SUBURBAN O'HARE COMMISSION

ANALYSIS OF CHICAGO O'HARE CURRENT AND FUTURE INM NOISE CONTOURS AND IMPACTS REPORT

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19 November 2015

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1. BACKGROUND

Chicago O'Hare International Airport (ORD) is one of the busiest and most complex airports in the World. According to the FAA Terminal Forecast, ORD had 879,142 operations in the year 2014 (FAA 2015). According to the same FAA forecast, ORD could reach one million flight operations in the year 2032.

ORD is going through a complex runway re-configuration. The original three runway orientation configuration is slowly being converted into a two runway orientation configuration. At the end of the O'Hare Modernization Program (OMP), the airport will have six parallel runways oriented 90/270 degrees and two crosswind runways oriented 40/220 degrees. The transition period towards the OMP final configuration has increased the number of operations over some community areas creating numerous complaints from the population.

The Suburban O'Hare Commission (SOC) has asked JDA Aviation Technology Solutions (JDA) to analyze the Chicago Department of Aviation and FAA Environmental Impact Statement (EIS) Integrated Noise Model (INM) contours and real world actual experienced noise including:

a) Document the differences between modeled EIS INM contours and actual noise experiences
b) Identify specific model inputs to ensure accuracy with current operations
c) Evaluate the noise impact of promising procedural/operational alternatives identified in the Fly Quiet analysis paper
d) Utilize INM and other tools to quantify the full geographic extent of noise-impacted homes around ORD

Dr. Antonio A. Trani, a JDA technical consultant, served as the primary technical research and INM expert. Dr. Trani is a Professor with the Department of Civil and Environmental Engineering at Virginia Tech University and is Co-Director of the National Center of Excellence for Aviation Operations Research (NEXTOR). He has been the Principal or Co-Principal Investigator on 68 research projects sponsored by the National Science Foundation, Federal Aviation Administration, National Aeronautics and Space Administration, National Consortium for Aviation Mobility, Federal Highway Administration, and the Center for Naval Analyses. Dr. Trani has also provided noise, capacity and safety consulting services to:

- Norman Manley International Airport
- Punta Cana International
- National Institute for Aerospace (NIA)
- Korean Aerospace University and Korean Ministry of Land
- Xcelar
- Quanta Technologies
- Los Angeles World Airport

- Charles Rivers Associates
- Boeing Phantom Works
- Civil Aviation Administration of China (CAAC)
- British Airports Authority (BAA)
- SEATAC Airport Authority
- Louisville International Airport
- Delta Airport Consultants
- Celanese
- MITRE Corporation.

The INM analysis presented in this report includes:

- Contours produced to verify the ORD EIS INM contours including:
  - 2002 Baseline
  - Construction Phase II Alternative C
  - OMP Build Out Alternative C
- Current and future contours modeled to determine likely actual noise experiences and quantify the geographic extent of related noise impacts including:
  - Today 2014-2015 ORD Noise Contour
  - Fall 2015 ORD Noise Contour
  - Modified OMP Build Out Alternative C Contour
- Verification and critique of all the inputs for the EIS ORD Contours and the FAA Re-Evaluation
- Evaluation of overflights for each of the 78 municipal areas around the airport
- Information on runway configuration changes effect on historical DNL values recorded at communities around the airport
- Evaluation of fly quiet recommendations potential for noise reduction

2. SUMMARY OF JDA INM TEAM FINDINGS AND RECOMMENDATIONS

2.1 JDA INM TEAM KEY FINDINGS:

JDA INMF-1: Analysis of the flight track data indicates that 10.5% of the operations at ORD occur at night whereas the FAA Re-evaluation utilized 5.1% and EIS OMP full build utilized 5.6%.

JDA INMF-2: The ORD airport fleet mix that has evolved in the last decade in ways the EIS study could not anticipate. Today, large regional jets are responsible for 25% of the departures at the airport.

JDA INMF-3: Baseline 2002 EIS contour assigned substantial numbers to heavy aircraft and modeled a significant number of aircraft that no longer operate at ORD.

JDA INMF-4: A dramatic shift of contours from the change from Baseline to May 2014-

April 2015 airfield configuration creates significant areas of newly impacted population both within the revised 65 DNL contour and the larger 55 DNL contour. Analysis of complaint data illustrates significant numbers of complaints outside the 65 DNL contour. This confirms the earlier findings of JDA expert Dr. Fidell that the 65 DNL is underestimating noise impact.

JDA INMF-5: EIS OMP predicted 3,070 operations/day in 2013 but according to the latest FAA Terminal Area Forecast (TAF 2015), Chicago O'Hare will not reach 3,070 average daily operations until the year 2038.

JDA-INMF-6: The **JDA OMP contour** analysis correcting fleet mix with 10.5% nighttime operations demonstrates a 65 DNL impact area of **23.1 square miles** (an area **increase of 28%** over the 65 DNL **EIS OMP contours**) affecting **45,449 people** (an **increase of 84%** compared to the **OMP EIS population impact**).

Figure 1 illustrates the comparison between the EIS OMP Full Build and the JDA OMP Full Build 65 DNL contour areas. The difference can be attributed to the significant increase in nighttime operations and larger regional jets in the fleet mix operating at ORD.

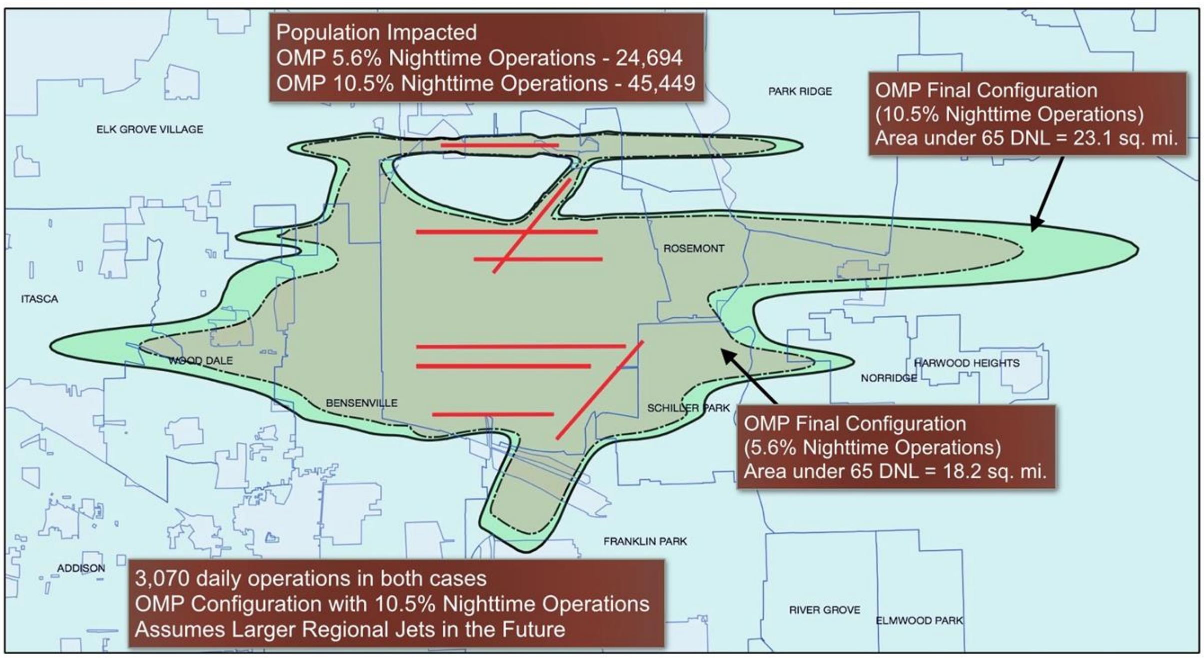


Figure 1: Comparison of ORD EIS OMP Contour to JDA ORD OMP Contour.

Figure 2 illustrates the comparison between Today's 2014-2015 65 DNL noise contour with 2,378 daily operations and the JDA OMP Full Build 65 DNL noise contour with 3,070 daily operations The area impacted by the 65 DNL is predicted to increase by 85% when daily operations meet design capacity anticipated in the original OMP EIS. The actual impacts could be better or worse depending on advances in quieter aircraft, improved methods to reduce noise and levels of flight activity.

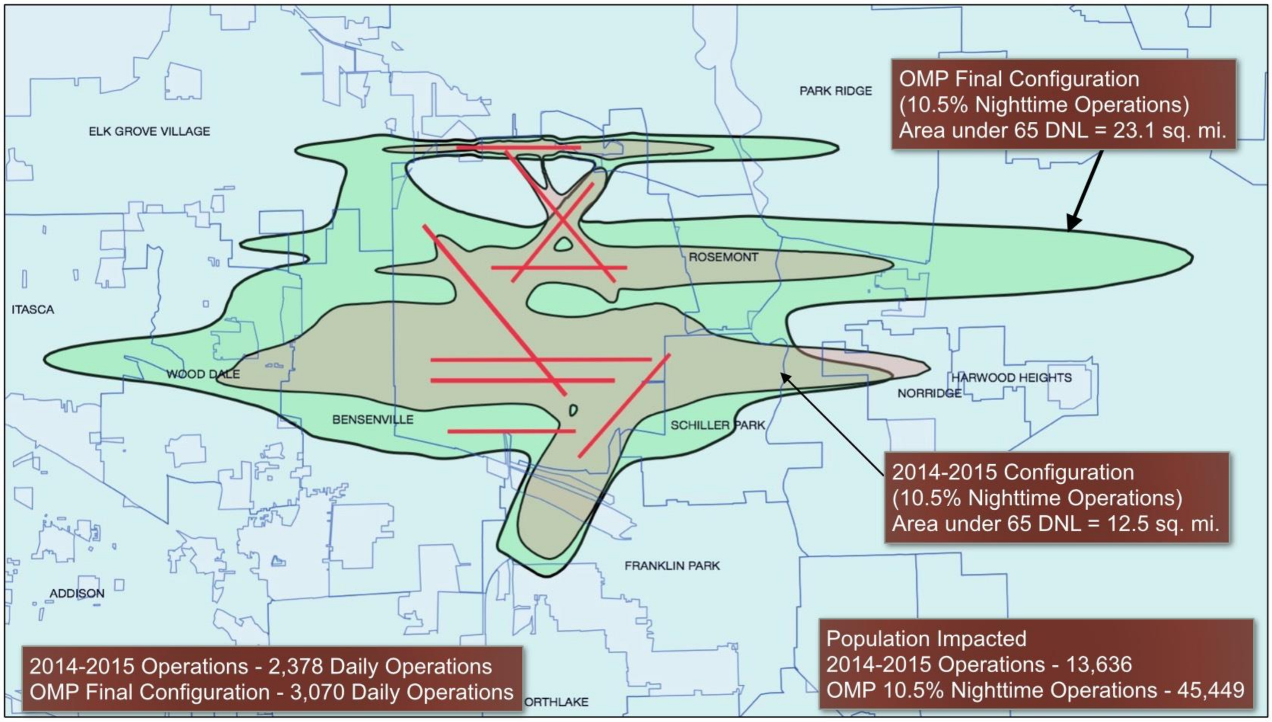


Figure 2: Comparison of 65 DNL Noise Contours for EIS OMP Full Build and Today's ORD Condition (Using May 2014- April 2015 Fleet Mix Data).

Figure 3 illustrates the contour areas predicted by several of the INM contours generated in the study. The decrease in the 65 DNL area from Baseline 2002 to Today 2014-2015 can be attributed to change in airfield configuration, larger fleet mix in 2002 and fewer operations than predicted in 2014-2015.

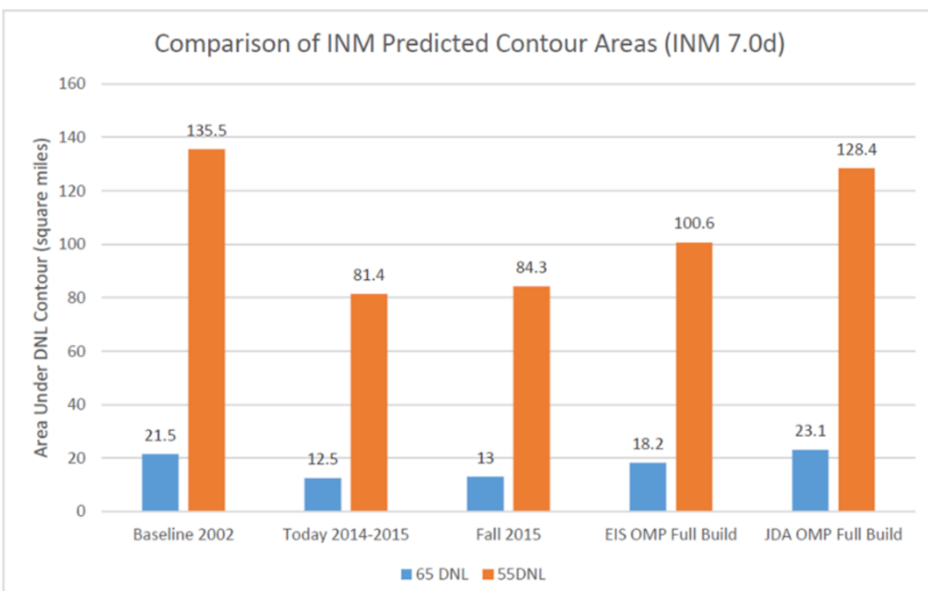


Figure 3: Geographic Impacts of Various ORD Contours Modeled.

Figure 4 illustrates the potentially affected population predicted by several of the INM contours from the study. Today, 13,636 people are estimated to be affected by the 65 DNL. The JDA Full Build 65 DNL contour predicts a 233% increase to 45,449 people affected.

