNOMS Validation Reports and Results

Periodically, the MACNOMS is tested to verify that it continues to meet a high standard of accuracy. The validation of the MACNOMS accuracy is prudent since it is relied upon daily for analysis of noise issues around the Twin Cities metropolitan area.

Evaluating the accuracy of the data extracted from the MACNOMS requires evaluation of the accuracy of the data-processing functions. To record and match the data associated with the MACNOMS noise-to-track function independently, MAC staff recorded noise events in close proximity to the RMTs. By working in the vicinity of an RMT with an independent noise monitor, staff was able to determine visually and aurally, and record, the sources that were creating the noise events.

In the 2001 and 2004 studies, MAC staff spent several days at RMT sites around the MSP working with an independent noise monitor and recording visually and making an aural determination of the actual noise sources that were creating the noise events (both aircraft and community events). The data collected in the field were processed independently and compared to the actual data extracted from the ANOMS for the same time period to determine the accuracy of the ANOMS noise-to-track function and the validity of the calculated noise values and metrics. In addition, several days were spent in the Air Traffic Control Tower (ATCT) collecting independent data in order to analyze the aircraft flight track and specific information processing functions within the ANOMS. Staff utilized the vantage point of the air traffic control tower to record the approximate start or stop time of actual aircraft operations and the specific information of each aircraft operation (aircraft type, airline, runway, and arrival/departure). This information was then compared to actual aircraft-specific information from the ANOMS to determine the accuracy of the aircraft radar flight track data and the aircraft-specific information processing functions within the ANOMS.

In the summer of 2001, MAC staff collected both sets of data (RMT noise data and ATCT operations data) simultaneously over a three-day period. Approximately 39.7 hours of monitoring was conducted in the ATCT, and approximately 48.2 hours of monitoring at the RMT

sites was performed. During this study, over 13 different RMT sites were used in the community monitoring.

In the summer of 2004, MAC staff collected the same data over a three-day period. During that time approximately 36 hours of monitoring in the ATCT, and approximately 29 hours of monitoring at RMT sites was performed. Seven different RMT sites were used in the community monitoring.

In 2005, MAC Noise Program Office staff decided to expand the scope of the ANOMS validation study to more thoroughly assess the accuracy of the data extracted from ANOMS and to identify any possible areas or situations that may need to be monitored, enhanced or further investigated. To accomplish this, the Noise Program Office employed a full-time noise monitoring position for the months of June, July and August 2005. A total 218 hours of noise monitoring was conducted at the 39 RMT sites and a total of 82 hours of monitoring was conducted in the ATCT.

The results for all three studies were similar. For the 2005 study, 95.9% of the observed operations from the ATCT correlated with ANOMS (flight track and specific information) and 94.3% of the total number of noise events observed at the RMT sites correlated with ANOMS (aircraft noise event information). For the 2004 study, 96.8% of the observed operations from the ATCT and 89.1% of the total number of noise events observed at the RMT sites correlated with ANOMS. In 2001, 97.8% of the observed operations from the ATCT and 90.9% of the total number of noise events observed at the RMT sites correlated with ANOMS.

Validation Methodology

Noise Data

2014 RMT Selection Criteria

Due to limited staffing resources, MAC staff determined that, in field validation tests, not all of the 39 RMTs could be monitored. The following criteria were used to establish the list of candidate RMT sites:

1. The RMT location must be easily accessible and have sufficient space to accommodate MAC staff and a team of observers.
2. Where multiple RMTs exist in a community, selection should be based upon the frequency of events and the proximity of flight tracks, and the location should be subjected to departure operations, arrival operations, or both.

Based on these criteria, the following eight RMT sites were included in this study:

Table 1

RMT #	Location
28	Richfield 6645 16th Ave. S.
27	Minneapolis Anthony School 5757 Irving Ave. S.
5	Minneapolis 12th Ave. & 58th St.
30	Bloomington 8715 River Ridge Rd.
23	Mendota Heights End of Kenndon Ave.
16	Eagan Avalon Ave. & Vilas Ln.
36	Apple Valley Briar Oaks & Scout Pond
33	Burnsville North River Hills Park

Field Testing Methods

Field monitoring was conducted at each individual RMT site to compile data for an Observation Log matrix as shown below.

Table 2

	Observation Log Details
✓	Event Date
✓	Start Time of Event
✓	End Time of Event
✓	LMAX
✓	Aircraft Type or Description of Community Noise Source
✓	Arrival or Departure
✓	Runway
✓	RMT
✓	Comments about the Event
✓	Observation Notes to include: ▪ Date of Observation ▪ Start Time of Monitoring Period ▪ Stop Time of Monitoring Period ▪ RMT ▪ Arrival/Departure ▪ Temp (At Site) ▪ Relative Humidity (At Site) ▪ Wind Direction (At Site) ▪ Wind Speed (At Site) ▪ Meter Serial #

- Calibrator Serial #
- Pre Cal Check/Change Level
- Post Cal Check Level
- Pre Ambient
- Post Ambient
- Observer Names

Upon completion of the field data collection, the field computer entries and the sound level meter data were downloaded into a software spreadsheet application for additional data comparison and analysis with the noise event and flight tracking data recorded independently by the MACNOMS for the same time period.

For the purpose of comparing the noise data, two parameters were established. First, MAC staff recorded the L_{Max} sound level of the flight as captured by the portable sound level meter (a Model LD 824 Type I) for comparison with the MACNOMS L_{Max} sound level recorded by the sound level meter on the RMT tower (LD 831 Type I). Second, the portable sound level meter was programmed manually to recognize a noise signal greater than a threshold of 65 decibels lasting at a level greater than 63 decibels for eight consecutive seconds as a possible "aircraft noise event". The second parameter is identical to the "aircraft noise event" programmed for the permanent sound level meters placed on the 39 RMTs. There are, however, community noise events such as loud vehicles that can generate noise events that meet the aircraft noise event threshold described in the second parameter. Therefore, matching the noise event to an aircraft track provides a secondary check that the noise event may have been caused by an aircraft.

Table 3 provides the date, times, duration, and pre/post ambient sound levels during the field observation in 2014.

Table 3

Date	Start	Stop	Duration	RMT	A/D	Pre/Post Ambient	Runway
4/7/2014	9:12:44	10:46:31	1:33:47	23	A	54/52	30R
4/7/2014	13:44:00	15:02:36	1:18:36	36	A	52/57	35
4/10/2014	12:55:09	14:59:01	2:03:52	30	A	64/54	35
4/11/2014	13:43:40	15:08:29	1:24:49	5	D	45/48	30L/R
4/14/2014	9:25:52	11:27:38	2:01:46	28	D	55/53	30L/R
4/15/2014	12:31:44	14:38:01	2:06:17	27	D	43/49	30L/R
4/15/2014	8:45:59	10:51:14	2:05:15	23	D	57/52	12L
4/15/2014	13:57:43	15:29:54	1:32:11	5	A	55/55	12R
4/17/2014	9:29:45	11:02:29	1:32:45	16	A	56/54	30L/R
4/21/2014	9:48:00	11:48:31	2:00:31	33	A	45/48	35
4/21/2014	13:33:56	15:03:40	1:29:44	30	A	54/58	35
4/22/2014	9:56:07	11:05:52	1:09:45	36	A	57/57	35
4/22/2014	12:23:14	14:30:35	2:07:21	27	D	45/48	30L/R
Total Duration			**22:26:37**				

Note: the pre-ambient of 64 at RMT 30 on 4/10/14 was caused by high wind speeds during the observation period.

Sound Level Meter Event Detection

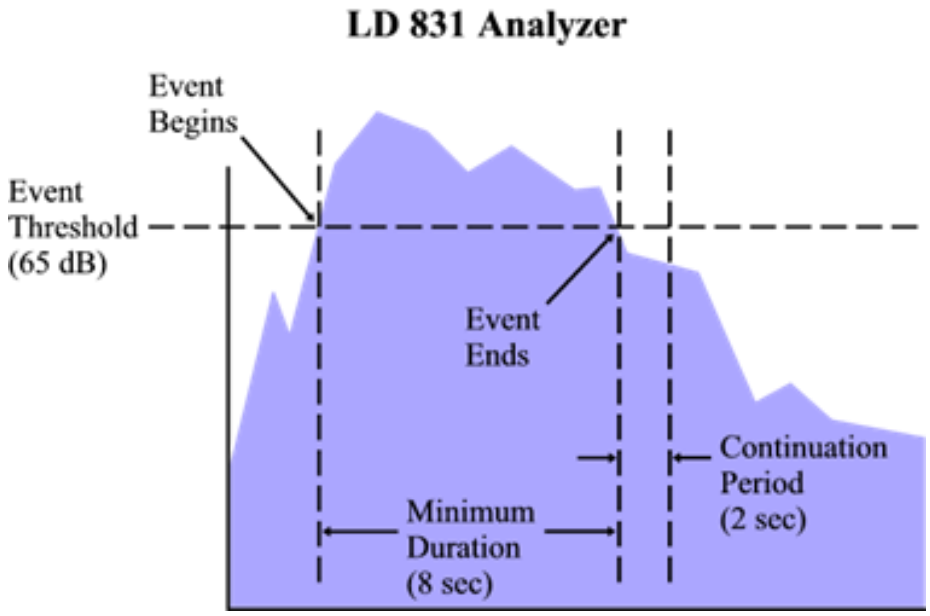
Transient noise events do not always begin or end abruptly. Both the LD 824 and the LD 831 sound level meters have a method to continue the measurement of an event as it is ending to avoid losing data and to eliminate multiple records for a single event.

The portable sound level meter LD 824 logged an event when the sound pressure level exceeded 65 dB and remained above 63 dB for more than eight seconds. The event detection was defined by three basic parameters: a threshold level (65 dB), a minimum duration (8 sec.), and hysteresis (2 dB).

The permanent sound level meter, LD 831, while using the same parameters for event counting, has an improved method of detection for event history. Rather than utilizing a hysteresis of the sound pressure level to define how an event ends, a user-definable continuation period is employed. The continuation period defines how long the analyzer will wait after the threshold level is no longer exceeded to ensure that the sound pressure level does not re-exceed the threshold level. The threshold and minimum duration parameters remain the same as the portable sound level meters.

To recap, the new analyzers log an event when the sound pressure level exceeds 65 dB and remains above 65 dB for at least eight seconds. When the sound pressure level no longer exceeds the threshold the continuation period begins. If within that time the sound pressure level re-exceeds the threshold, then the event continues; if not it ends when the sound pressure level drops below 65 dB.

Figure 1



L_{Max} Comparison

The Maximum A-Weighted Sound Level, L_{Max}, measures the highest root mean square sound level that occurs during a single event in which sound level varies with time. The L_{Max} metric can be used to describe a single aircraft noise event and is measured in decibels. During the field measurement data collection, the portable sound level meter L_{Max} was captured after the sound level reached 65 decibels for eight seconds during an aircraft operation. These L_{Max} levels were then compared to the sound level captured by the sound level meter on the RMT for the same event at the same time by querying the MACNOMS database. The results of the comparison are shown in Table 4.

Table 4

RMT#	Events	Over	Under	AVE
5	61	1.5	-1.8	0.8
16	30	1.1	-0.8	0.5
23	36	3.8	-1.4	1.1
27	15	2.1	-1.5	1.1
28	17	3.4	-1.5	1.0
30	11	1.7	-1.3	0.6
36	27	1.4	-2.3	1.0
Total	197			0.9

Note: The Over value represents the maximum variation when the portable sound level meter reading was above the RMT sound level reading for all of the events recorded at the specific RMT. The Under value represents the

maximum variation when the portable sound level meter reading was below the RMT sound level reading for all of the events recorded at the specific RMT. The average (AVE) is the absolute value of both the Over and Under variations

The close agreement in the L_{Max} average levels is consistent with acoustical performance levels for laboratory grade Type I sound level meters. While it is rare for two sound level meters to give exactly identical readings when placed side by side and exposed to a variable noise source (such as an aircraft overflight), average agreement within 0.9 of a decibel is the result of the precision of the sound level meters, which are calibrated annually by the manufacturer and by MAC staff as needed. In addition, early every morning, each RMT performs an automated calibration check. This calibration check utilizes an electrostatic actuator mounted on the RMT's microphone to generate a precision level. This daily level is then checked against an established reference level to determine changes in the system's calibration, whether in the microphone, instrumentation, cabling or the electrostatic actuator itself.