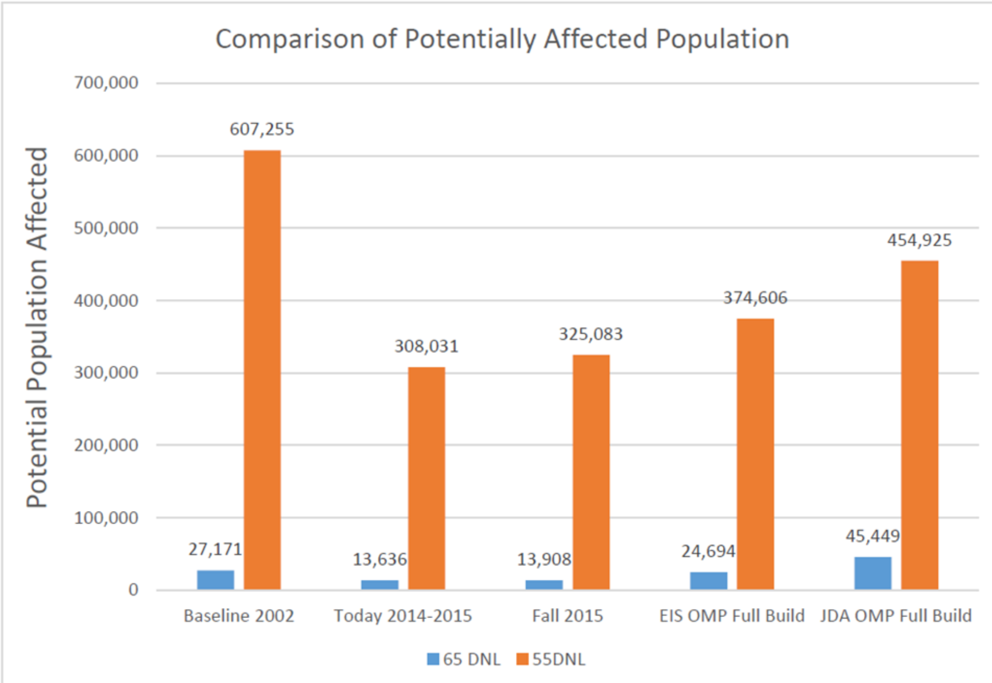


Figure 4: Potential Population Impacts of Various ORD Contours Modeled.

The analysis shows that the size of the area within the 65 DNL contour and the size of the affected population with the 65 DNL contour has decreased between the 2002 baseline and the 2014 airport. This change in the location and size of the impacted geographic area and size of the impacted population appears attributable to three factors. First the level of operations in 2014 is 55,000 less than the 2002 baseline. Second, there has been a considerable shift since 2002 to increased use of small regional jets (RJs) which produce less noise than full sized commercial jets. Finally, the directional headings of many of the runways have significantly changed leading to changes in the geographic distribution of noise.

However, the analysis shows that both aircraft sizes and air traffic operations volume is predicted to increase in the future. As a result, both the geographic size of the 65 and 55 DNL contours as well as the size of the adversely affected population within these contours will increase in the future as compared to the noise contours of the 2014 O'Hare configuration. At the projected full build OMP traffic levels used by the FAA in the 2005 Final EIS using 10.5% nighttime operations, the adversely impacted area at 65 DNL will rise from 12.5 square miles to 23.1 square miles as compared to the 2014 airfield and the 55 DNL impacted area will rise from 81.4 square miles to 128.4 square miles. Similarly, the size of the 65 DNL impacted population will rise from 13,636 people to 45,449 people and the 55 DNL impacted population will rise from 308,031 people to 454,925 people as compared to 2014.

2.2 JDA INM TEAM RECOMMENDATION SUMMARY:

JDA INMR-1: The FAA Re-evaluation noise analysis should report noise contours using the actual aircraft fleet mix observed at the airport in the interim conditions 2015.

JDA INMR-2: The FAA Re-evaluation noise analysis should revise the number of nighttime operations used in the noise analysis for the airport interim conditions 2015.

JDA INMR-3: The OMP EIS noise analysis should revise assumptions about future fleet mix to include larger regional jets operating at ORD. The larger capacity aircraft would be consistent with the FAA forecast of faster growth in enplanements at the airport compared to flight operations.

JDA INMR-4: The OMP EIS analysis should revise the number of nighttime operations used in the noise analysis for future airport conditions. Airline scheduling practices and network delays make it difficult to justify that ORD will ever have 5.6% percent nighttime operations in the future. ORD's effort to increase cargo activity has and will continue to increase nighttime operations. Future EIS analyses should examine ORD's potential plans to increase cargo operations beyond current levels.

JDA INMR-5: Any future INM contour analysis should include measures of variability in the results presented in the EIS OMP noise contour analysis and should describe sources of uncertainty in the noise contour estimates.

JDA INMR-6: Utilize the metric of equivalent overflights (giving appropriate weight to night time flights) to devise a runway rotation plan during fly quiet hours to minimize noise impacts for the maximum population.

JDA INMR-7: Utilize INM to quantify Fly Quiet Recommendations such as optimal departure headings and use of a third runway on a rotating basis to reduce noise impacts.

JDA INMR-8: Encourage voluntary changes to airline scheduling practices to reduce the number of nighttime operations at ORD.

JDA INMR-9: CDA should undertake a careful examination of existing and future approach and departure flight tracks and quantify their noise impact to develop a "Playbook" of runway strategies for ORD that from inception considers noise as a key design element.

JDA INMR-10: Given the number of noise complaints by communities outside the 65 DNL contour, both FAA and CDA should consider Dr. Fidell's recommendation to utilize 55 DNL as a valid threshold for noise compatibility studies.

3. DATA COLLECTION AND ANALYSIS

Detailed flight track data was provided by CDA after a request made by JDA. Data provided by CDA included 30 days of good data shown in Appendix 1. Data requested included the sixteen typical days of the National Airspace System (NAS) used in many FAA investment studies. The data was judged to be representative of the many operations at ORD. The data encompassed 70,900 flights at the airport over a period of 12 months starting in November of 2013 and ending in October 2014. The data included information on aircraft type, flight identification, detailed flight track (three dimensional information), time of day of the operation and runway used. Figure 5 illustrates the flight track data for May 1, 2014 (West flow day). Figure 6 illustrates the flight track data for May 28, 2014 (East flow day).

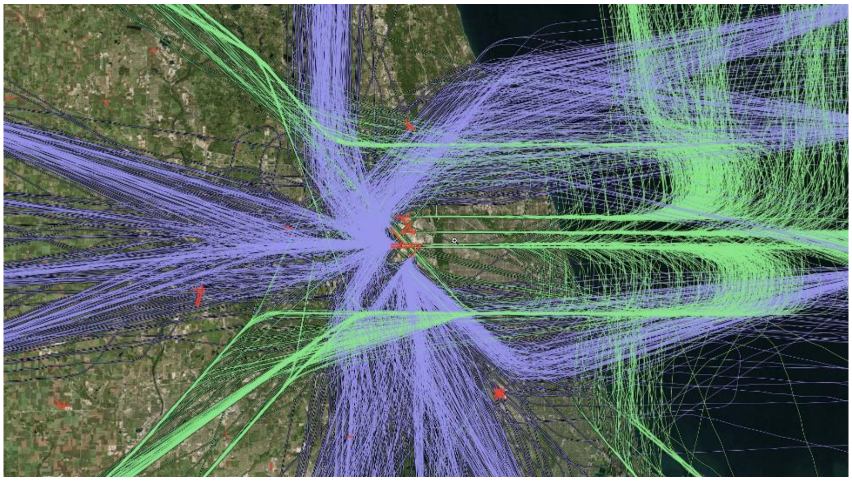


Figure 5: Sample Flight Track Data Provided by CDA (May 1, 2014). West Flow Day. Arrivals in Green. Departures in Blue.

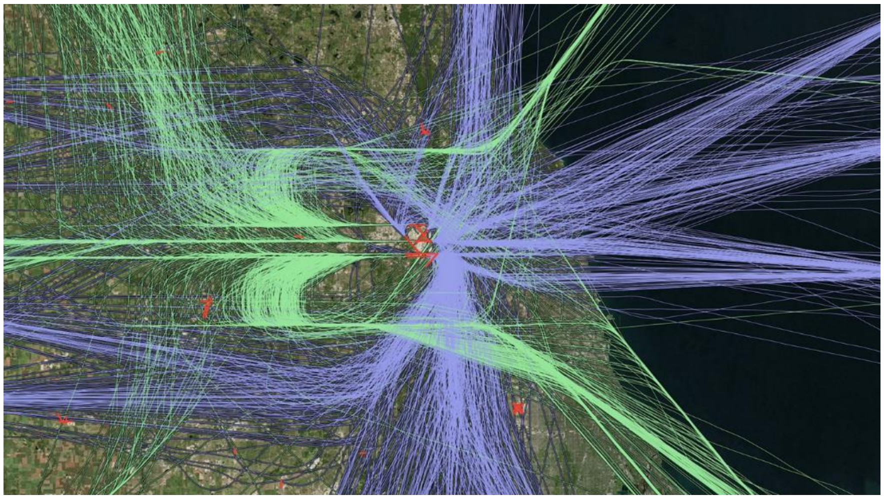
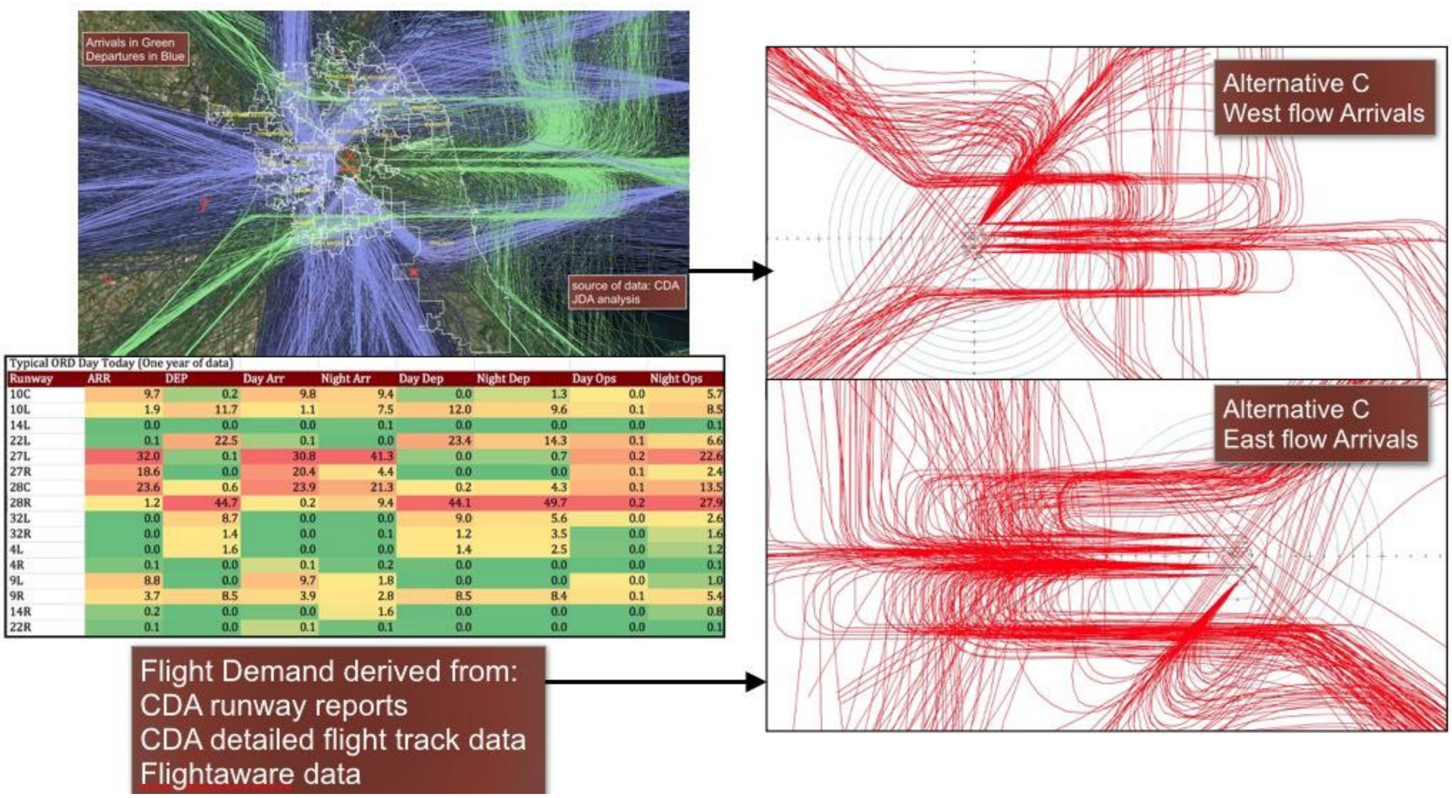


Figure 6: Sample Flight Track Data Provided by CDA (May 28, 2014). East Flow Day. Arrivals in Green. Departures in Blue.

The information was used to build a realistic model using the Federal Aviation Administration Integrated Noise Model (INM) case representing Chicago O'Hare International Airport (ORD) operations last year (since data was gathered from days in 2014). The same data was also used to compare assumptions made by the team that performed the noise analyses for CDA and the FAA during the 2004 Environmental Impact Statement (EIS) study.

3.1 NOISE CASE STUDY CONTRUCTION METHOD

The construction of INM cases was carried out re-using the flight tracks developed for the EIS study but loading these tracks according to observed flights tracks obtained from the flight track data provided to the Joe DelBalzo and Associates (JDA) team. Whenever necessary, we adjusted the flights tracks to reflect observed conditions. Similarly, we varied the number of daytime and nighttime operations in the noise simulations to reflect current ORD operating conditions. INM models were produced in INM version 7.0d. Figure 7 illustrates the methods used to construct INM models. Another important factor in the study is the aircraft fleet mix operating at the airport and more specifically, operating from each runway. These conditions were carefully studied in the data provided and appropriate flight operation files were prepared in INM to reflect the most recent ORD operating conditions. The following sections provide more insight on this.



Typical ORD Day Today (One year of data)

Runway	ARR	DEP	Day Arr	Night Arr	Day Dep	Night Dep	Day Ops	Night Ops
10C	9.7	0.2	9.8	9.4	0.0	1.3	0.0	5.7
10L	1.9	11.7	1.1	7.5	12.0	9.6	0.1	8.5
14L	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1
22L	0.1	22.5	0.1	0.0	23.4	14.3	0.1	6.6
27L	32.0	0.1	30.8	41.3	0.0	0.7	0.2	22.6
27R	18.6	0.0	20.4	4.4	0.0	0.0	0.1	2.4
28C	23.6	0.6	23.9	21.3	0.2	4.3	0.1	13.5
28R	1.2	44.7	0.2	9.4	44.1	49.7	0.2	27.9
32L	0.0	8.7	0.0	0.0	9.0	5.6	0.0	2.6
32R	0.0	1.4	0.0	0.1	1.2	3.5	0.0	1.6
4L	0.0	1.6	0.0	0.0	1.4	2.5	0.0	1.2
4R	0.1	0.0	0.1	0.2	0.0	0.0	0.0	0.1
9L	8.8	0.0	9.7	1.8	0.0	0.0	0.0	1.0
9R	3.7	8.5	3.9	2.8	8.5	8.4	0.1	5.4
14R	0.2	0.0	0.0	1.6	0.0	0.0	0.0	0.8
22R	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.1

Figure 7: Method to Construct an INM Case Study.

3.2 DAYTIME VS NIGHTTIME OPERATIONS

The number of daytime and nighttime operations is one of the most critical aspects of any noise study. Nighttime operations are weighted more heavily than daytime operations. In fact, the day-night average sound level DNL metric used in the US weighs ten times more in a logarithmic scale – each nighttime operation compared to a daytime operation. Nighttime airport operations occur between 10:00 PM and 7:00 AM. Daytime operations occur between 7:00 AM and 10:00 PM.

Analysis of the flight track data indicates that 10.5% of the operations at ORD occur at night. This number was checked against one year of runway use monthly reports published by CDA. We also verified the number against one year of FAA Aviation Systems Performance Management system data (FAA 2015). In all cases, we arrived to the same conclusion. To understand how airline schedules related to the number of night operations at the airport, we also examined airline schedules contained in the Official Airline Guide (OAG) for years 2004, 2007, 2010 and 2014. Our observation is that airlines schedule 8.5% of their flights as nighttime operations at ORD. However, because airline schedules are disrupted by daily activities with flights across the network, the number of flights that end up arriving or departing beyond 10:00 PM increases the percent of nighttime operations at the airport. Moreover, the OAG does not consider cargo flights, many of which are performed at night. Note that network delay effects due to weather, mechanical failures, and crew scheduling issues at other airports do not depend on the runway or gate capacity of ORD. Hence adding runway capacity to ORD in the future will not eliminate many of the causal factors that induce late flight arrivals and departures to the airport.

Figure 8 illustrates the percent of nighttime operations for various noise analyses performed in the past. In the EIS Baseline 2002 study as well as in two related studies (called Phase 1 and Phase II), the number of nighttime operations assumed in the noise input files was 7.7% and 7.3%, respectively.

For the O'Hare Modernization Program (OMP) final configuration (called Alternative C in the FAA posted INM files) and in the recent 2015 airport re-evaluation, the number of nighttime operations were 5.6% and 5.1%, respectively. Such low levels of nighttime operations need to be re-examined. To our knowledge, ORD has never operated with 5-6% nighttime operations. The analysis points out that both the 2015 re-evaluation and the OMP EIS noise contour development assumed unrealistic numbers of nighttime operations at the airport. Table 1 shows the absolute numbers of daytime and nighttime operations assumed in each noise study. For completeness, the table shows the number of daytime and nighttime operations derived from CDA flight track data and from CDA runway use reports published monthly. In the noise study, we employed 10.5% of nighttime operations for the airport.

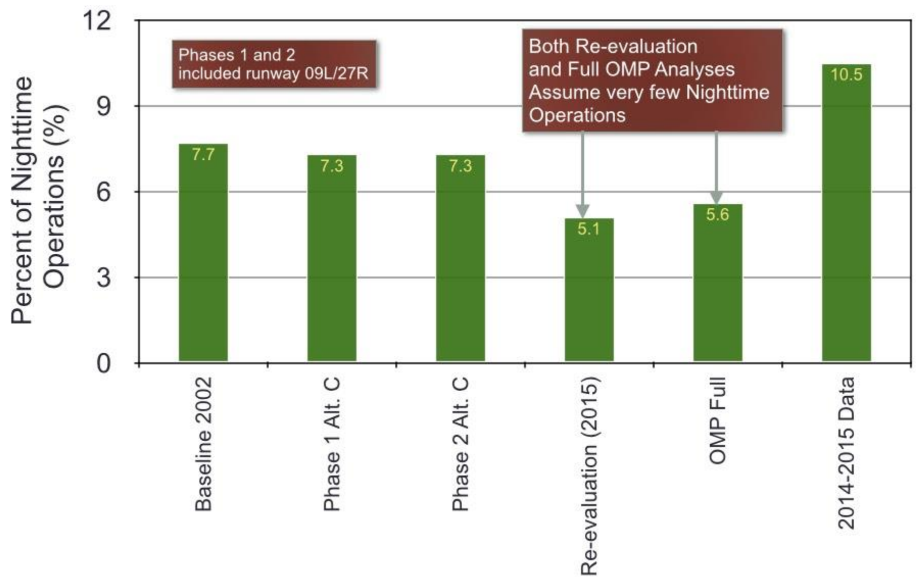


Figure 8: Percent of Nighttime Operations for Various INM Analyses.

Table 1: Daytime and Nighttime Operations for Various Noise Studies and for Flight Track Data.

Noise Study or Data Source	*Daytime Operations*	*Nighttime Operations*	*Total Operations*	*Percent Daytime Operations (%)*	*Percent Nighttime Operations (%)*
Baseline 2002	2334	194	2528	92.3	7.7
EIS Phase 1 Alternative C	2607	205	2812	92.7	7.3
EIS Phase II Alternative C	2607	205	2812	92.7	7.3
Re-evaluation 2015 with 10R/28L	2670	142	2812	94.9	5.1
Re-evaluation OMP (2020) with 10R/28L	2665	147	2812	94.9	5.2
Full OMP (EIS)	2898	172	3070	94.4	5.6
Modified OMP (JDA)	2749	321	3070	89.5	10.5
30 Days of CDA Data	2128	235	2363	90.1	9.9
CDA Monthly Reports (1 year)	2129	249	2378	89.6	10.5

3.3 CHICAGO O'HARE AIRPORT FLEET MIX

The fleet mix operating at ORD was estimated using 30 days of CDA flight track data. The data shows the 38 most popular aircraft operating at ORD. The aircraft, presented in

Appendix 2, were used in the noise analysis and are identified by their INM model designation (see column 1 in the table presented in Appendix 2). ORD is a unique airport due to its large number of regional jet operations. According to 70,900 flights examined for the study, 60.6% of the flights operating at ORD are regional jets with capacities less than 115 seats. Moreover, 39% of regional jet operations at the airport have fewer than 55 seats. The bulk of the small regional jet operations are carried by Embraer 135/145 and Bombardier CRJ-200 aircraft. This is significant because small regional jets add significant number of operations yet they maintain the passenger enplanements relatively low. For example, last year Atlanta Hartsfield-Jackson International Airport (ATL) and Chicago O'Hare had almost the same number of operations. However, ATL had 38% more passenger enplanements because of its larger average seating capacity per flight.

The trends of regional jet operations at the airport are shown in Figure 9. During the last decade, ORD experienced a rapid growth in the number of flight operations performed by small regional jets (55 seats or less). Such operations peaked in the year 2010 with 43% of the daily departures per day performed by small regional jets. In the last four years, the number has decreased to 39% of departures performed by small regional jets.

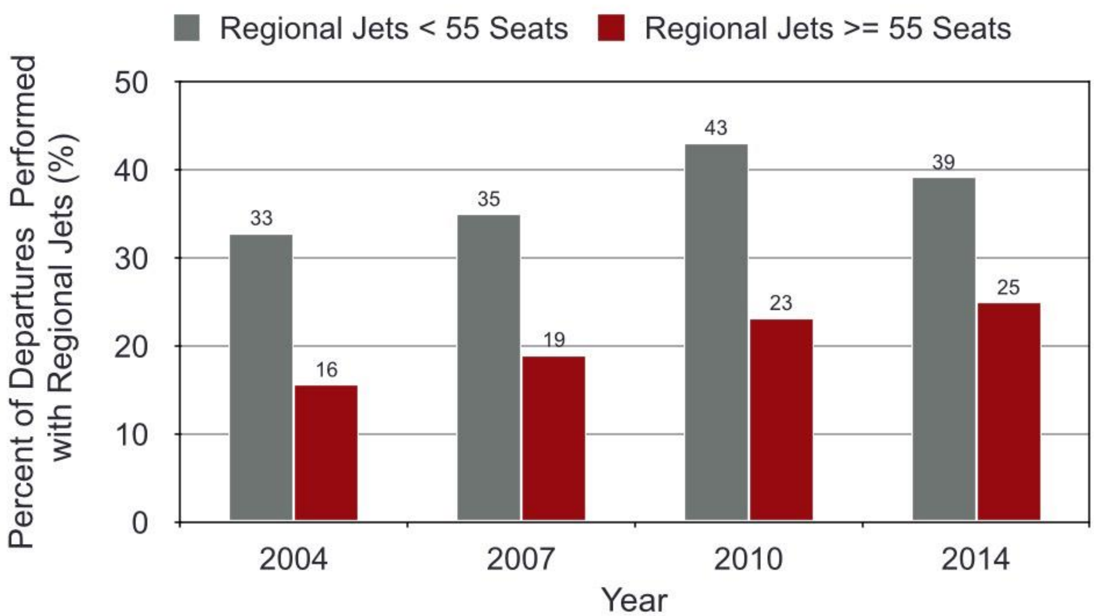


Figure 9: Trends in Regional Jet Operations at Chicago O'Hare International Airport. Source of Data: Official Airline Guide.

Recent trends indicate that airlines nationwide are deploying larger regional jets (with more than 55 seats) such as the Embraer E170/175/E190 and Bombardier CRJ-700/CRJ-900. This trend is nationwide but affects ORD because many of the smaller regional jets are being retired by regional and national carriers. Figure 9 indicates a growing trend of large regional jets at ORD in the past decade. In the year 2004, 16% of the departures at

ORD were performed using regional jets with more than 55 seats. Today, large regional jets are responsible for 25% of the departures at the airport.

Many of the key assumptions made during the EIS OMP noise study in 2004 relate to aircraft size in the future. The ORD airport fleet mix that has evolved in the last decade perhaps in ways the EIS study could not anticipate. For this reason, we also examine the average seating capacity of flights at ORD today. Figure 10 shows the seating capacity of domestic, international and all flights at ORD. Since regional jets are such large percent of the operations at ORD, the average seating capacity of flights is modest at 97 seats per departure today. Note that according to the data presented in Figure 10 the average seating capacity at ORD actually decreased from 109 seats to 97 seats per departure in the last decade. Year 2010 had the highest concentration of small regional jets at the airport and this fact decreased the average seat per departure to a record low of 93 seats per flight. The retirement of many small regional jets in the past 4 years is showing a small but positive trend in the average aircraft seating capacity at the airport. This is significant because, in general, larger aircraft tend to generate more noise. This factor will be explored in the noise analysis presented in the following sections.

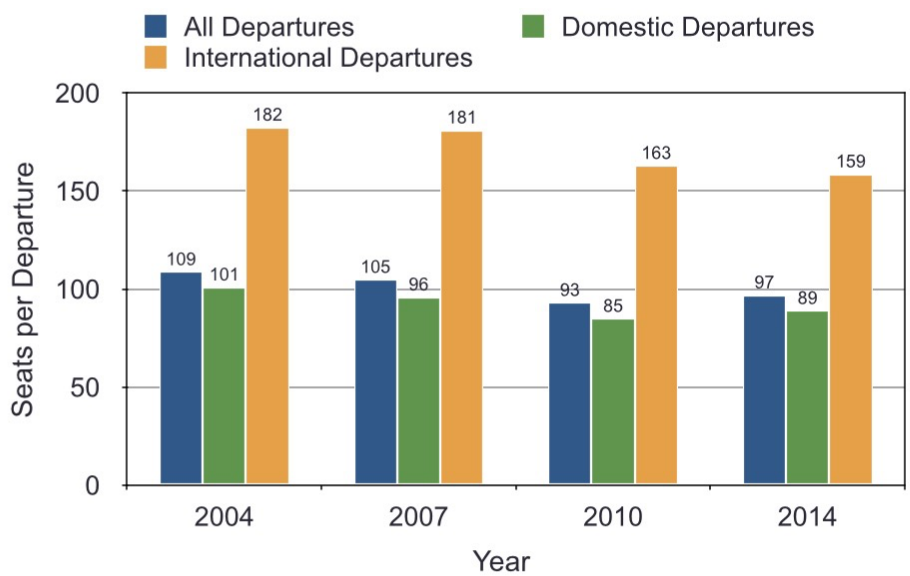


Figure 10: Trends Aircraft Seat Capacity at Chicago O'Hare International Airport. Source of Data: Official Airline Guide.

4. COMPUTER NOISE MODELING AND ANALYSES

This section presents pertinent noise analysis conducted by JDA to:

a) To verify and re-evaluate assumptions of the original Environmental Impact Statement analysis conducted by the Federal Aviation Administration (FAA) and Chicago Department of Aviation (CDA)
b) To establish a baseline noise model of the operations at O'Hare today

c) To perform a noise analysis of the potential noise contours when runway 10R/28L is commissioned in the Fall 2015
d) To produce various mitigation strategies to reduce noise for some communities around ORD International Airport

All of the noise analyses presented in this section use the same atmospheric conditions to facilitate comparisons. The airport atmospheric reference values used are: temperature (59 deg. Fahrenheit), humidity (70%), atmospheric pressure (29.92 inches of Mercury) and headwind (8 knots). All runs were made with the Integrated Noise Model (INM) Noise Power Distance (NPD) flag turned on and the analysis used refinement level 12 with a tolerance of 0.10. We used the INM version 7.0d.

4.1 EIS 2002 BASELINE NOISE ANALYSIS

The FAA, CDA and their engineering contractors developed noise contours for ORD using the fleet mix operating at the airport in 2002. The EIS study was published in 2004 and the noise files made available a few years ago. We examined these files in order to understand the rationale of the original noise contour development. A few changes to aircraft designations (no changes to fleet mix) brought these files in compliance with INM version 7.0d. The JDA team ran the 2002 baseline scenario using INM 7.0d. The results are shown in Figure 11: Baseline 2002 Noise Contours at ORD Airport. It is important to note that the original noise analysis runs during the EIS analysis used INM 6.