There was one event at RMT 23 for which the portable sound level meter and the RMT sound level meter varied by 3.8 decibels. A review of the field observation log during the events determined that community noise (a truck) was the cause of the measured variance. Similarly, there was one event at RMT 28 for which the portable sound level meter and the RMT sound level meter varied by 3.4 decibels. A review of the field observation log during the events determined that community noise (a motor vehicle braking) was the cause of the measured variance. These two events had the greatest variance of the 197 events examined.

When community noise and aircraft noise are present simultaneously at an RMT, the L_{Max} of the louder of the two sources is recorded in the MACNOMS. Therefore, there may be a small number of instances in the MACNOMS where the L_{Max} attributed to the aircraft flight is slightly greater than that generated by the flight itself, due to the community noise that occurred at the same time.

Flight Tracks

Airfield operation observations took place at the MSP Orange Parking Ramp, located next Terminal 2 – Humphrey—one of the tallest structures on the MSP campus with a height of 979 feet above sea level. The top of the Orange Parking Ramp offers good sightlines to Runway 4/22, Runway 17/35 and Runway 30L/12R. Views of Runway 30R/12L are acceptable for the observation purposes of the 2014 MACNOMS Validation Study.

Airfield Observation Methods

Observations were taken during normal MAC business hours on April 23-25, 2014 for a total of 8 hours and 29 minutes. Table 5 shows the documented dates and times of airfield operation observations.

Table 5

Orange Ramp Field Observation Duration Summary			
Date	Start Time	Stop Time	Duration
4/23/2014	10:12:20	11:33:11	1:20:51
4/23/2014	12:37:14	13:07:30	0:30:16
4/24/2014	12:22:21	13:48:42	1:26:21
4/24/2014	14:05:58	15:24:36	1:18:37
4/25/2014	10:03:54	11:54:08	1:50:14
4/25/2014	13:09:24	15:12:42	2:03:18
Total			8:29:37

MAC staff visually observed each aircraft operation and recorded the following information for each operation: date, time of operation, aircraft type, runway, arrival or departure.

During the documented airfield operation observation periods there were a total of 649 operations: 283 arrivals and 366 departures. Table 6 shows the number of operations documented for each runway.

Table 6

Count of Observations by Runway							
Date	**17**	**35**	**12L**	**12R**	**30L**	**30R**	**Grand Total**
Arrivals		57	73	83	25	45	283
4/23/2014			25	33			58
4/24/2014			48	50			98
4/25/2014		57			25	45	127
Departures	104		61	5	118	78	366
4/23/2014	42		20	2			64
4/24/2014	62		41	3			106
4/25/2014					118	78	196
Grand Total	**104**	**57**	**134**	**88**	**143**	**123**	**649**

Note: There were no aircraft observations for Runway 4/22 during the observation period.

The observed data were compared to actual data from the MACNOMS for the same period to determine the accuracy of the MACNOMS flight track information.

Table 7

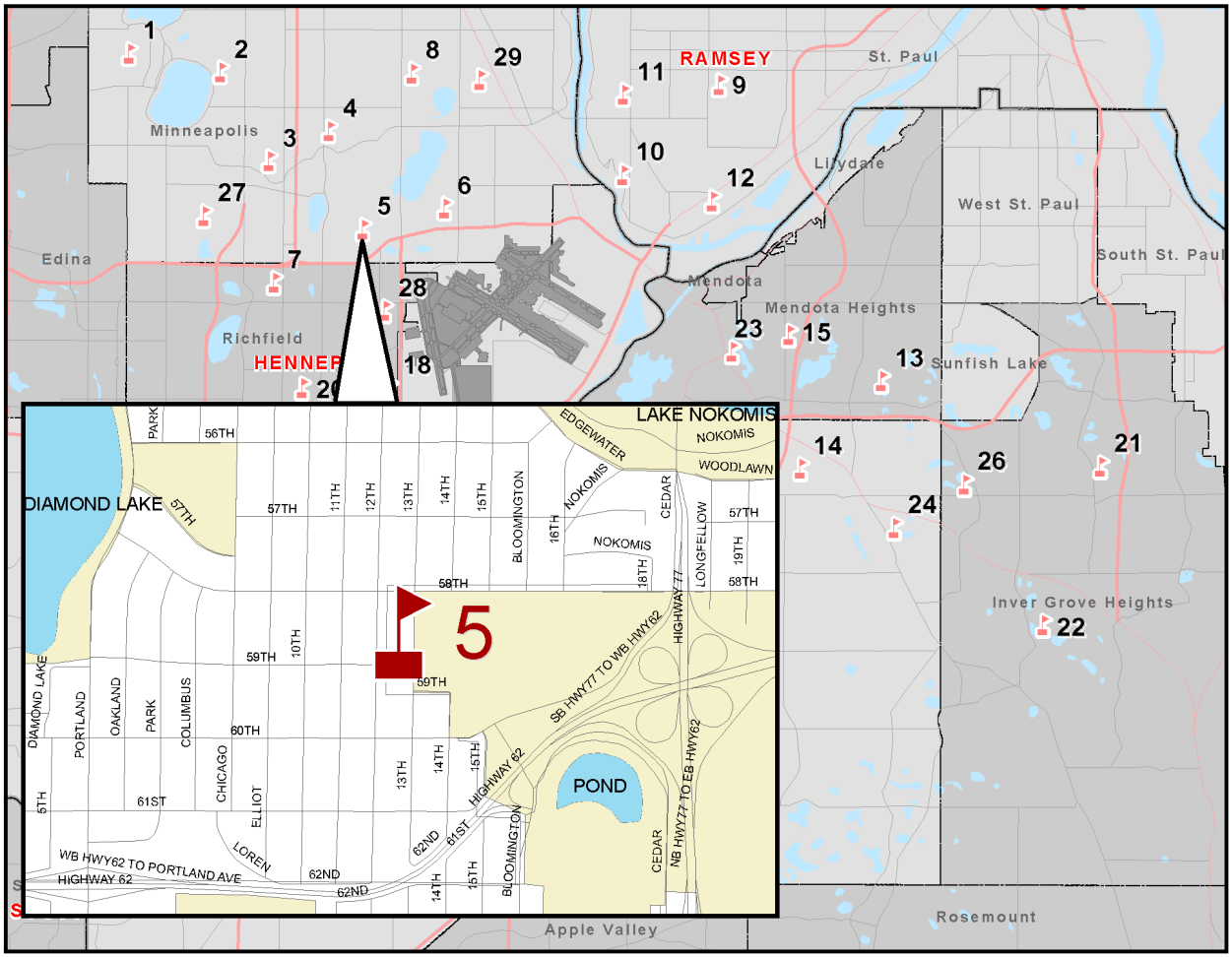
Date	Number of Operations Observed	Observations that matched MACNOMS	Observations that did not match MACNOMS	% correlation =observed/ MACNOMS
4/23/2014	122	118	4	96.7%
4/24/2014	204	199	5	97.5%
4/25/2014	323	313	10	96.9%
Totals	649	630	19	97.1 % ave.

Note: Several of the observations that did not match the MACNOMS were military flights that, generally, are not included in the Exelis Next Gen data feed.

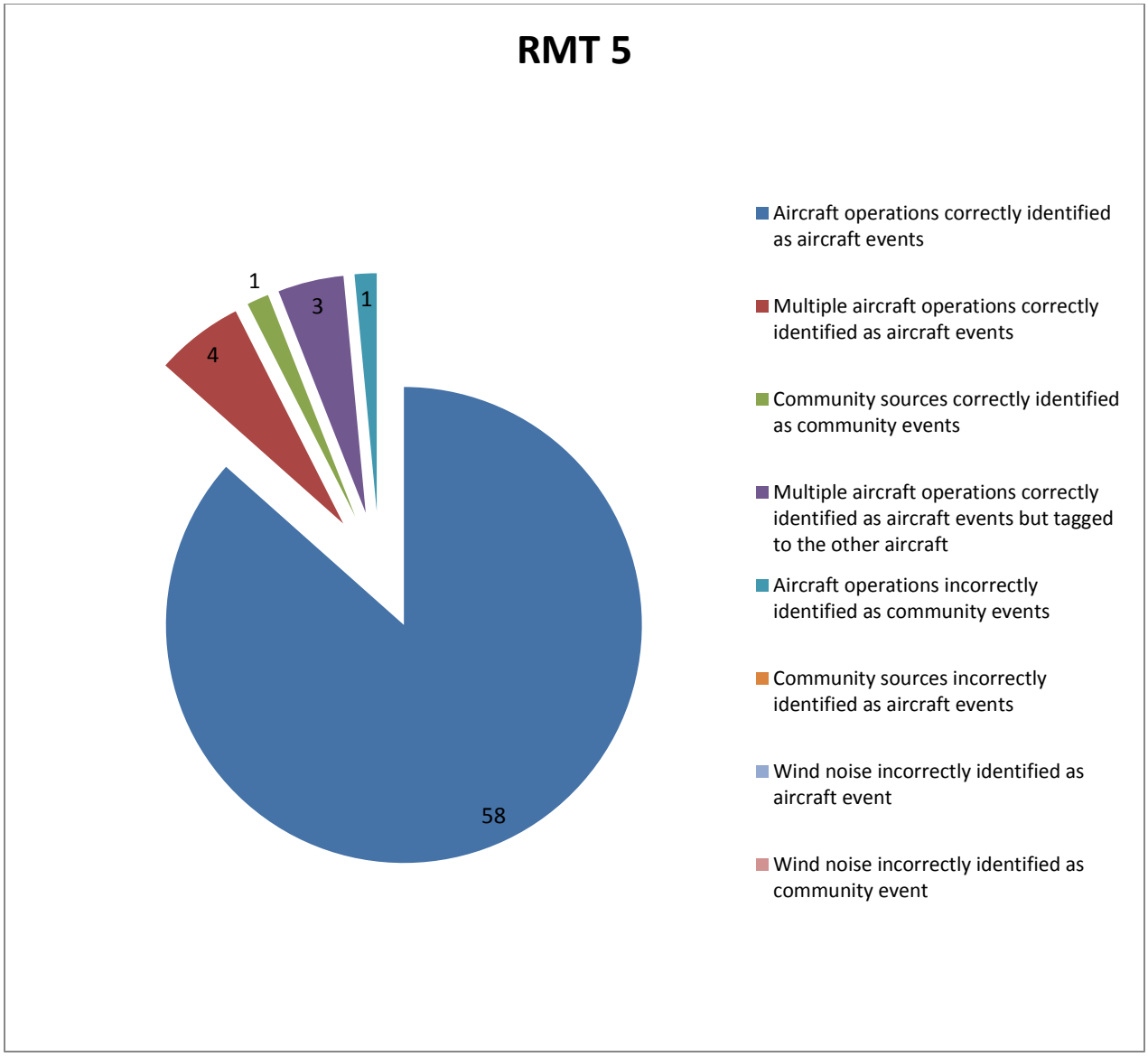
MACNOMS/Observed Correlation

The findings from the observed operations at each RMT site were compared to the noise data that were obtained from the MACNOMS for the same monitoring period. Each observed noise event was compared to the actual MACNOMS data for the same monitoring period to determine if the event correlated with the field observations made at the RMT sites. In addition, the findings also present the number of single noise events in the MACNOMS that were observed in the field to be created by multiple aircraft noise sources and/or observed to be created by both aircraft and community noise (e.g., loud truck driving by while an aircraft is flying over a RMT). This additional information helps to assess the overall noise environment and what type of activity (aircraft and community noise) may be occurring at each RMT site that is not attributed to an aircraft noise event in the MACNOMS.