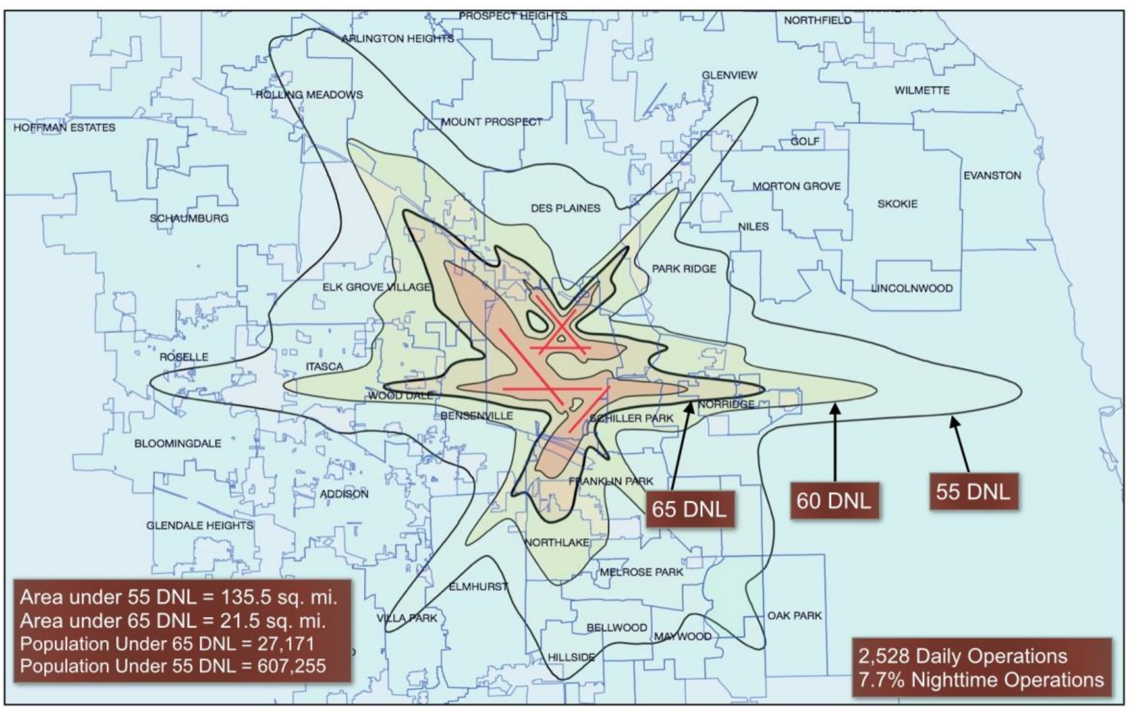


Figure 11: Baseline 2002 Noise Contours at ORD Airport. 2528 Daily Operations.

The baseline airport configuration in 2002 used the original ORD airport configuration with three sets of parallel runways for a total of six runways in use. Figure 12 shows the Baseline 2002 noise contour for the airport. With 2,528 daily flights, using the ORD fleet mix of 2002 produces a 65 DNL contour of 21.5 square miles. The percent of nighttime operations assumed in the analysis shown in Figure 11 is 7.7%. Using the Census population data for the year 2010 the 65 DNL contour would affect 27,171 people living in the neighborhoods around the airport. Figure 12 shows more detail of the Baseline 2002 contours with special emphasis on the 65 DNL level boundary.

The noise patterns before the O'Hare Modernization Program shows a very characteristic star-shape contour. At the time, the airport had three distinct runway orientations. The 65 DNL contours extended well into Elk Grove Village on the NW corner of the airport due to modest use of runways 32R (2.8%) and 32L (0.8%). In its original configuration, runways 27L and 27R handled 13.3% and 4.2% of the traffic, respectively. Runways 09R and 09L were used 10.6% and 8% of the time, respectively. Runways 22L and 22R were used 14.1% and 9.5% of the time, respectively. Runways 04R and 04L were used 7.6% and 5.8% of the time, respectively. This points out that back in 2002, the airport used all three runway orientations depending upon wind conditions.

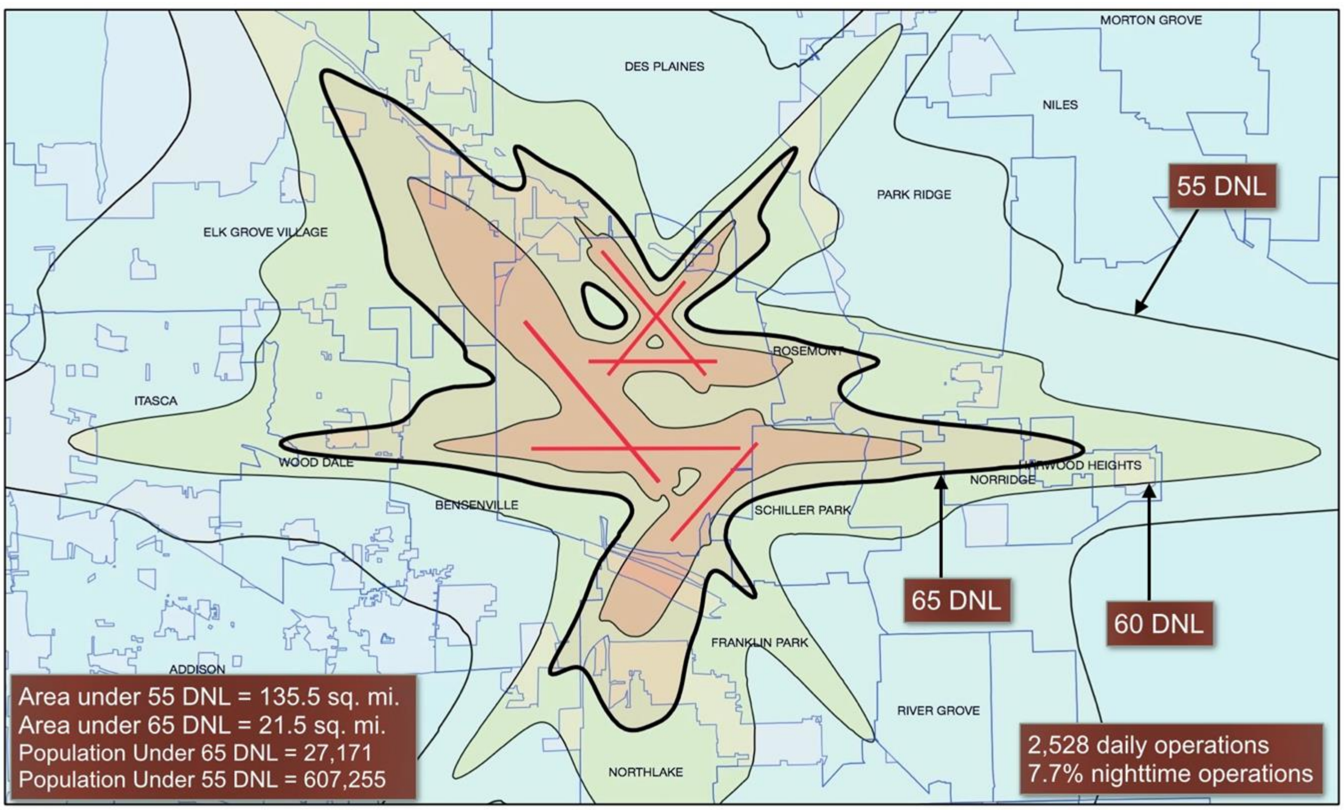


Figure 12: 65 DNL Detail of Baseline 2002 Noise Contours at ORD Airport. 2528 Daily Operations.

The aircraft fleet mix used in the Baseline 2002 EIS analysis is summarized in Appendix 3. According to the fleet mix used, 24.4% of the flights at ORD were performed by regional jets with fewer than 55 seats. Similarly, commercial aircraft with more than 90 seats and fewer than 160 seats accounted for 50.3%. Heavy aircraft and Boeing 757 aircraft (including cargo aircraft) made up 21.4% of the fleet in the year 2002. Corporate aircraft and small turboprops made up the remaining 4.5% of the fleet. Appendix 3 shows a significant number of aircraft that no longer operate at ORD or in the United States (e.g., Fokker F100-65, BAE-146, DC9-30 and DC9-50). Similarly, the number of operations assigned to “noisy” aircraft are substantial. For example, MD-80, MD-82 and MD-88 have a stronger noise signature compared to newer generation of Boeing 737 and Airbus A320 family aircraft. Similarly, DC9-30 and DC9-50 have very large noise footprint compared to the newer generation aircraft with more than 120 seats.

The construction of the ORD Baseline 2002 noise file employed 6550 tracks with a total of 156,200 segments. By comparison, Alternative C in the EIS used 1194 tracks and 33,114 track segments. In other words, the Baseline 2002 case has more detail in the construction of the tracks than Alternative C EIS presented later in this section. This is expected because the OMP runway configuration is simpler and because in the modeling of a future operation, many assumptions and hence simplifications, need to be made.

4.2 EIS CONSTRUCTION PHASE II ALTERNATIVE C ANALYSIS

The FAA, CDA and their engineering contractors developed a variation of the ORD noise contours to understand the impact of commissioning runway 9L/27R. This configuration assumed a rapid growth in demand at the airport from 2,538 daily flights in 2002 to 2,812 by the year 2007. This growth did not occur due to security impacts and trends in the economy. The noise configuration is relevant to understand the shift in noise contours from a star-configuration back in 2002 to an East-West configuration today. Figure 13 shows the Phase II noise contour for the airport. Phase II estimated 2,812 daily flights with 7.3% nighttime operations. The analysis used an aircraft fleet mix reflecting newer aircraft types at the airport expected in 2007 (i.e., the year when Phase II was expected to be implemented). The JDA noise analysis produces a 65 DNL contour area of 20.6 square miles as shown in Figure 13.

Using the Census population data for the year 2010 the 65 DNL contour in Phase II would affect 23,114 people living around the airport. The 55 DNL contour was estimated to be 123.1 square miles. The 65 DNL contour clearly shows the influence of runway 09L/27R in the Northside of the airport with the creation of a new horizontal noise “branch” in the middle of Park Ridge. A comparison of the Baseline 2002 and Phase II noise contours is shown in Figure 14. Note the substantial reduction in the noise footprint over Elk Grove Village. The graphic shows the slow shift in the noise contours from a star-pattern to an East-West noise footprint. It is important to remind the reader that Phase II traffic levels predicted in the EIS did not occur at the airport. According to the latest FAA Terminal Area Forecast (TAF) for ORD, the levels of traffic predicted in the Phase II contour development will not occur at the airport until the year 2031.

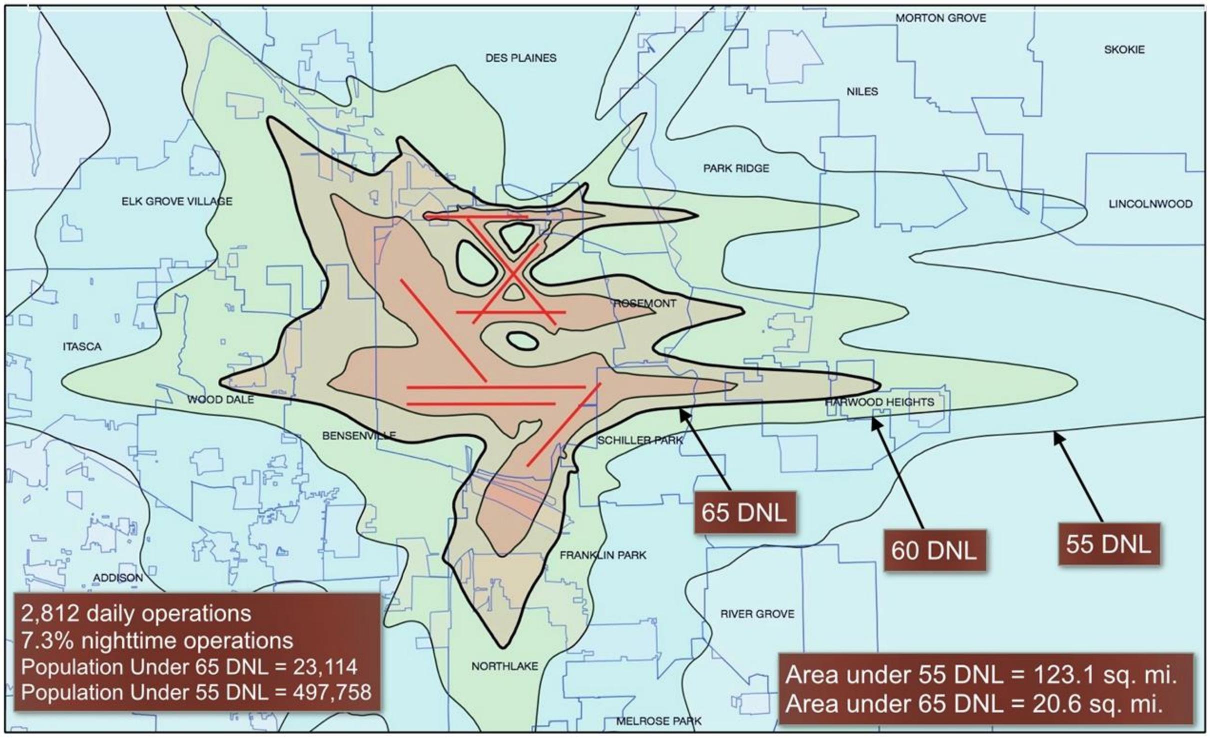


Figure 13: Phase II Noise Contours for ORD Airport. This Airport Configuration was Studied to See the Impact of Runway 09L/27R. 2812 Daily Operations.