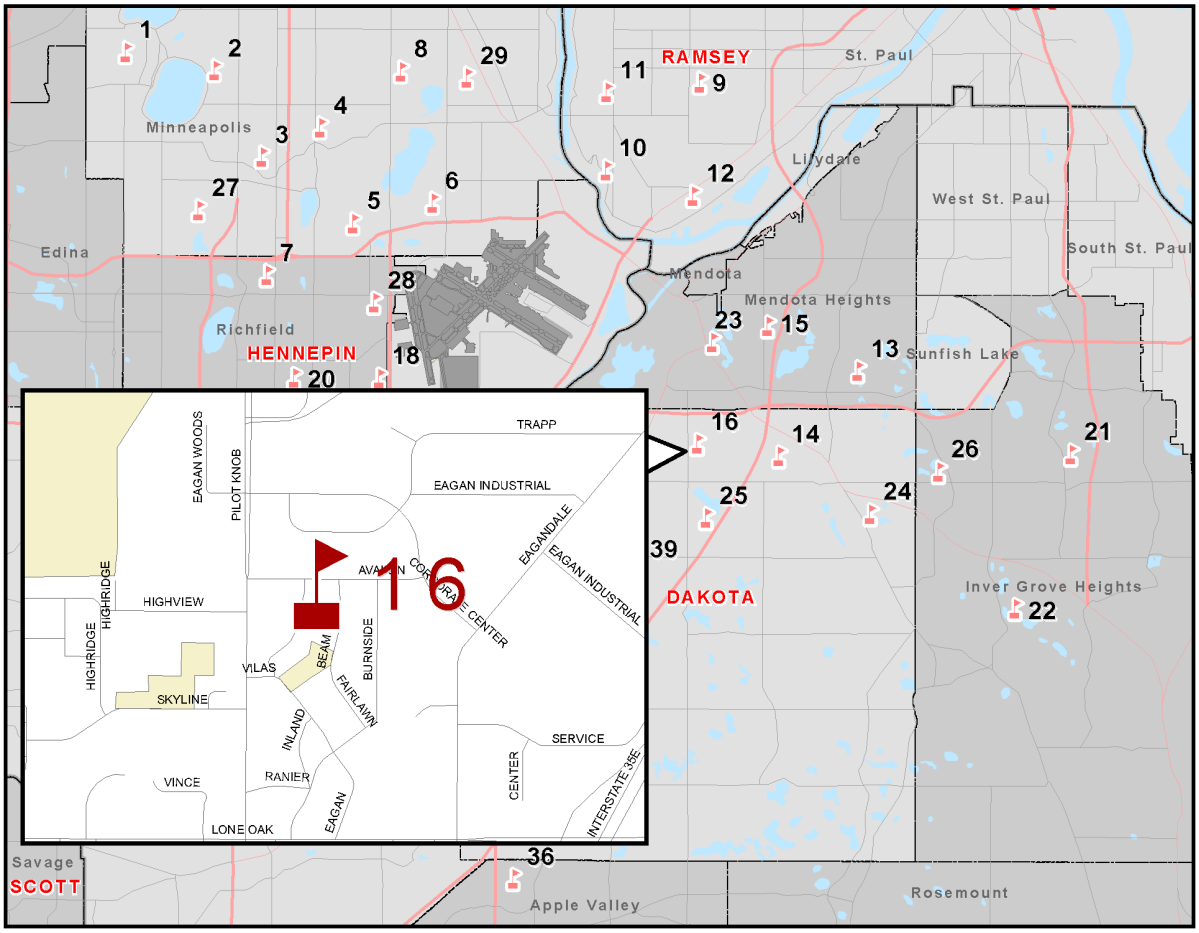
RMT #5 – 12th Avenue & 58th Street, Minneapolis



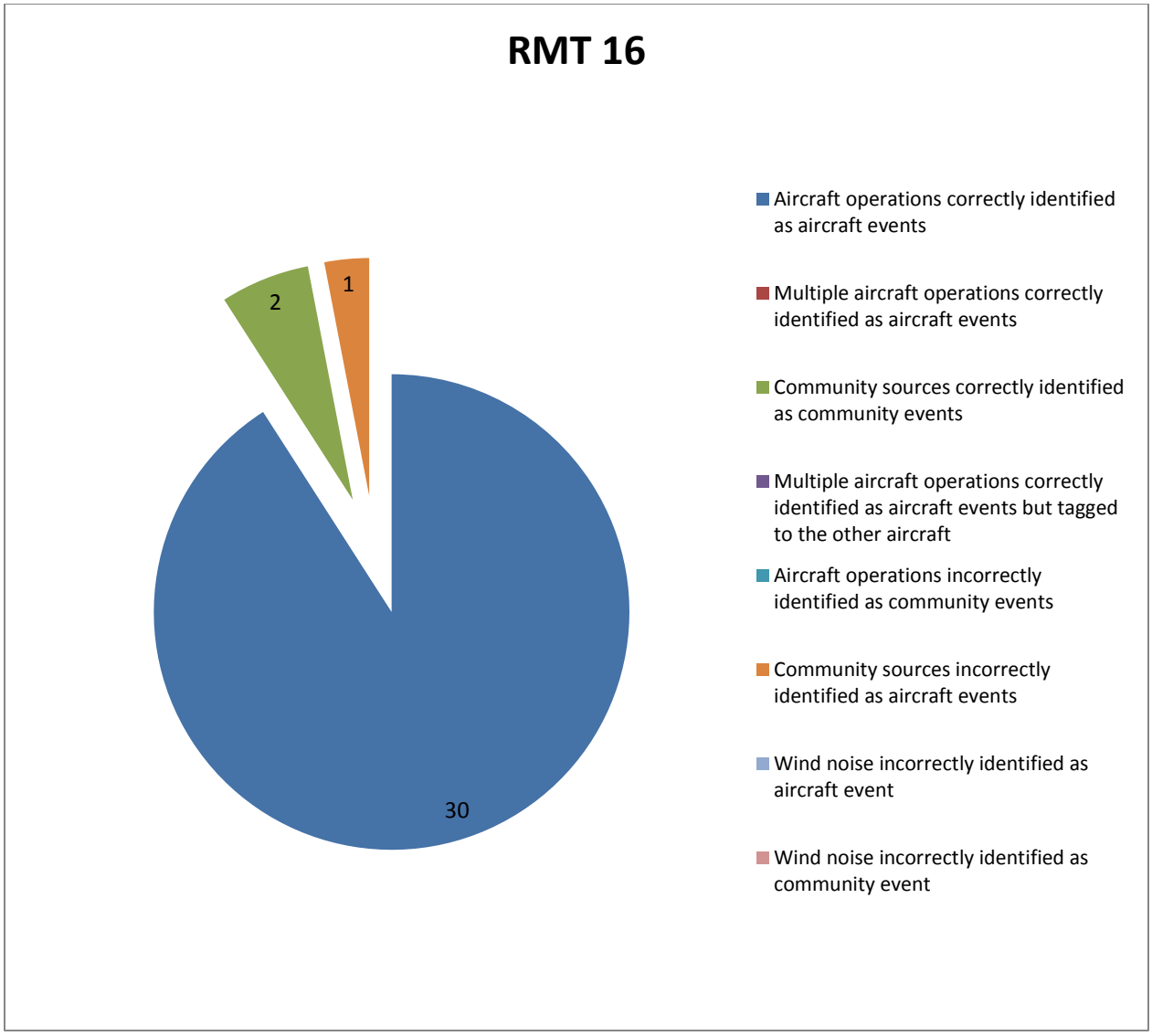
Aircraft operations correctly identified as aircraft events	58
Multiple aircraft operations correctly identified as aircraft events	4
Community sources correctly identified as community events	1
Multiple aircraft operations correctly identified as aircraft events but tagged to the other aircraft	3
Aircraft operations incorrectly identified as community events	1
Community sources incorrectly identified as aircraft events	0
Wind noise incorrectly identified as aircraft events	0
Wind noise incorrectly identified as community events	0
All events	67
Correlation with wind events	94.0%
Correlation without wind events	94.0%


RMT 5
1
3
1
4
58
Aircraft operations correctly identified as aircraft events
Multiple aircraft operations correctly identified as aircraft events
Community sources correctly identified as community events
Multiple aircraft operations correctly identified as aircraft events but tagged to the other aircraft
Aircraft operations incorrectly identified as community events
Community sources incorrectly identified as aircraft events
Wind noise incorrectly identified as aircraft event
Wind noise incorrectly identified as community event

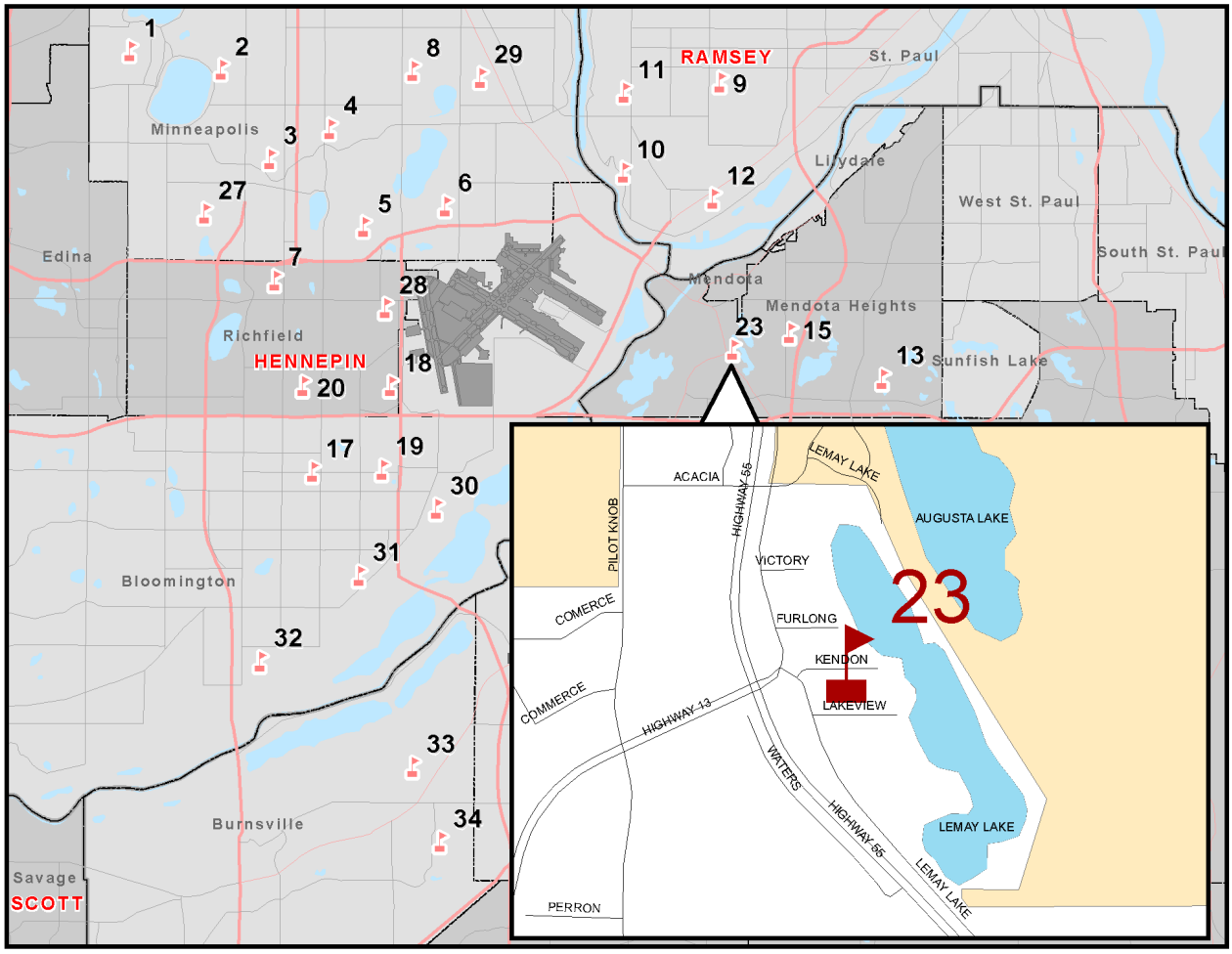
RMT #16 – Avalon Avenue & Vilas Lane, Eagan



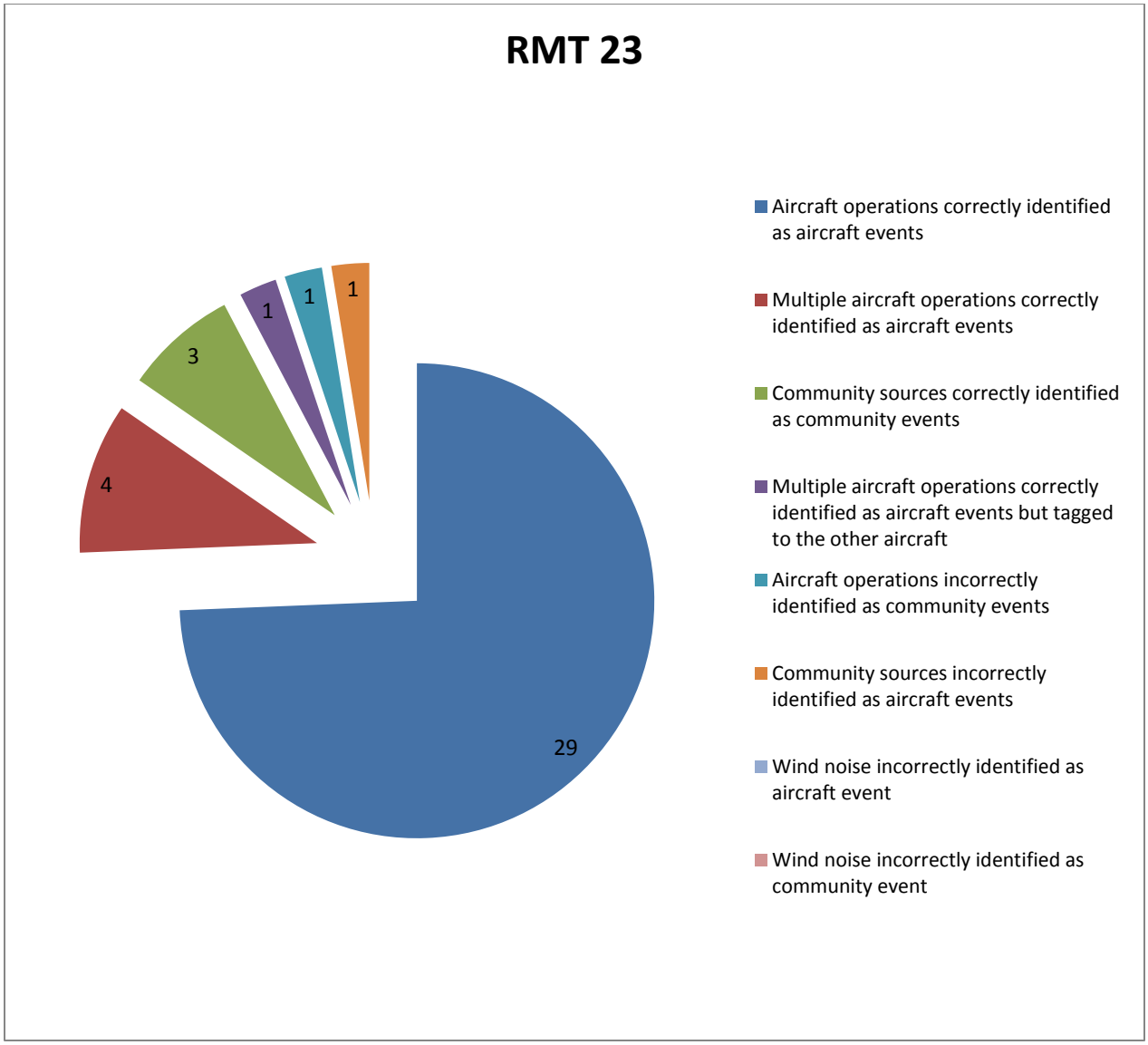
Aircraft operations correctly identified as aircraft events	30
Multiple aircraft operations correctly identified as aircraft events	0
Community sources correctly identified as community events	2
Multiple aircraft operations correctly identified as aircraft events but tagged to the other aircraft	0
Aircraft operations incorrectly identified as community events	0
Community sources incorrectly identified as aircraft events	1
Wind noise incorrectly identified as aircraft events	0
Wind noise incorrectly identified as community events	0
All events	33
Correlation with wind events	97.0%
Correlation without wind events	97.0%


RMT 16
2
1
30
Aircraft operations correctly identified as aircraft events
Multiple aircraft operations correctly identified as aircraft events
Community sources correctly identified as community events
Multiple aircraft operations correctly identified as aircraft events but tagged to the other aircraft
Aircraft operations incorrectly identified as community events
Community sources incorrectly identified as aircraft events
Wind noise incorrectly identified as aircraft event
Wind noise incorrectly identified as community event

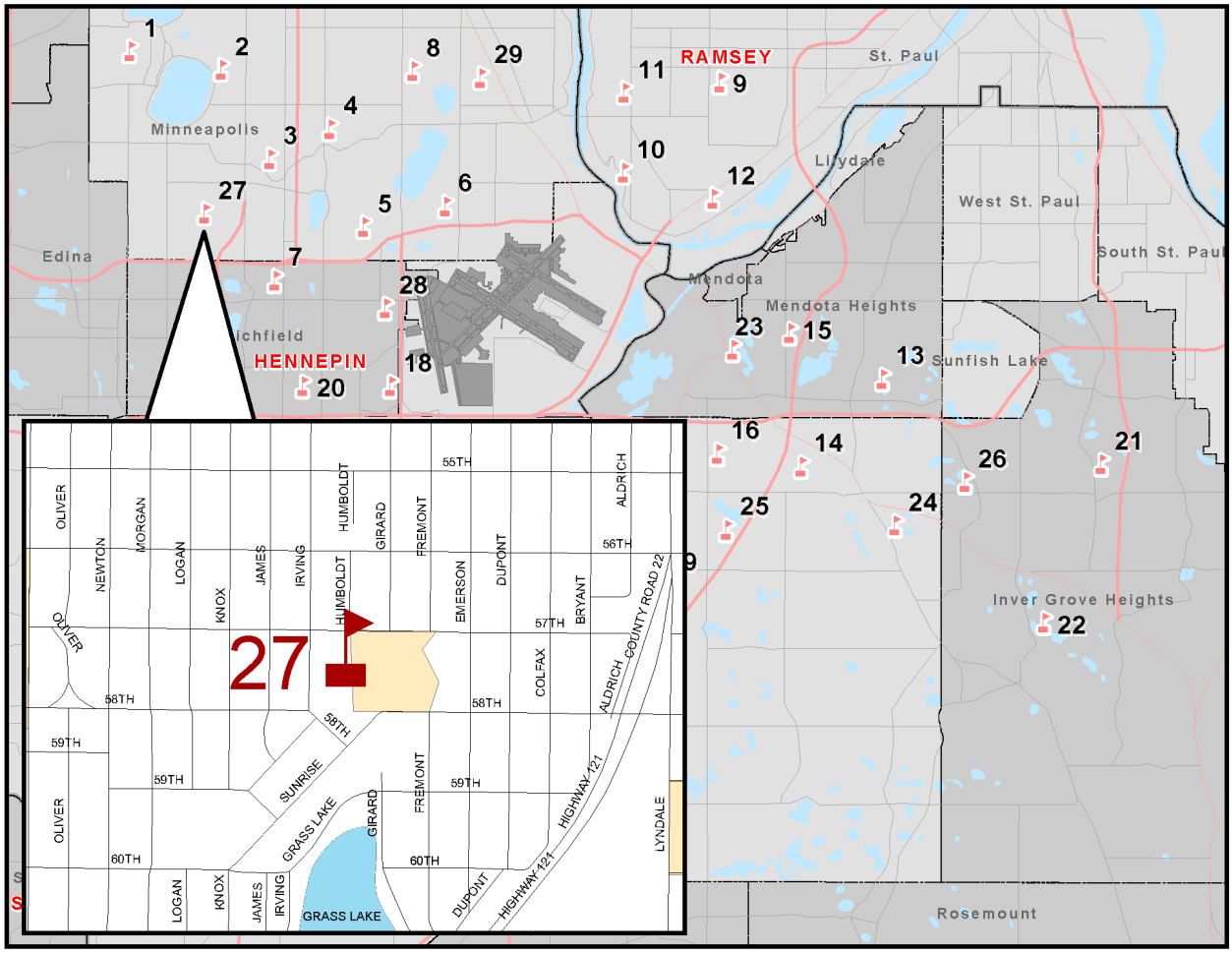
RMT #23 – End of Kenndon Avenue, Mendota Heights



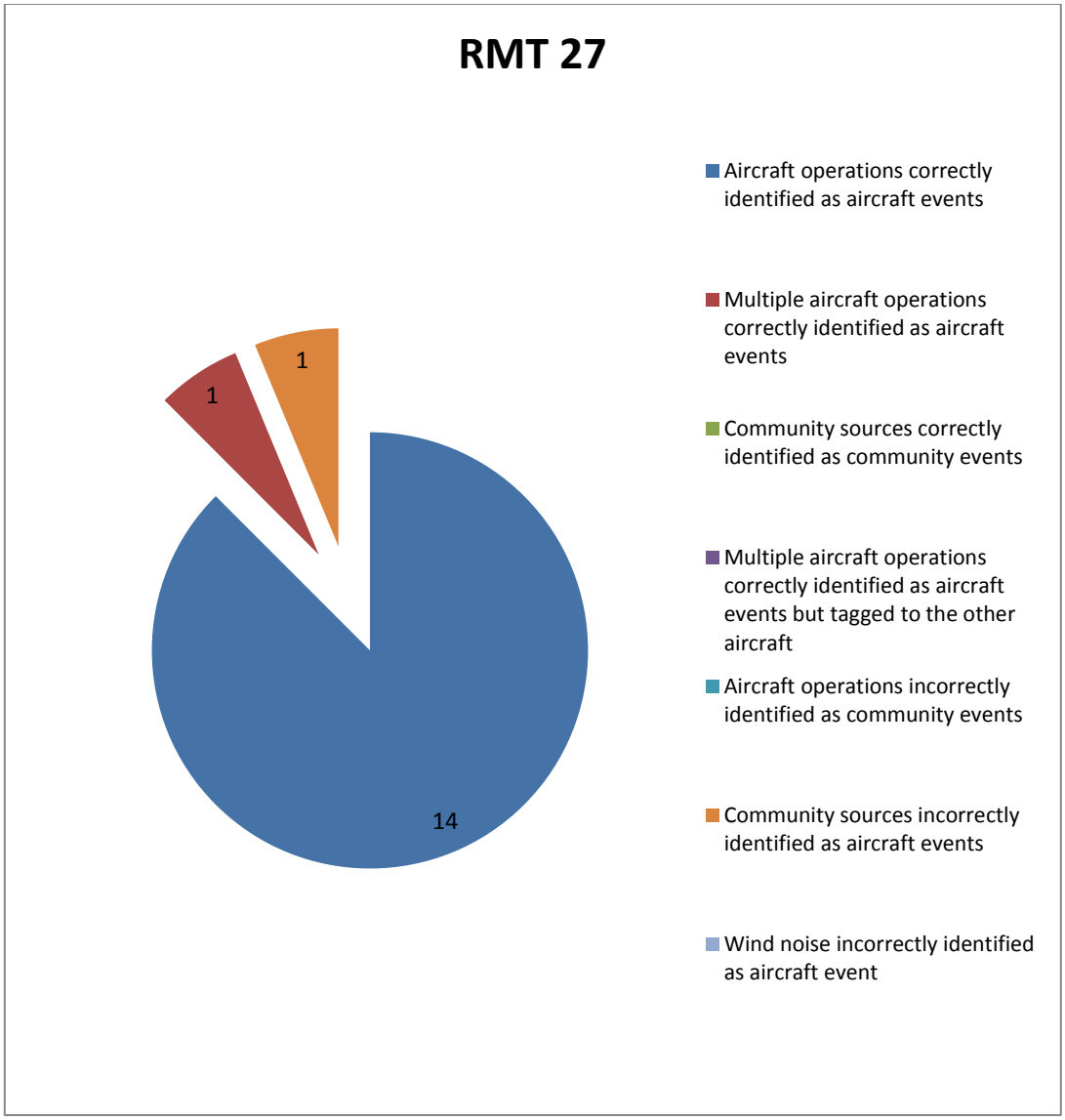
Aircraft operations correctly identified as aircraft events	29
Multiple aircraft operations correctly identified as aircraft events	4
Community sources correctly identified as community events	3
Multiple aircraft operations correctly identified as aircraft events but tagged to the other aircraft	1
Aircraft operations incorrectly identified as community events	1
Community sources incorrectly identified as aircraft events	1
Wind noise incorrectly identified as aircraft events	0
Wind noise incorrectly identified as community events	0
All events	39
Correlation with wind events	92.3%
Correlation without wind events	92.3%