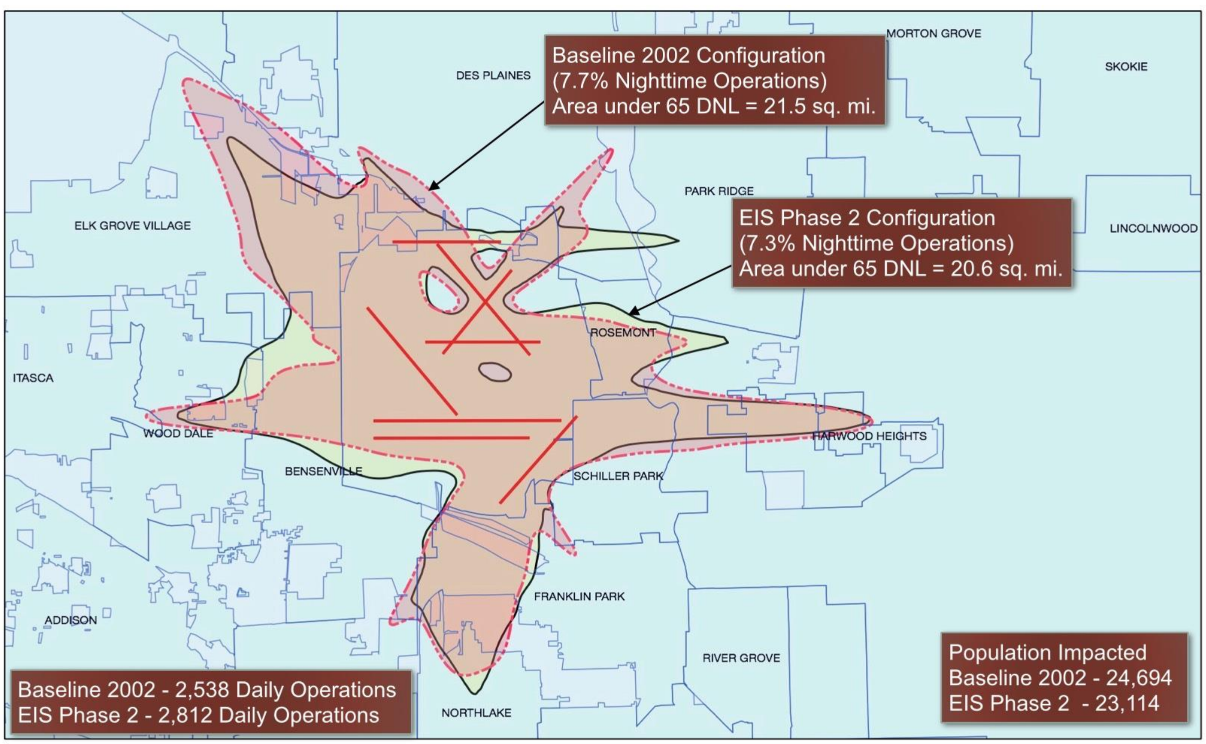


Figure 14: Comparison of 65 DNL Noise Contours for Baseline 2002 and Phase II.

The aircraft fleet mix used in the Phase II EIS analysis is summarized in Appendix 4. According to the fleet mix used in Phase II noises analyses, 33% of the flights at ORD would be performed by regional jets with fewer than 55 seats (as modeled in the EIS Phase II). Similarly, commercial aircraft with more than 90 seats and fewer than 160 seats account for 52%. Heavy and Boeing 757 aircraft (including cargo aircraft) made up 11.5% of the fleet. Corporate aircraft and small turboprops made up the remaining 4.5% of the fleet.

4.3 TODAY 2014-2015 ORD NOISE CONTOUR

JDA developed noise contour for the airport using various sources of data explained in Section 1 of the report. The contours developed in our analysis reflect two major runway operational shifts at the airport in the year 2014:

a) Implementation of new Converging Runway Operation (CRO) rule at the airport (FAA 2015); and
b) Closure of runway 32L for maintenance over a period of several months.

The implementation of the CRO rule at ORD limits the future use of runway 32L as an alternative departure runway during daytime operations. This is shown in Figure 15. The left hand side of the figure illustrates heavy use of Runway 32L before the CRO rule. The right hand-side of Figure 15 illustrates the typical day of West Flow operations at the airport today, with little or no use of runway 32L. The impact on airport capacity is very significant and from the noise stand point, the communities to the West and South of the airport are exposed to greater number of departures conducted from runways 28R and 22L.

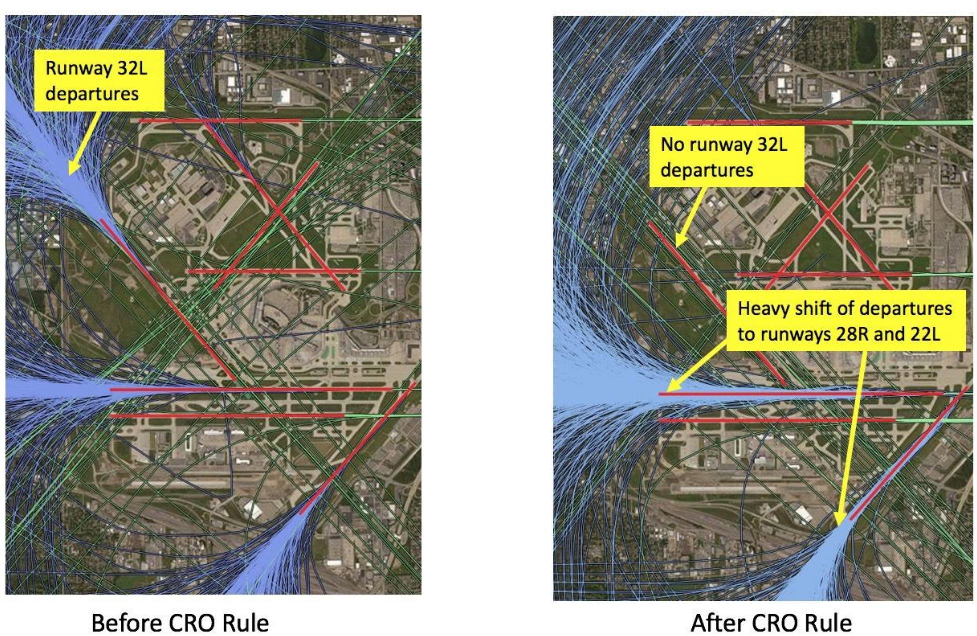


Figure 15: Chicago O'Hare Shift in Operations Due to Converging Runway Operation Rule.

Figure 16 shows the ORD noise contour using runway use data spanning from May 2014 to April 2015. The runway use data has been obtained from CDA public records (CDA, 2015). The estimated average daily flight demand at ORD during that period was 2,378 daily flights. According to the analysis, the 65 DNL contour area is estimated to be 12.5 square miles. Using year 2010 population Census data, the 65 DNL contour affects 13,636 people. The 55 DNL contour affects 308,031people. Figure 17 shows more detail of the contours for communities around ORD.

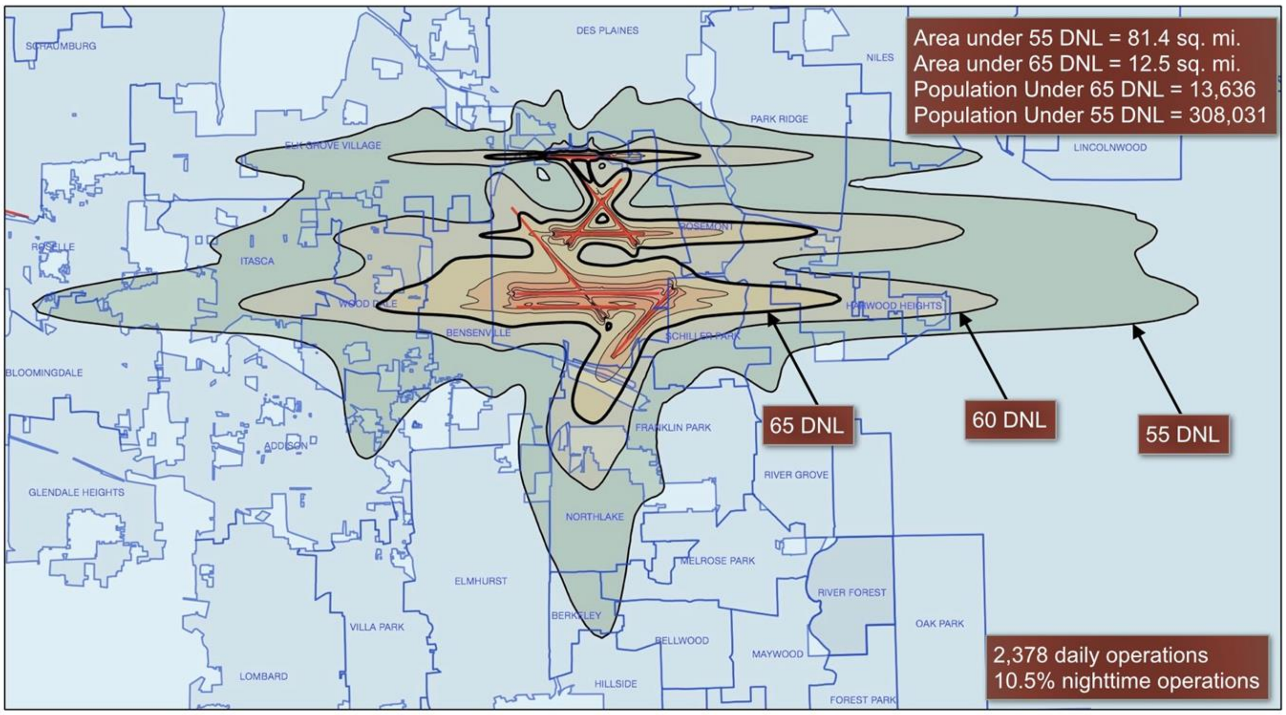


Figure 16: May 2014-April 2015 ORD Noise Contours. 2378 Daily Operations. This Contour Uses the Observed 10.5% Nighttime Operations at ORD.

The relative small noise contour produced is a result of two important trends at the airport: a) the large number of small regional aircraft and b) fewer operations compared to the EIS forecast made a decade ago. ORD has a disproportionate number of regional jet operations (60.6%) in comparison with other large hub airports in the US. This fact has an important characteristic in relation to noise: it exposes the population to “weaker”, yet more frequent, noise events. In general, regional jets generate smaller noise footprints than larger commercial aircraft such as the Boeing 737 and Airbus A320 class vehicles (see Figure 18). Noise contours account for both the frequency and the magnitude of the noise produced by individual flights.

The aircraft fleet mix used in the 2014-2015 noise contour analysis is summarized in Appendix 5. According to the fleet mix shown in the table, 60.6% of the flights at ORD were performed by regional jets. Similarly, commercial aircraft with more than 90 seats and fewer than 160 seats accounted for 29.2% of the flights. Heavy and Boeing 757 aircraft (including cargo aircraft) made up 8.4% of the fleet. Corporate aircraft and small turboprops made up the remaining 2% of the fleet.

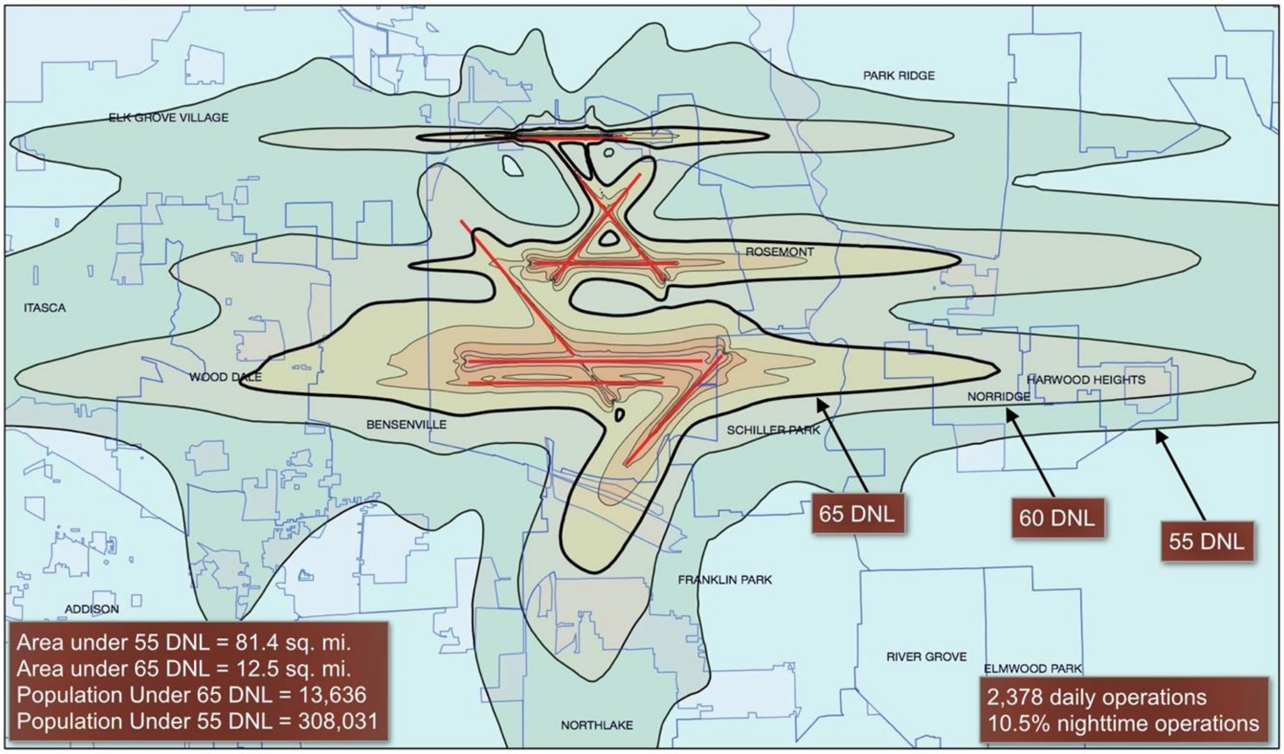


Figure 17: Detail of May 2014-April 2015 ORD Noise Contours. 2378 Daily Operations. This Contour Uses the Observed 10.5% Nighttime Operations at ORD.