RMT 23
29
4
3
1
1
1
Aircraft operations correctly identified as aircraft events
Multiple aircraft operations correctly identified as aircraft events
Community sources correctly identified as community events
Multiple aircraft operations correctly identified as aircraft events but tagged to the other aircraft
Aircraft operations incorrectly identified as community events
Community sources incorrectly identified as aircraft events
Wind noise incorrectly identified as aircraft event
Wind noise incorrectly identified as community event

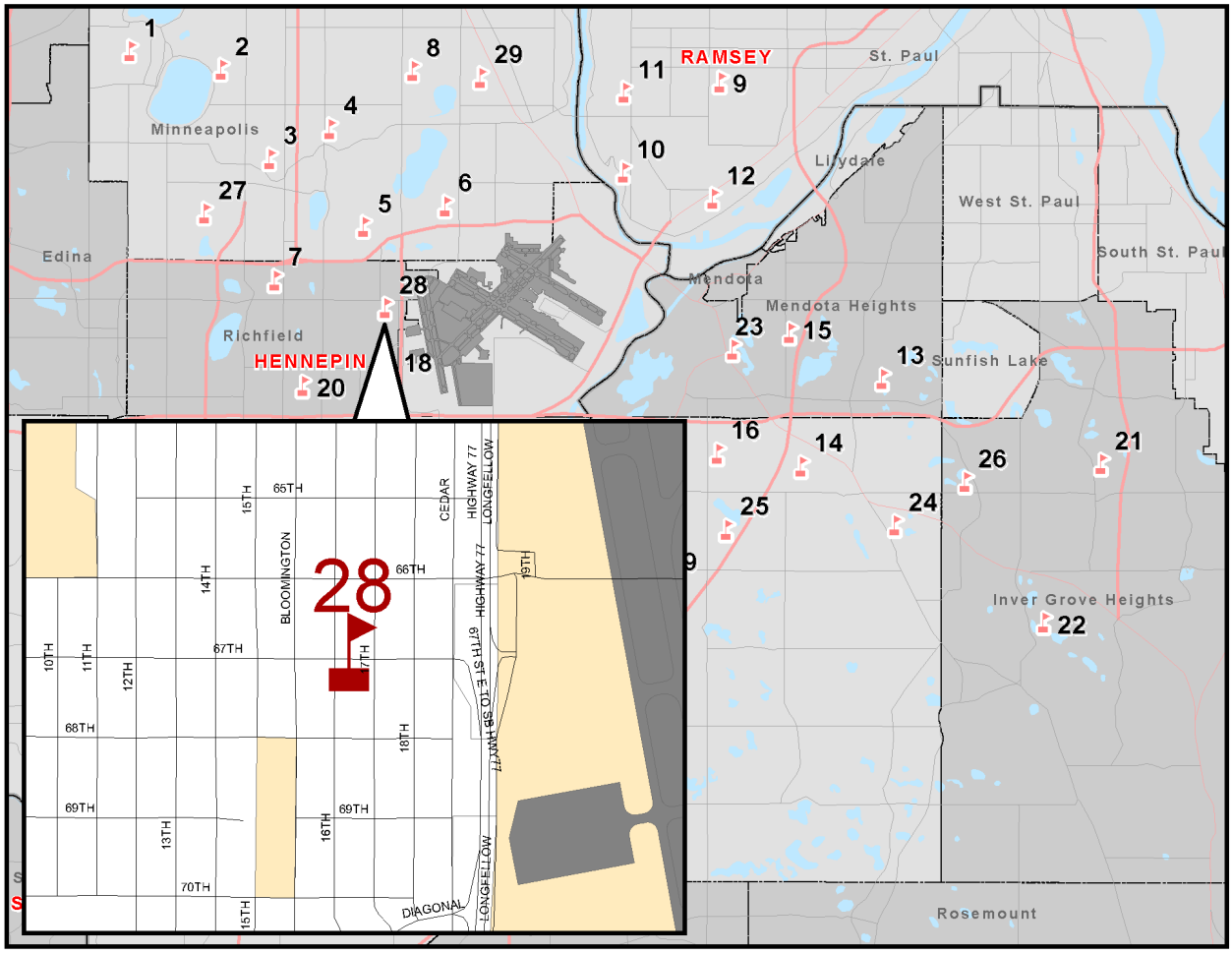
RMT #27 – Anthony Middle School, 5757 Irving Avenue South, Minneapolis



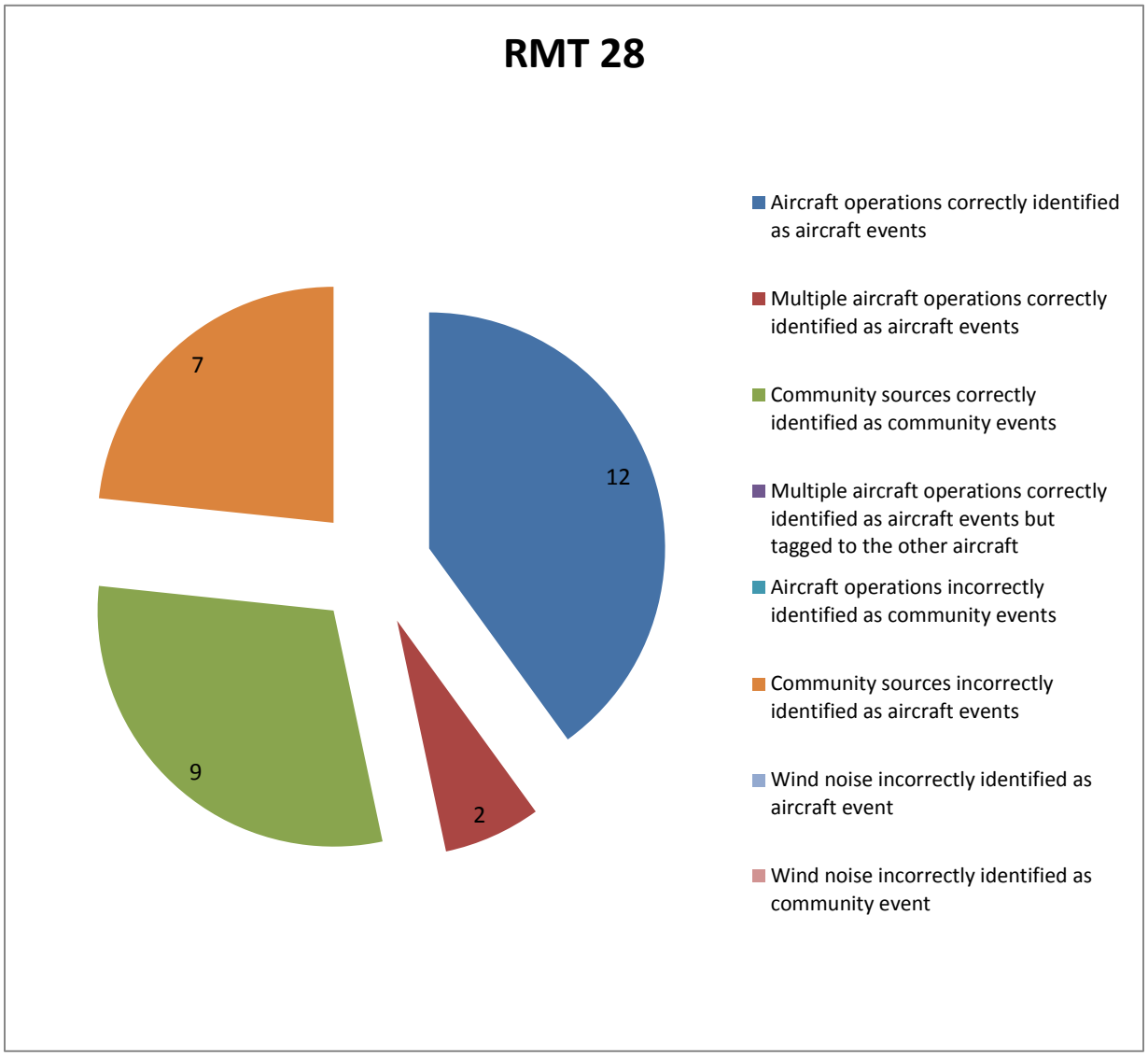
Aircraft operations correctly identified as aircraft events	14
Multiple aircraft operations correctly identified as aircraft events	1
Community sources correctly identified as community events	0
Multiple aircraft operations correctly identified as aircraft events but tagged to the other aircraft	0
Aircraft operations incorrectly identified as community events	0
Community sources incorrectly identified as aircraft events	1
Wind noise incorrectly identified as aircraft events	0
Wind noise incorrectly identified as community events	0
All events	16
Correlation with wind events	93.8%
Correlation without wind events	93.8%


RMT 27
1
1
14
Aircraft operations correctly identified as aircraft events
Multiple aircraft operations correctly identified as aircraft events
Community sources correctly identified as community events
Multiple aircraft operations correctly identified as aircraft events but tagged to the other aircraft
Aircraft operations incorrectly identified as community events
Community sources incorrectly identified as aircraft events
Wind noise incorrectly identified as aircraft event

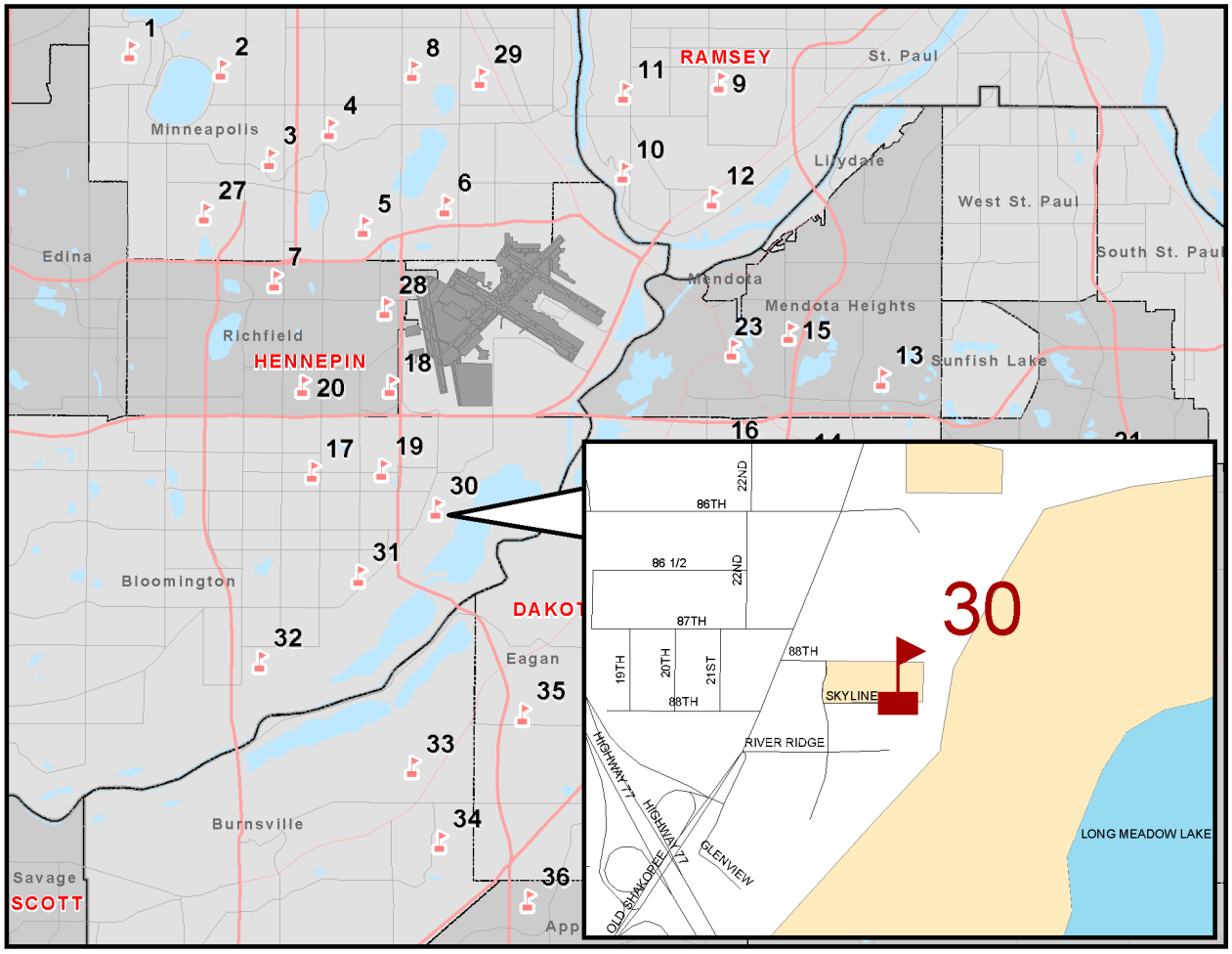
RMT #28 – 6645 15th Avenue South, Richfield



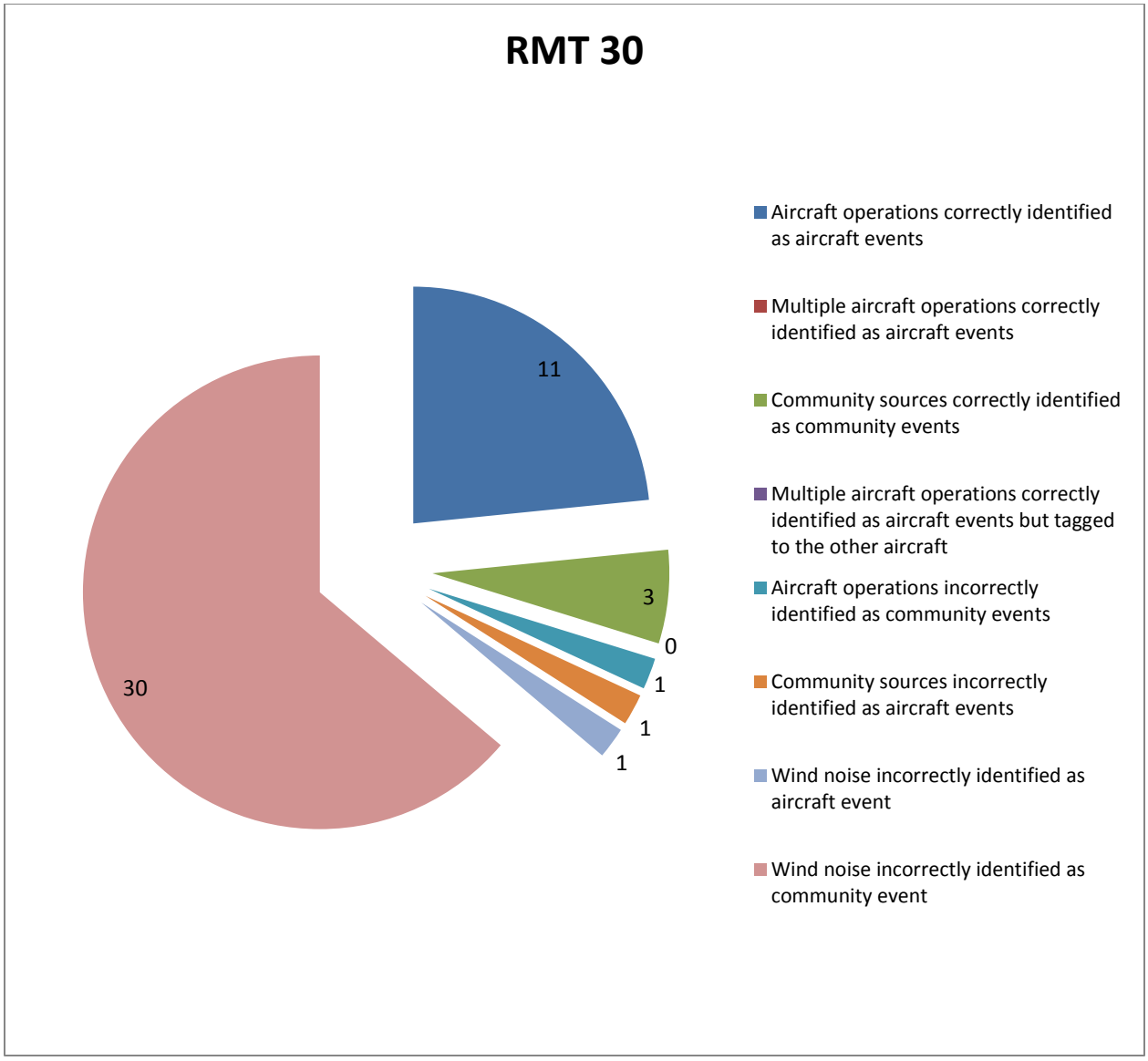
Aircraft operations correctly identified as aircraft events	12
Multiple aircraft operations correctly identified as aircraft events	2
Community sources correctly identified as community events	9
Multiple aircraft operations correctly identified as aircraft events but tagged to the other aircraft	0
Aircraft operations incorrectly identified as community events	0
Community sources incorrectly identified as aircraft events	7
Wind noise incorrectly identified as aircraft events	0
Wind noise incorrectly identified as community events	0
All events	30
Correlation with wind events	76.7%
Correlation without wind events	76.7%


RMT 28
7
12
9
2
Aircraft operations correctly identified as aircraft events
Multiple aircraft operations correctly identified as aircraft events
Community sources correctly identified as community events
Multiple aircraft operations correctly identified as aircraft events but tagged to the other aircraft
Aircraft operations incorrectly identified as community events
Community sources incorrectly identified as aircraft events
Wind noise incorrectly identified as aircraft event
Wind noise incorrectly identified as community event

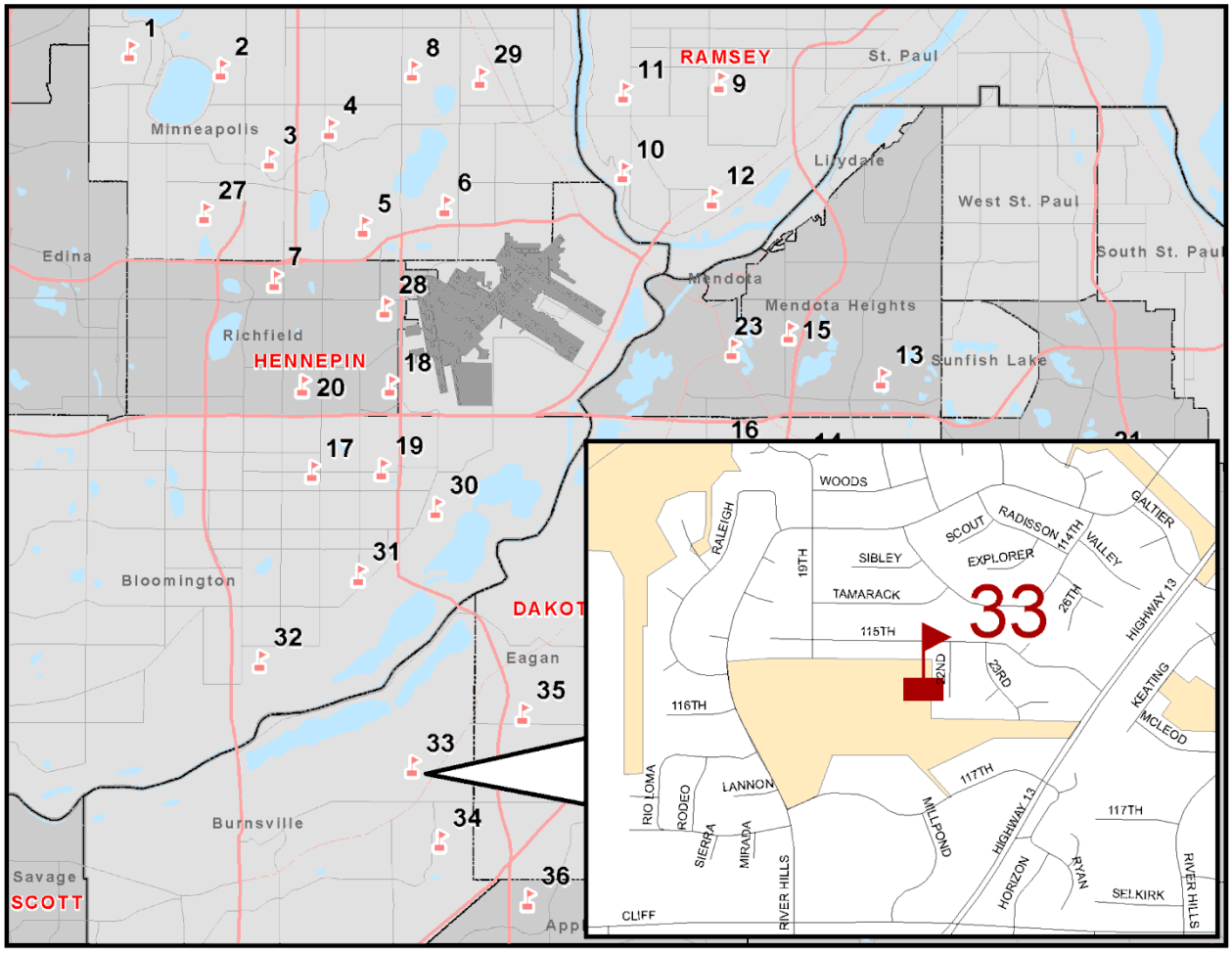
RMT #30 – 8715 River Ridge Road, Bloomington



Aircraft operations correctly identified as aircraft events	11
Multiple aircraft operations correctly identified as aircraft events	0
Community sources correctly identified as community events	3
Multiple aircraft operations correctly identified as aircraft events but tagged to the other aircraft	0
Aircraft operations incorrectly identified as community events	1
Community sources incorrectly identified as aircraft events	1
Wind noise incorrectly identified as aircraft events	1
Wind noise incorrectly identified as community events	30
All events	47
Correlation with wind events	29.8%
Correlation without wind events	87.5%


RMT 30
11
3
0
1
1
1
30
Aircraft operations correctly identified as aircraft events
Multiple aircraft operations correctly identified as aircraft events
Community sources correctly identified as community events
Multiple aircraft operations correctly identified as aircraft events but tagged to the other aircraft
Aircraft operations incorrectly identified as community events
Community sources incorrectly identified as aircraft events
Wind noise incorrectly identified as aircraft event
Wind noise incorrectly identified as community event