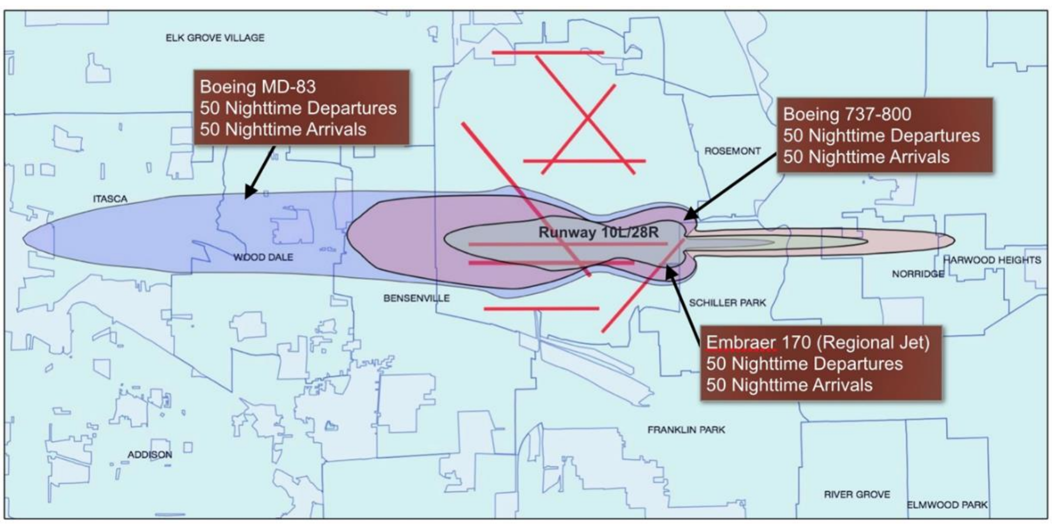


Figure 18: Comparison of 65 DNL Noise Contours Generated by 50 Nighttime Arrivals and 50 Nighttime Departures for Three Distinct Aircraft: Boeing MD-83, Boeing 737-800 and Embraer 170 (Regional Jet).

4.4 FAA O'HARE RE-EVALUATION NOISE ANALYSIS

The original EIS Modernization Plan developed by CDA and FAA in 2005 did not consider interim runway conditions at the airport. The primary focus of the original EIS study was an estimation of the noise impacts for a final six parallel runway configuration oriented East-West and two crosswind runways oriented Northeast-Southwest (4R/22L and 4L/22R). Because of the large period of time between the original EIS noise analysis and the actual implementation of new runways, many of the original assumptions made in 2004 (when the original EIS study was performed) may no longer apply.

FAA commissioned a re-evaluation analysis in 2014. The new re-evaluation consists of airport simulations using the Total Airspace and Airport Model (TAAM) and INM noise analyses to understand the impacts to the airport performance and community noise exposure levels of interim runway configurations. The simulation results of the study are reported in two draft documents:

1) O'Hare Modernization EIS Written Re-Evaluation Simulation Data Package: Airfield with Runway 10R-28L, Draft Report, April 2015.
2) O'Hare Modernization EIS Written Re-Evaluation Simulation Data Package: Airfield with Runway 9C-27C, Draft Report, April 2015.

The JDA team had access to Appendix C of the Draft Re-Evaluation of the O'Hare Modernization EIS (2015). This appendix explains some of the noise analysis conducted for two interim configurations: a) 2015 and b) 2020.

The INM noise files for these re-evaluations are not available for scrutiny thus a full replication of the results is not possible. However, in the following sub-sections we provide some comments on the assumptions made in the re-evaluation study for the reader to understand how different assumptions can play a significant role in the outcomes of noise evaluations.

4.5 COMMENTS ABOUT ORD RE-EVALUATION ANALYSIS:

(Airfield with Runway 10R-28L interim condition 2015)

The Re-evaluation study models interim airfield conditions that were not reported in the original 2005 final EIS ORD report (Ricondo 2005). Appendix C of the Draft Re-Evaluation of the O'Hare Modernization EIS provides some context on how the noise analysis was done to insure consistency.

"For consistency between the EIS and this Re-Eval, the noise analysis here parallels the noise analysis of the interim conditions in the EIS, including following the same methodology, using the same noise model, and reporting comparable findings. (Ricondo, 2015)"

In the interim configuration, the airfield consists of five parallel runways oriented East-West (10R/28L, 10C/28C, 10R/28R, 9R/27L and 9L/27R), two runways oriented

Northeast-Southwest (4L/22R and 4R/22L) and a single runway oriented Southeast-Northwest (14R/32L). This runway configuration assumes runway 14L/32R has been decommissioned.

The analysis used flight records for calendar year 2014 provided by the City from O'Hare Airport Noise Management System (ANMS). This is the same source of the records employed by the JDA team for our noise evaluations. It is important to state that JDA had access to a sample set of 30 days of detailed track data. The Re-evaluation process looked at the new fleet mix operating at ORD during the year 2014. It noted that back in 2004 (when the EIS study was conducted), Phases 1 and 2 construction assumptions (i.e., forecasted demand year 2007) predicted 2812 daily operations at the airfield. However, the Re-evaluation noise analysis identified an average daily traffic of 2416 flights (1208 landing and takeoff cycles) reported by the facility in 2014.

The Re-evaluation study predicts a 65 DNL contour area of 10.1 square miles using the 2014 fleet mix at ORD. The original Phase I analysis with forecast demand for 2007 predicted 16.8 square miles of area for the 65 DNL level contour. The difference between the two contours is attributed to: a) a substantially different aircraft fleet mix and b) the larger number of flight operations between the two cases (2812 flights for Phase 1 2007 and 2416 flights for 2014 Re-evaluation analysis). The Re-evaluation study suggests that nighttime operations have increased at ORD (20 more nighttime events) compared to the assumptions made for Phases 1 and 2. These two facts are used to suggest that a conservative estimate of the interim contours can be made using the fleet mix employed for the Phase 1 analysis. The Re-evaluation study concludes:

"Because the Construction Phase I fleet will result in larger noise exposure contours for the interim conditions than those that would be generated by a newer, quieter fleet, its use in the Re-Eval will reflect a conservative but reasonable representation of the noise impacts for the interim conditions.

In our opinion, if the objective of a Re-evaluation is to predict the **"actual"** community noise exposure level conditions of the airport today, it seems unclear why would the study use an old fleet mix and a flight demand function that has not materialized at the airport in 2015. Appendix C recognizes that aircraft fleet mix and the number of night operations are two very important factors in shaping noise contours around an airport. In our opinion, using two inconsistent assumptions about critical noise model parameters to perform a Re-evaluation provides little evidence to enable an understanding of what the DNL levels around the airfield are today. In our opinion, using Phase 1 or Phase II 2007 demand assumptions and fleet mix assumptions do not provide equivalent conditions to the noise situation at ORD today.

Recommendation

The FAA Re-evaluation noise analysis should have reported noise contours using the actual aircraft fleet mix observed at the airport in the interim conditions 2015.

Recommendation

The FAA Re-evaluation noise analysis should have revised the number of nighttime operations used in the noise analysis for the airport interim conditions 2015.

4.6 FALL 2015 ORD NOISE CONTOURS WITH RUNWAY 10R/28L

Using the JDA developed reference noise contour using flight track data and CDA runway use profiles we developed a Fall 2015 noise contour with a new runway 10R/28L on the south. The runway operations on the new runway considered a few factors:

a) The new runway will be mostly operated during daytime conditions because a new ATC control tower will not be manned during most of the nighttime hours
b) The runway length of 7,500 feet limits the use of the new runway to regional jets and narrow body aircraft flying short to medium routes

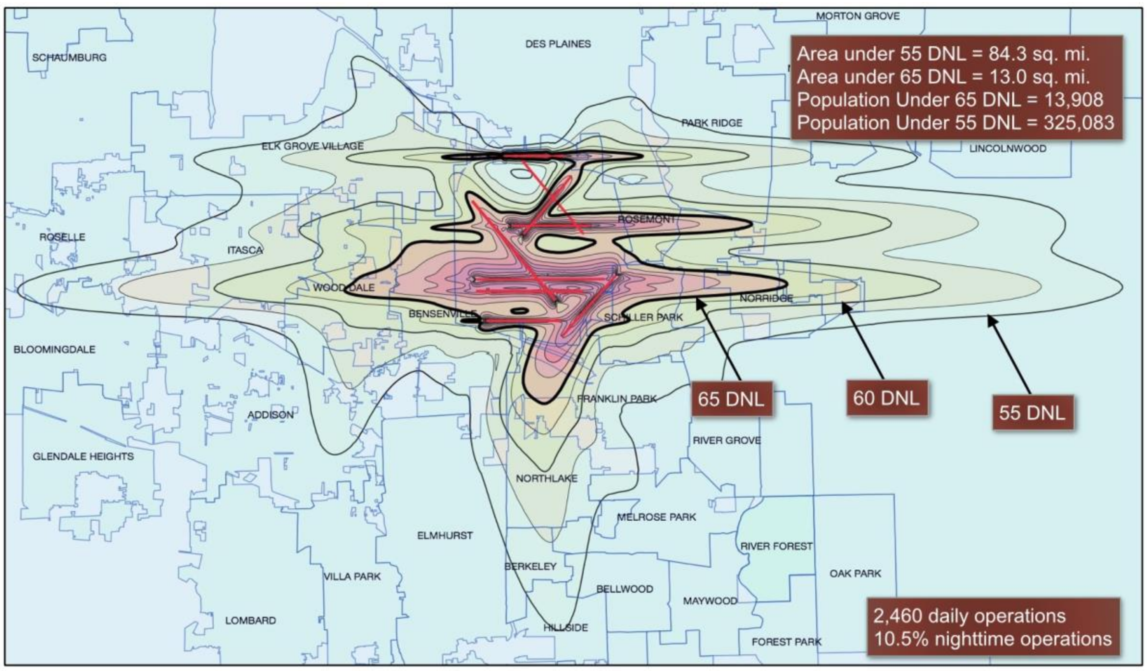


Figure 19: Predicted Fall 2015 ORD Noise Contours. 2460 Daily Operations. This Contour Assumes 10.5% Nighttime Operations.

Figure 19 shows the estimated noise contour for ORD after the commissioning of runway 10R/28L. The number of daily operations is estimated to be 2,460 flights of which 165 operations are assigned to the new runway. With the new runway load, the noise analysis produces a 65 DNL contour area of 13.0 square miles. Using year 2010 population Census data, the 65 DNL contour affects 13,908 people. The 55 DNL contour affects 325,083 people.

Because flight demand is uncertain, we performed variations in the flight demand to understand the rate of change of the 65 DNL contour area with flight demand. Figure 20 shows the potential noise contour for ORD after the commissioning of runway 10R/28L with 2,660 daily flights. This represents a future that according to the FAA TAF forecast would not be achieved until the year 2028 (see Figure 22). With the new runway loads, the noise analysis produces a 65 DNL contour area of 13.8 square miles. Using year 2010 population Census data, the 65 DNL contour affects 16,652 people. The 55 DNL contour covers 88.3 square miles and would affect 342,157 people.

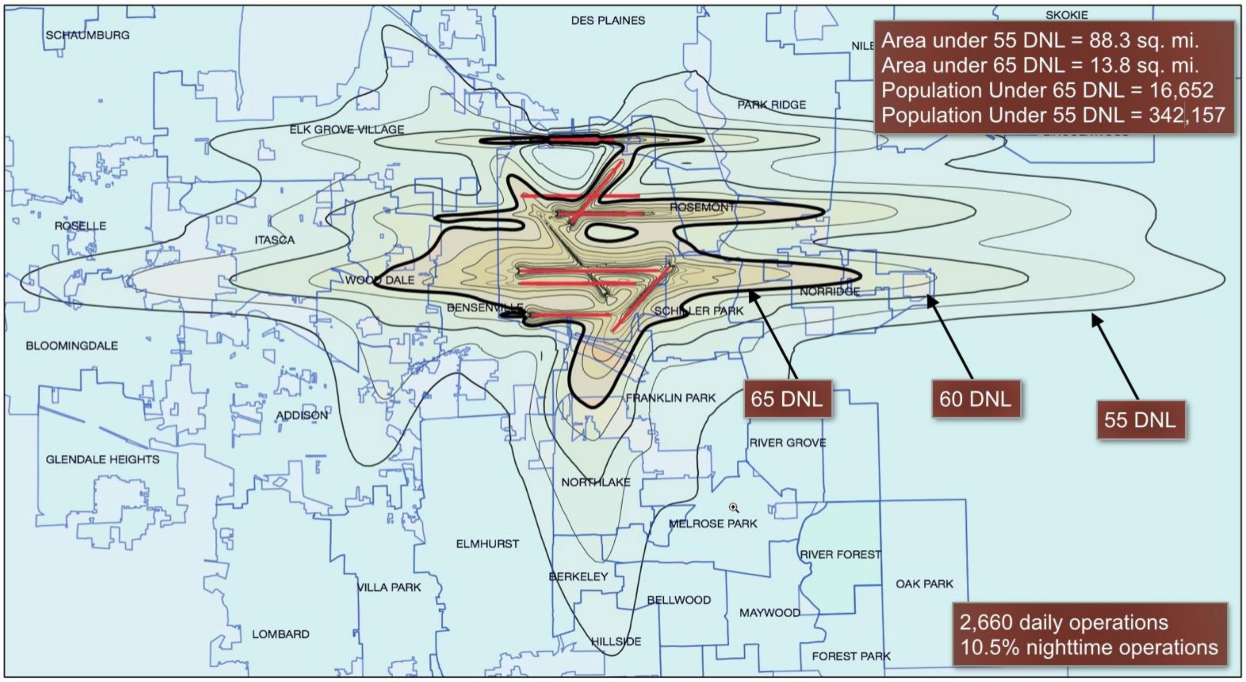


Figure 20: Potential ORD Noise Contours with Runway 10R/28L. 2660 Daily Operations. This Contour Assumes 10.5% Nighttime Operations.

The aircraft fleet mix used in the noise analysis for ORD configuration with runway 10R/28L is summarized in Appendix 6. According to the fleet mix shown in the table, 60.6% of the flights at ORD, were performed by regional jets. Similarly, commercial aircraft with more than 90 seats and fewer than 160 seats account for 29.2% of the flights. Heavy and Boeing 757 aircraft (including cargo aircraft) made up 8.2% of the fleet. Corporate aircraft and small turboprops made up the remaining 2% of the fleet. In the analysis, we consolidated two types of regional jets to be represented by the Embraer 145 (modeling regional jets with fewer than 55 seats) and the Embraer 170 to represent regional jets with more than 55 seats (i.e., Embraer 170/175/190 and Bombardier CRJ-700/900 family).