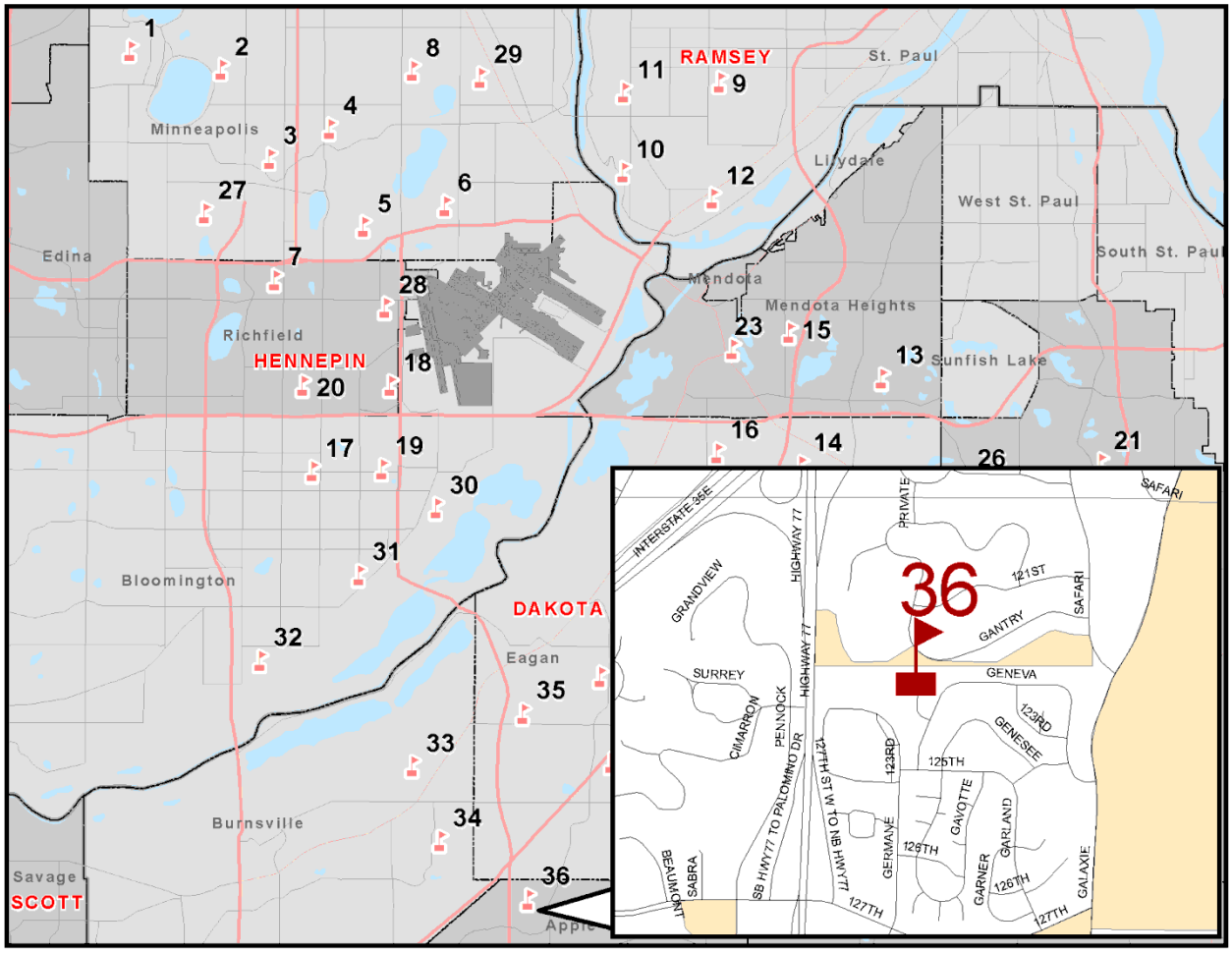
RMT #33 – North River Hills Park, Burnsville



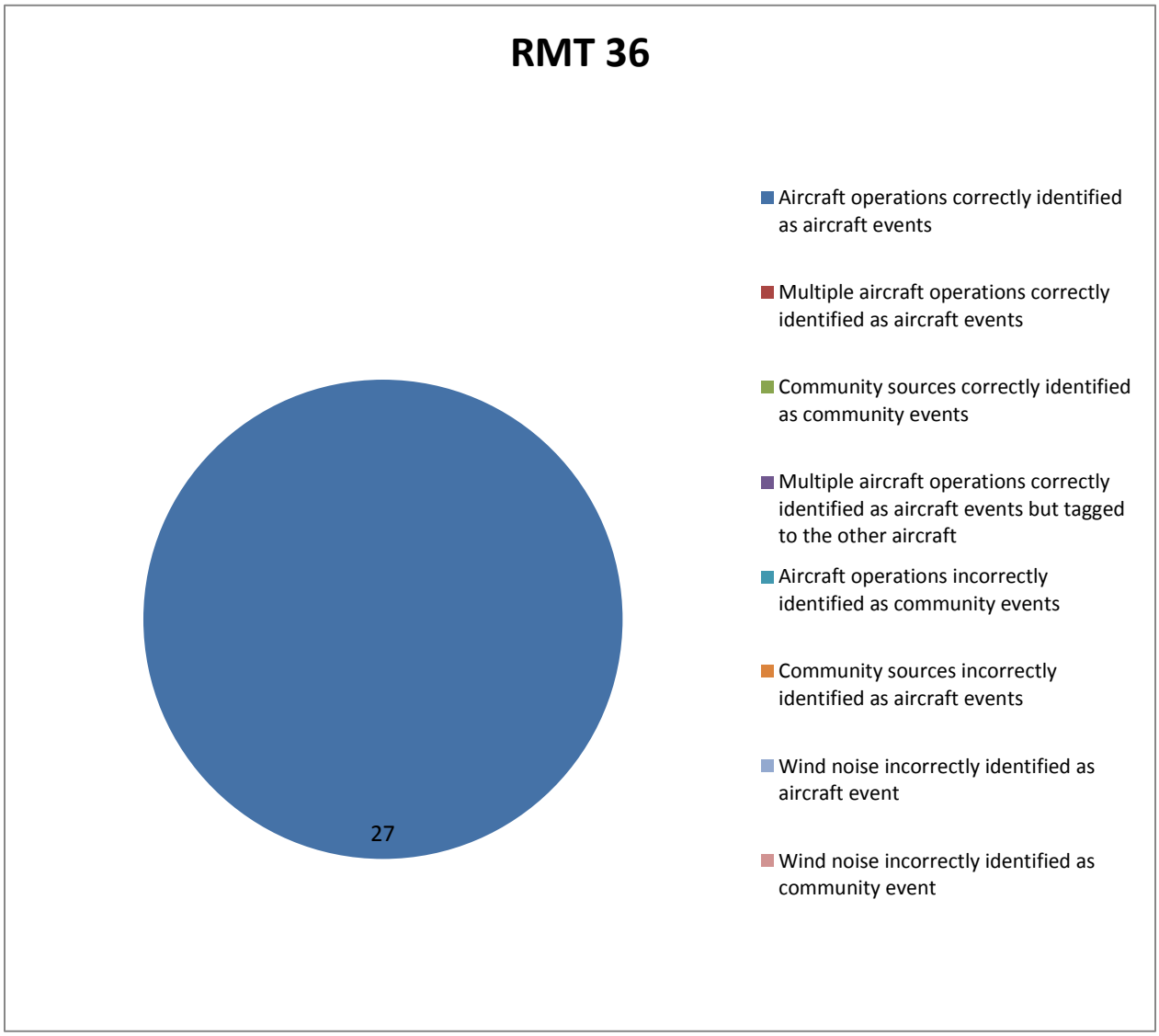
Aircraft operations correctly identified as aircraft events	0
Multiple aircraft operations correctly identified as aircraft events	0
Community sources correctly identified as community events	0
Multiple aircraft operations correctly identified as aircraft events but tagged to the other aircraft	0
Aircraft operations incorrectly identified as community events	0
Community sources incorrectly identified as aircraft events	0
Wind noise incorrectly identified as aircraft events	0
Wind noise incorrectly identified as community events	0
All events	0
Correlation with wind events	100.0%
Correlation without wind events	100.0%

Note: There were no flight tracks or noise events observed or in the MACNOMS for this site during the time period of the field observation.

RMT #36 – Briar Oaks & Scott Pond, Apple Valley

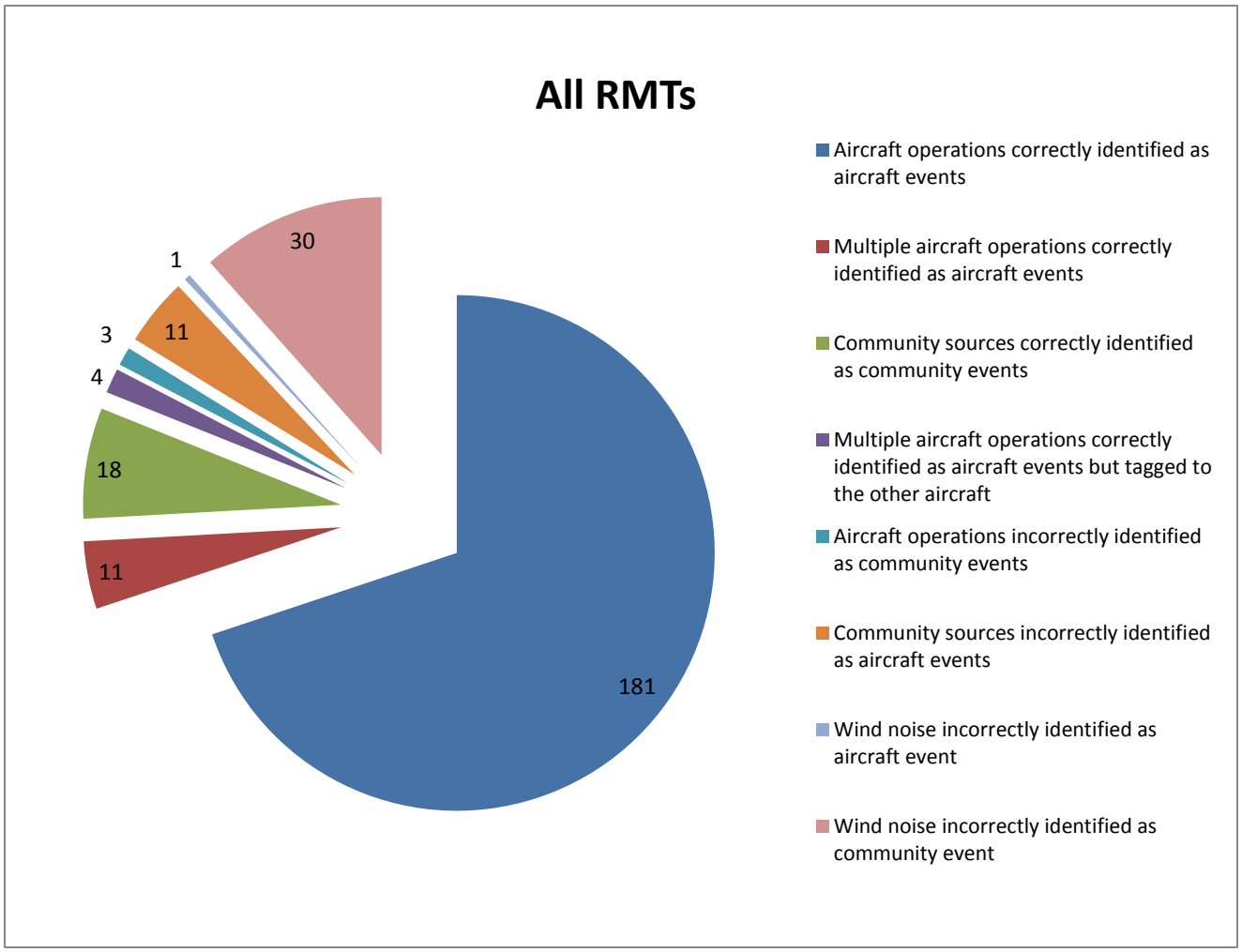


Aircraft operations correctly identified as aircraft events	27
Multiple aircraft operations correctly identified as aircraft events	0
Community sources correctly identified as community events	0
Multiple aircraft operations correctly identified as aircraft events but tagged to the other aircraft	0
Aircraft operations incorrectly identified as community events	0
Community sources incorrectly identified as aircraft events	0
Wind noise incorrectly identified as aircraft events	0
Wind noise incorrectly identified as community events	0
All events	27
Correlation with wind events	100.0%
Correlation without wind events	100.0%


RMT 36
27
Aircraft operations correctly identified as aircraft events
Multiple aircraft operations correctly identified as aircraft events
Community sources correctly identified as community events
Multiple aircraft operations correctly identified as aircraft events but tagged to the other aircraft
Aircraft operations incorrectly identified as community events
Community sources incorrectly identified as aircraft events
Wind noise incorrectly identified as aircraft event
Wind noise incorrectly identified as community event

Summary All RMT's: 5, 16, 23, 27, 30, 33, 36

Aircraft operations correctly identified as aircraft events	181
Multiple aircraft operations correctly identified as aircraft events	11
Community sources correctly identified as community events	18
Multiple aircraft operations correctly identified as aircraft events but tagged to the other aircraft	4
Aircraft operations incorrectly identified as community events	3
Community sources incorrectly identified as aircraft events	11
Wind noise incorrectly identified as aircraft events	1
Wind noise incorrectly identified as community events	30
All events	259
Correlation with wind events	81.1%
Correlation without wind events	92.1%