4.7 EIS O'HARE MODERNIZATION PLAN (OMP) NOISE CONTOURS

A task of the Environmental Impact Assessment Study (EIS) performed in the year 2004 included a detailed noise analysis for the airport using the final O'Hare Modernization Program (OMP) configuration with six parallel runways plus two crosswind runways (4R/22L and 4L/22R). The aircraft fleet mix used in the OMP EIS analysis is summarized in Appendix 7. According to the fleet mix forecast, narrow body commercial aircraft with more than 100 seats (Boeing 737, Airbus A320 and Boeing 717/MD80 families) will be the largest group of aircraft operating at the airport with 54.6% of the total fleet. Regional jets with 45-55 seat aircraft (CL601 and EMB145) will comprise 33.1% of the fleet mix. Heavy commercial aircraft (including cargo aircraft) will comprise 8.9% of the fleet. Corporate aircraft will make up the remaining 3.5% of the fleet.

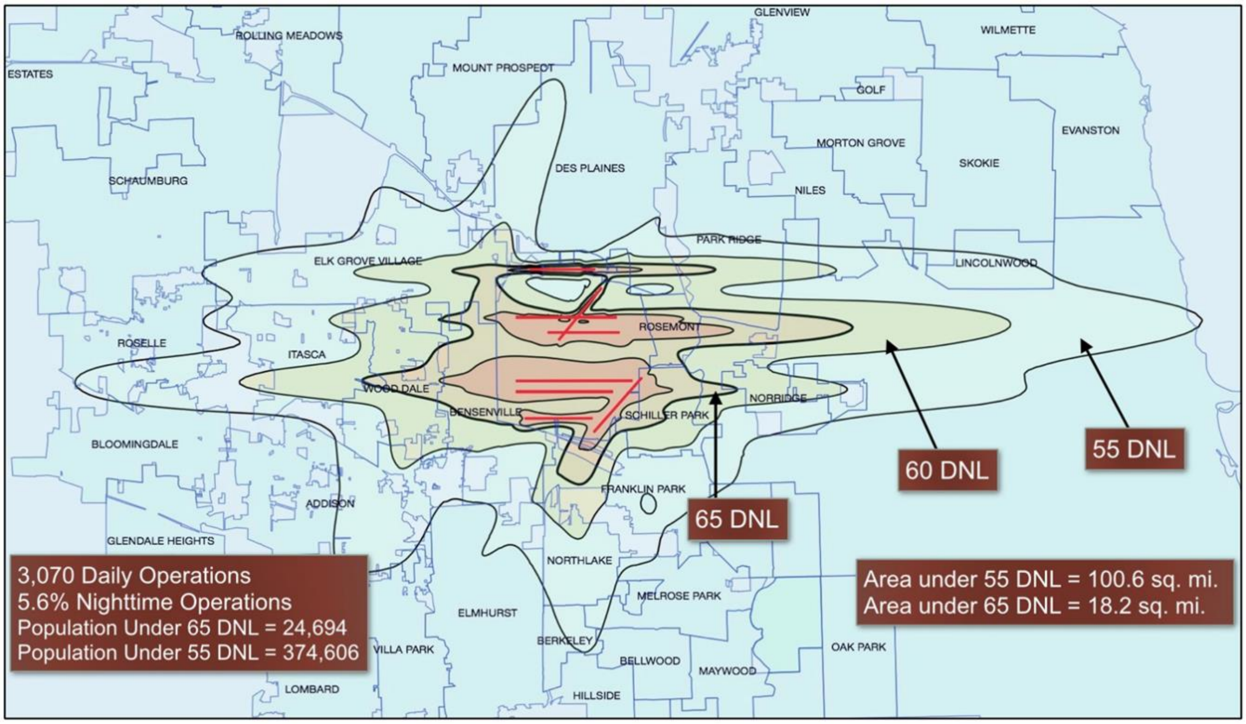


Figure 21: EIS OMP Noise Contours for ORD Airport. 3070 Daily Operations. 5.6% Nighttime Operations.

Figure 21 shows the contours predicted using 3,070 daily flights with 5.6% nighttime operations (172 flights). Figure 23 provides more detail of the 65 DNL level contours and the surrounding communities. The analysis provides a picture of what Chicago communities could expect in a future with high levels of demand. The analysis shows a 65 DNL contour area of 18.1 square miles. Using year 2010 population Census data, the 65 DNL contour would affect 24,694 people. The 55 DNL contour affects 374,606 people. These numbers are significant because they represent an increase of 77 percent in the number of people affected in the 65 DNL compared to our estimate of the Fall 2015 contours after the commissioning of runway 10R/28L.

The 65 DNL contour area is expected to increase by 39% between our estimate for Fall 2015 and when the demand reaches 3,070 daily operations (on an annual basis). According to the latest FAA Terminal Area Forecast (FAA 2015), Chicago O'Hare will not reach 3,070 average daily operations until the year 2038 as shown in Figure 22.

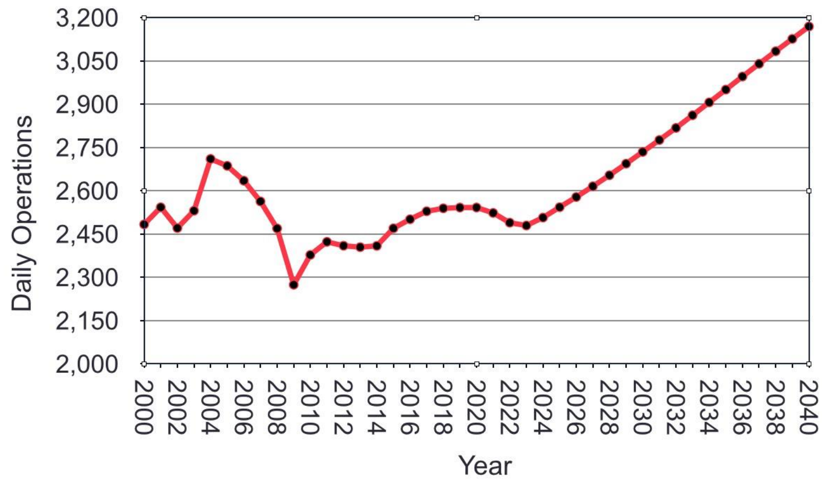


Figure 22: Average Daily Operations at ORD. Annual Operations in 2015 FAA Terminal Area Forecast Data Converted to Daily Operations.

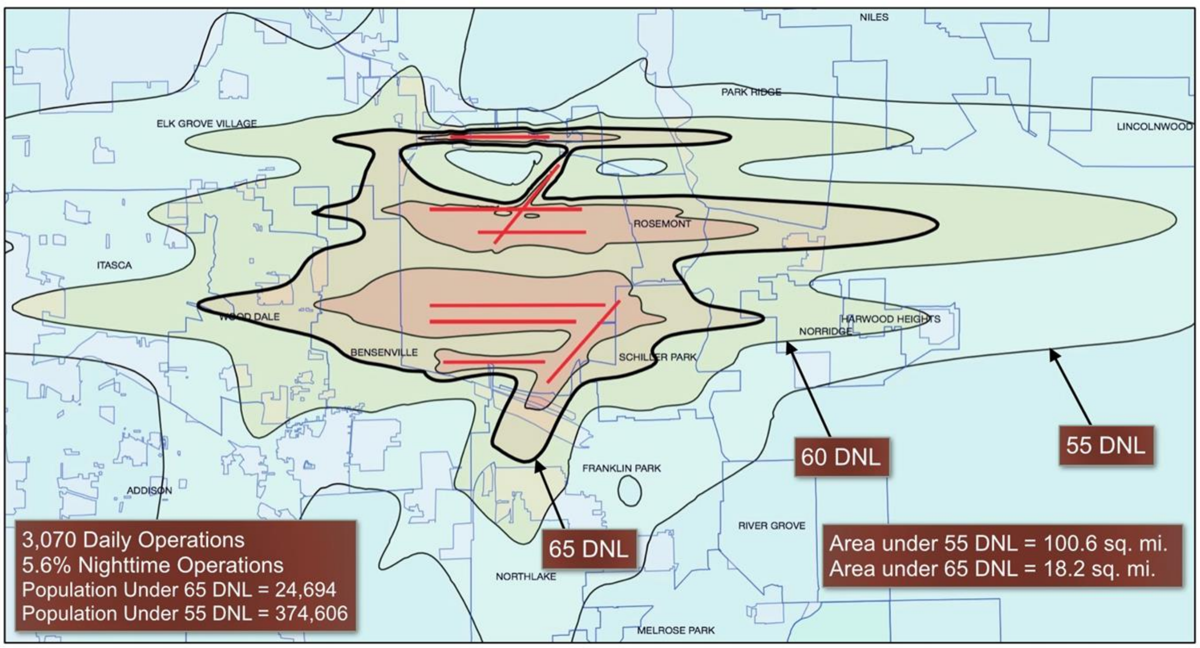


Figure 23: Detail of 65 DNL Noise Contours for ORD EIS OMP Airport Configuration. 3070 Daily Operations. 5.6% Nighttime Operations.

4.8 MODIFICATIONS TO OMP NOISE CONTOURS

At the time of the EIS 2004 analysis, the ORD fleet mix was different to the fleet mix operating today. As part of this study, we reviewed many of the assumptions made in the EIS noise study and we offer the following observations:

a) The percent of nighttime operations assumed in the original EIS OMP study was low and inconsistent with historical trends at ORD

b) The use of mostly small regional jets (such as the CRJ-200 and E145) is not consistent with the expected growth in passengers at the airport.

These observations are relevant because noise contours are influenced by the aircraft fleet mix operating at the airport. Moreover, in the calculation of day-night average noise levels (DNL), nighttime operations are weighted ten times more than daytime operations. Small changes in the number and spatial distribution of nighttime operations affects the noise contours significantly.

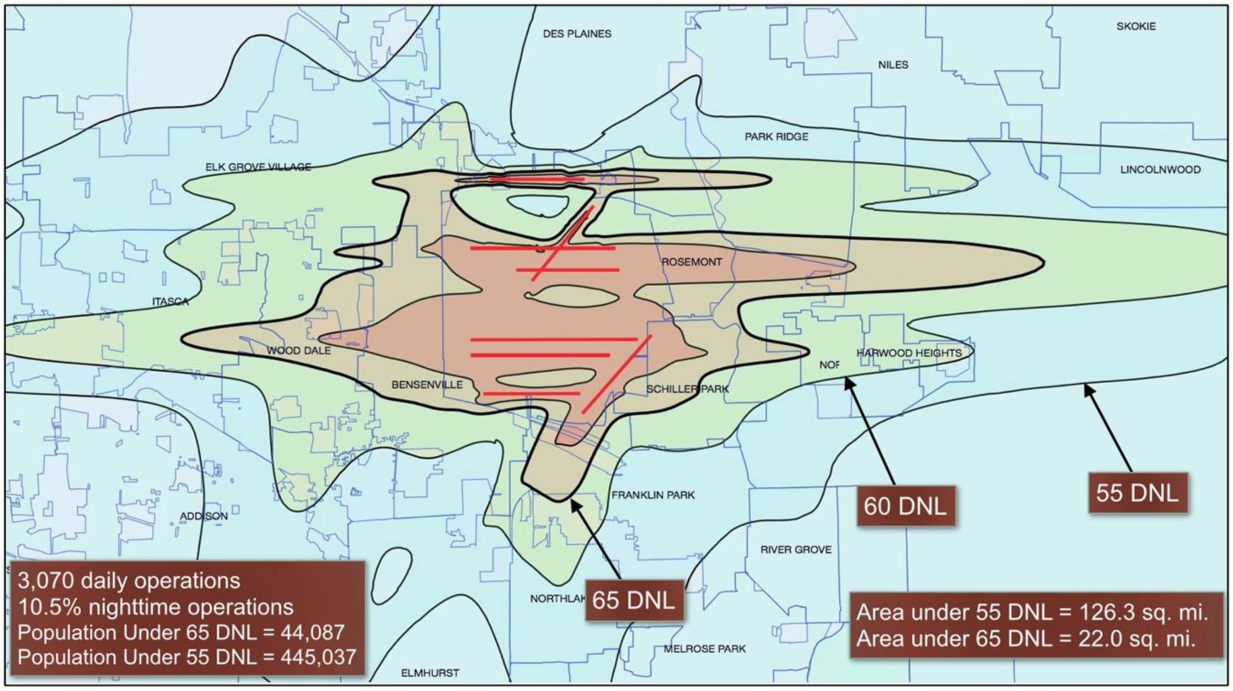


Figure 24: Detail of Modified 65 DNL Noise Contours for ORD Airport. 3070 Daily Operations. Modified Analysis Used EIS Fleet Mix but Assumed 10.5% Nighttime Operations.

To illustrate the point consider the revised OMP contours shown in Figure 24. The graphic shows a revised noise contour using the same OMP tracks, runway configuration and track loadings used in the EIS OMP study. The analysis uses a more realistic assumption of 10.5% nighttime operations. This has been the trend observed at the airport over the last few years. The new analysis shows a 65 DNL contour area of 22.0 square miles (an increase of 37% over the EIS OMP contours). Using year 2010 population Census data, the 65 DNL contour with 10.5% nighttime operations could affect 44,087 people (an increase of 79% compared to the OMP EIS contour). The 55 DNL contour could affect 445,037 people.

A second modification to the EIS OMP noise analysis is a revision to the future fleet mix for selected aircraft operating at the airport. The revisions are necessary because US carriers are changing their fleets to reduce the cost per seat-mile and to better match market demand. US airlines are also replacing many small regional jets (with fewer than 55 seats) with larger regional jets with 70-95 seats due to better operational economics of the larger aircraft. Larger regional jets include the Embraer 170/175/190 and Bombardier CRJ-700/900. Figure 9 shows the trends in regional jet size at ORD in the past decade. The EIS OMP noise analysis only considered smaller regional jets. The first fleet mix modification is to replace a fraction of the Bombardier CRJ-200 and Embraer 145 operations with larger regional jets (i.e., Embraer 170 and CRJ-900). Appendix 8 shows the aircraft fleet mix used in the modified OMP analysis. Note that regional jets still constitute 32% of the fleet. Narrow body commercial aircraft with more than 100 seats (Boeing 737, Airbus A320 and Boeing 717/MD80 families) will be the largest group of aircraft operating at the airport with 54.1% of the total fleet. Heavy and Boeing 757 aircraft (including cargo aircraft) will comprise 10.5% of the fleet. Corporate aircraft will make up the remaining 3.5% of the fleet.