Discussion

Sound propagation from aircraft is the result of vibrations in air that are caused primarily by the aircraft's jet engines. However, there are also many instances when sound is propagated by a community source which is audible and detected by the RMT sound level meters; an even more complex situation arises when elevated wind speeds cause air pressure changes that are detected by the RMT microphone as an "event" of over 65 dB for eight seconds. Wind events are barely audible on the audio playbacks and sound like a "hiss". The sound level meter does not distinguish aircraft noise events, community noise events, or wind events from one another. The dissimilarity of noise patterns from wind and aircraft is shown in the charts below:

Figure 2

Wind Event Sound Pattern at RMT 30

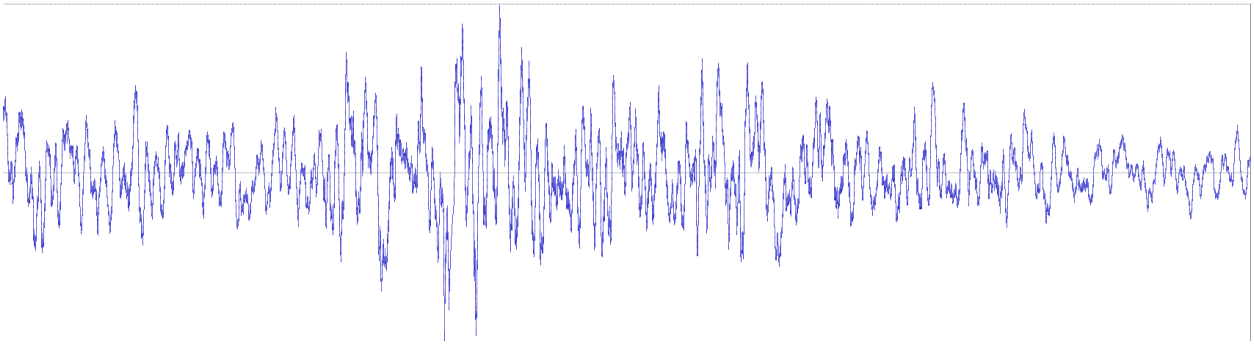
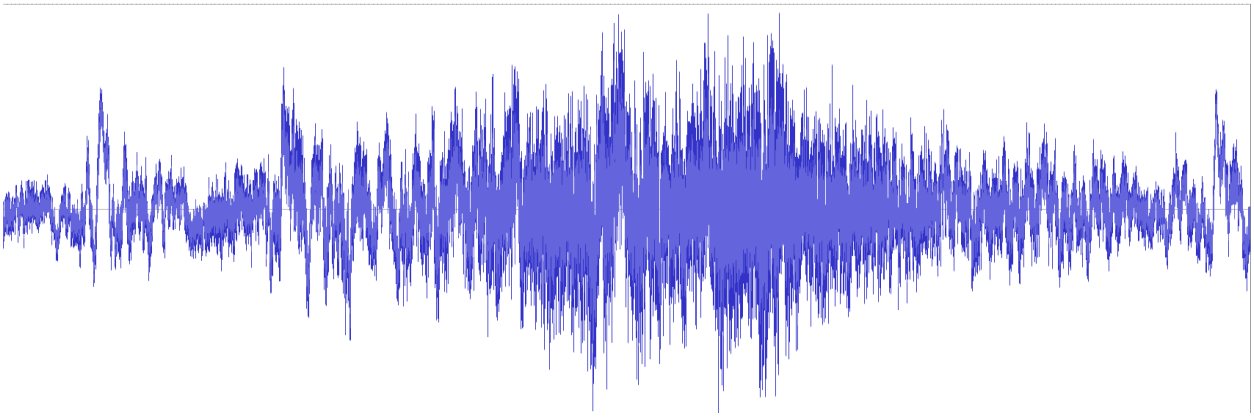


Figure 3

A320 Arrival Event Sound Pattern at RMT 5

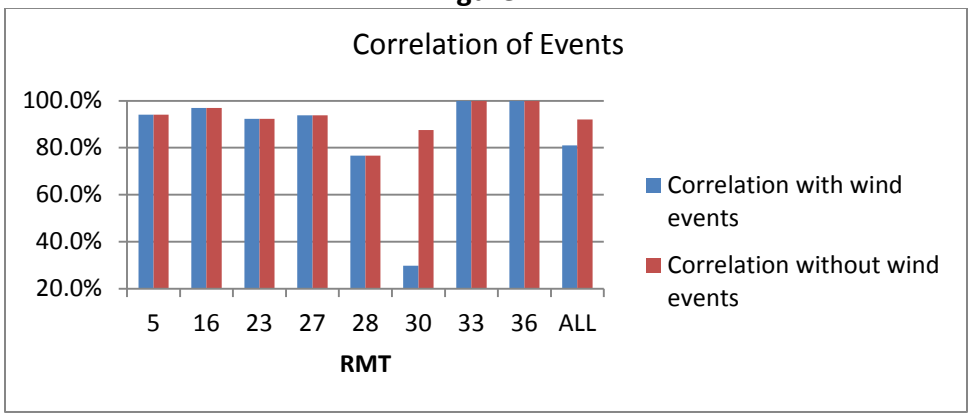


These charts illustrate the importance of correlating the noise event to a flight track within the MACNOMS system as initially, based on noise levels derived exclusively from the RMT data, both patterns shown above met the "event" threshold.

Matching the noise "event" to a flight track is a function of the MACNOMS software that merges the Exelis data feed with the noise data sent by the RMT modems. In the current

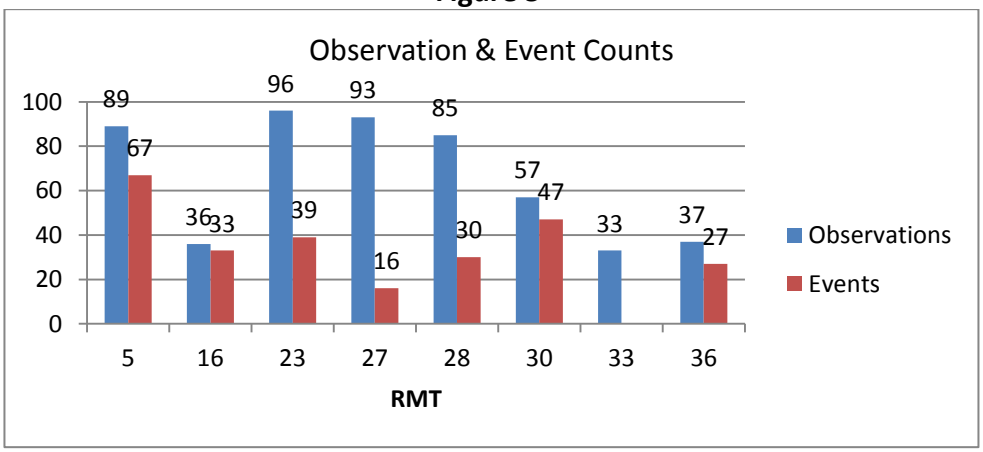
validation study, this merger was successful for 92% of the events observed in the field, following the manual flight track processing and noise match validation done by MAC staff. It is important to note that the automated functions of the MACNOMS are highly accurate. In short, the system is precise when there is an aircraft track that triggers an event at an RMT. The complex situations arise when there is an event at an RMT and no flight track recorded in the vicinity at the same time. These are generally assigned as a "community" event caused by a noise source, such as a lawn mower near the RMT, rather than an aircraft. Further complexity is introduced when the wind causes a noise "event" at the RMT and there was neither an aircraft nor a community noise source present. These wind events were prominent at RMT 30 during the field observation study and resulted in a higher percentage of community noise events matching. Wind and community noise events do not affect the operations counts or aircraft noise data that are contained in numerous MAC reports, including the monthly NOC Technical Advisor's Monthly Report. The correlation of events with and without the wind is shown on the chart below:

Figure 4



There were many instances of aircraft operations observed that did not trigger an event because the noise level at the specific RMT was less than 65dB for eight seconds. Again, the purpose of the event threshold is to minimize the events recorded that are caused by extraneous sources.

Figure 5



When two aircraft tracks match one noise event recorded at an RMT, the MACNOMS software is programmed to assign the event at the RMT to one or the other flight. In Figure 6 below, an example is provided illustrating an Embraer 170 (E170) arriving on Runway 12L and an McDonnell Douglas – 80 (MD 80) departing on Runway 17 within five seconds of one another.

Figure 6

When the MACNOMS matches two flights that trigger an event at an RMT in nearly-aligned timeframes, the software selects the louder of the two aircraft based on its Federal Aviation Regulation (FAR) Part 36 sound level certification. In this case the FAR Part 36 Take-off Sound Level for an E170 is 83.7 and the MD 80 sound level is 91.5. The MACNOMS correctly selected the MD 80 as the source of the event at RMT 28. There were four instances out of 259 events (1.5%) during the validation study when the MACNOMS chose the higher FAR Part 36 take-off sound level aircraft during multiple aircraft events.

Findings

During the course of the MACNOMS Validation Study, MAC staff made some minor discoveries of processing issues that affected the data. These are described below:

Daylight Savings Time (DST)

Departure operations were recorded with a time stamp one hour earlier than the actual departure due to the change in DST in March 2014. A software programming correction was applied to the time stamp for departure operations.

One Data Point Flight Tracks
It was found that on rare occasions the Exelis Next Gen data feed would produce one data point for a flight track that did not occur. A proper flight track has hundreds of data points. This one data point flight track was reported to Exelis and the data feed for MSP was filtered to ensure one data point flight tracks are not included.

Study constraints and limitations

It is important to understand the limitations of this study. While conducting independent noise monitoring at sample RMT sites can provide valuable information as to what is occurring at the site and the overall accuracy of the MACNOMS, practical limitations do exist. At many of the RMT sites, multiple events may be occurring at any given time and therefore the scope of the data is limited to the individual abilities of the person performing the monitoring. In addition, practical limitations such as line of sight, audible range, and directionality of aircraft and community noise events may exist.

Conclusions
MACNOMS, owned and operated by the MAC is one of the largest arrays of noise monitors for a single airport in the United States. The extent of the noise monitoring coverage around MSP is expansive. Ever since the system was installed in 1992, extensive programming effort, hardware and software upgrades, and fine-tuning have been done to ensure the highest degree of accuracy for noise-to-track correlation, noise measurement, and operations counts. MACNOMS is complex, robust, and stable; it provides reliable data output that is critical for the MAC Noise Programs Office and the public.

This validation study involved 22 ½ hours of field noise measurement and observation at eight RMT sites and 8 ½ hours of runway observation from the MSP Orange Parking Ramp at Terminal 2-Humphrey. Although the sample selection was smaller than previous MACNOMS validation studies, the overall results were similar when compared to past reports, as shown in Table 8.

Table 8

	2014	2005	2004	2001
Percentage of Noise Events Correlating with MACNOMS Flight Track Data	92.10%	94.30%	89.10%	90.90%
Percentage of Observed Operations Correlating with MACNOMS Flight Track Data	97.10%	95.90%	96.80%	97.80%

The report also determined that the sound levels measured by the sound level meters closely match those measured by the portable sound levels meters for identical aircraft overflight.

There were a few minor software programming issues discovered including a daylight savings time correction for departures, a new filter to eliminate one data point flight tracks and a filter to eliminate squawk 1200 transponder beacon codes for operations at MSP. These corrections have been implemented with good results and no data was lost in the process.

The study found that high wind speeds can trigger the recording of a noise event; however, there was only one instance of the MACNOMS assigning the wind event to a flight operation. There were a larger number of wind events that were assigned by the MACNOMS as community events, due to the lack of a flight track in proximity to the RMT when the wind event occurred. The wind events that were assigned as community events have no effect on the noise data reported by the MAC for aircraft operations at MSP.

Overall, the 2014 MACNOMS validation study confirmed that the system is working within historical norms and its outputs have a high degree of accuracy and precision.