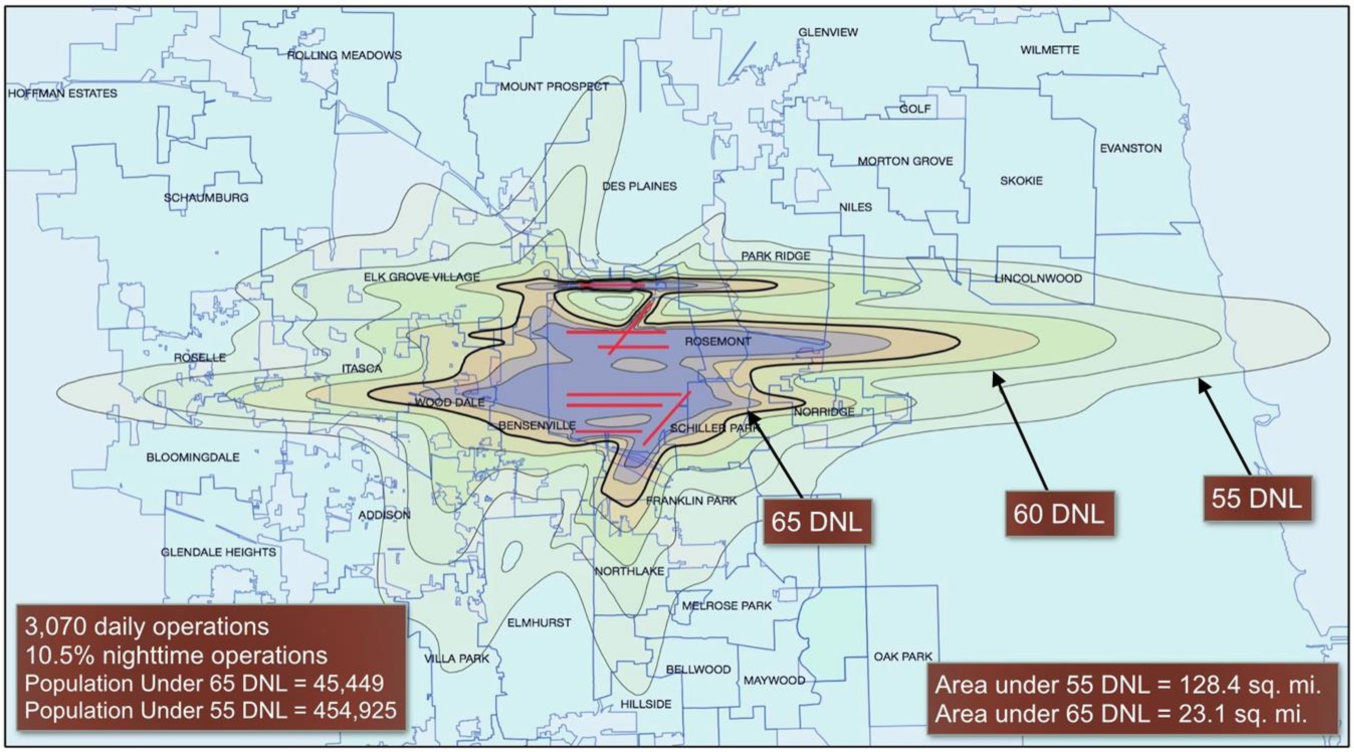


Figure 25: Modified OMP Noise Contours for ORD Airport. 3070 Daily Operations. 10.5% Nighttime Operations. Modified Analysis Used Larger Regional Jets.

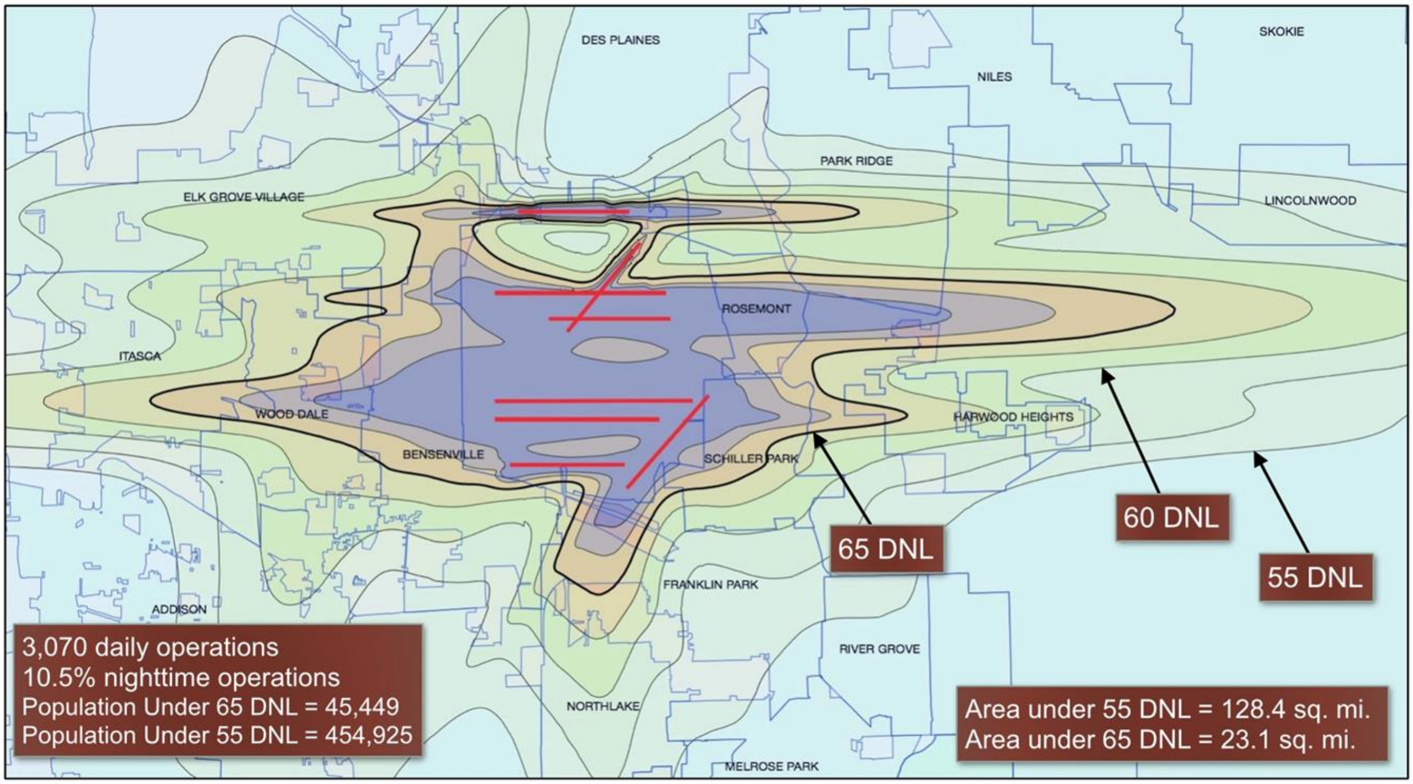


Figure 26: Detail of Modified 65 DNL Contour for ORD Airport. 2751 Daytime Operations, 319 Nighttime Operations. Modified Analysis Used 10.5% Nighttime Operations and Larger Regional Jets in the Future.

Modifications to the fleet mix OMP assumptions produce the noise contours shown in Figure 25. Note that the 55 DNL contour extends to Lake Michigan. The modified analysis shows a 65 DNL contour area of 23.1 square miles (an area increase of 28% over the 65 DNL EIS OMP contours). Using year 2010 population Census data, the new 65 DNL contour could affect 45,449 people (an increase of 84% compared to the OMP EIS contour). The 55 DNL contour would affect 454,925 people. Figure 26 shows more detail of the 65 DNL contour and the communities affected. Figure 27 compares the original EIS OMP contours and the modifications suggested by JDA. The communities to the East of the airport affected by the noise contour expansion are Schiller Park, Norridge, Park Ridge and to the greatest extent, the City of Chicago. Communities affected to the West of the airport are Bensenville, Wood Dale and Elk Grove Village. These communities have some of the largest numbers of overflights, as it will be described in the next section.

A comparative analysis between 65 DNL contours of the full OMP implementation and today's ORD conditions is shown in Figure 28. The figure illustrates an increase of 84.8% in the 65 DNL contour area compared to today's 65 DNL condition. The relative large increase can be attributed to several factors: a) a 29% increase in daily operations (from 2378 to 3,070 daily flights; b) an increase in the number of narrow body aircraft such as Boeing 737-800 and Airbus A320 families; and c) an increase in the number of large regional jets at the airport in the future.

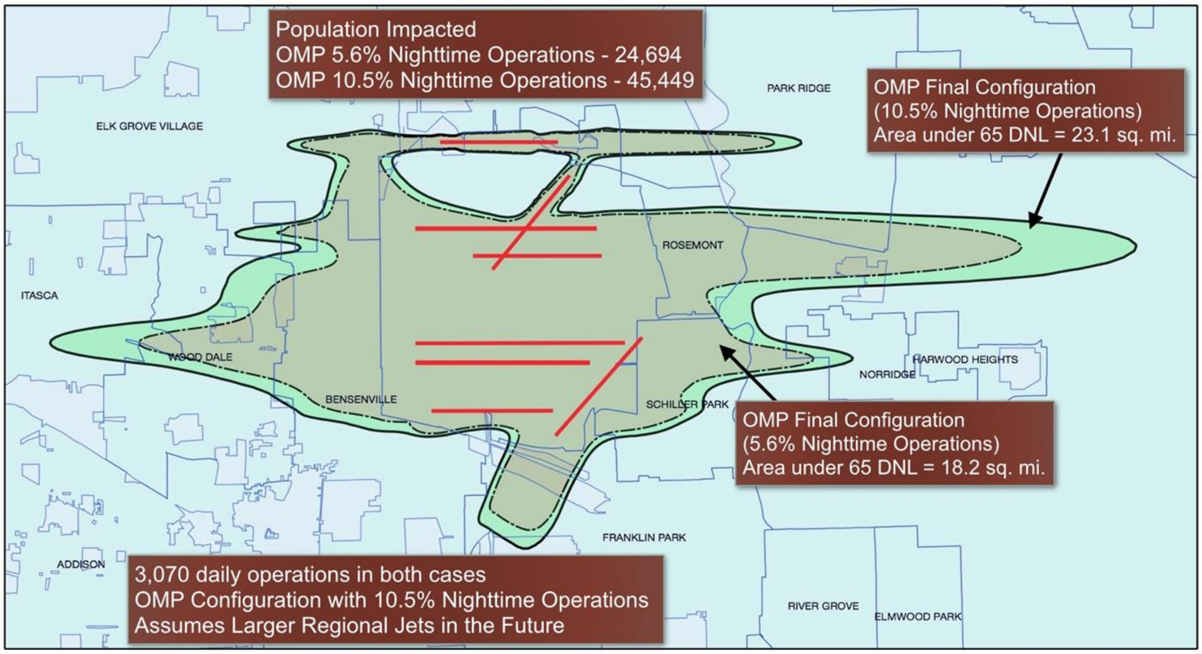


Figure 27: Comparison of Two Noise Contours at Full OMP Implementation for ORD Airport.

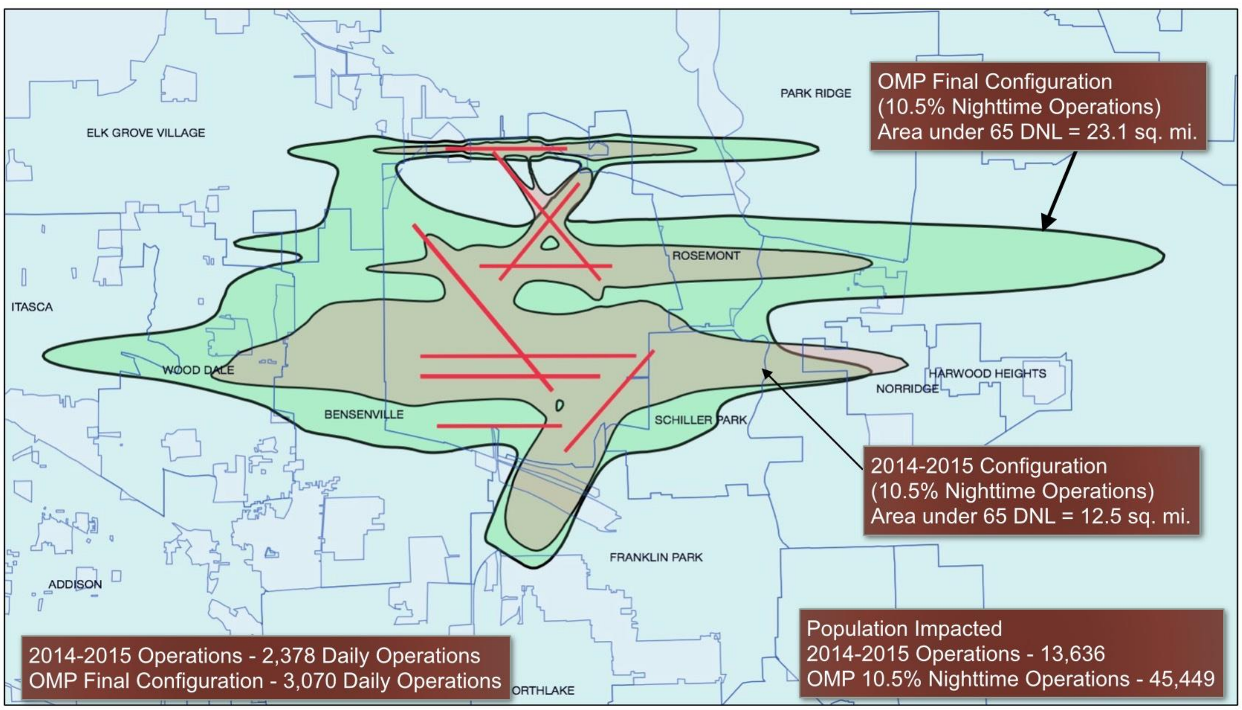


Figure 28: Comparison of 65 DNL Noise Contours for Full OMP Implementation and Today's ORD Condition (Using May 2014- April 2015 Fleet Mix Data).

Figure 29 compares the 55 DNL contours of the modified OMP runway configuration and Today's ORD configuration. According to our analysis, the 55 DNL contour area at full OMP implementation is expected to grow 36.7% compared to today's airport condition.

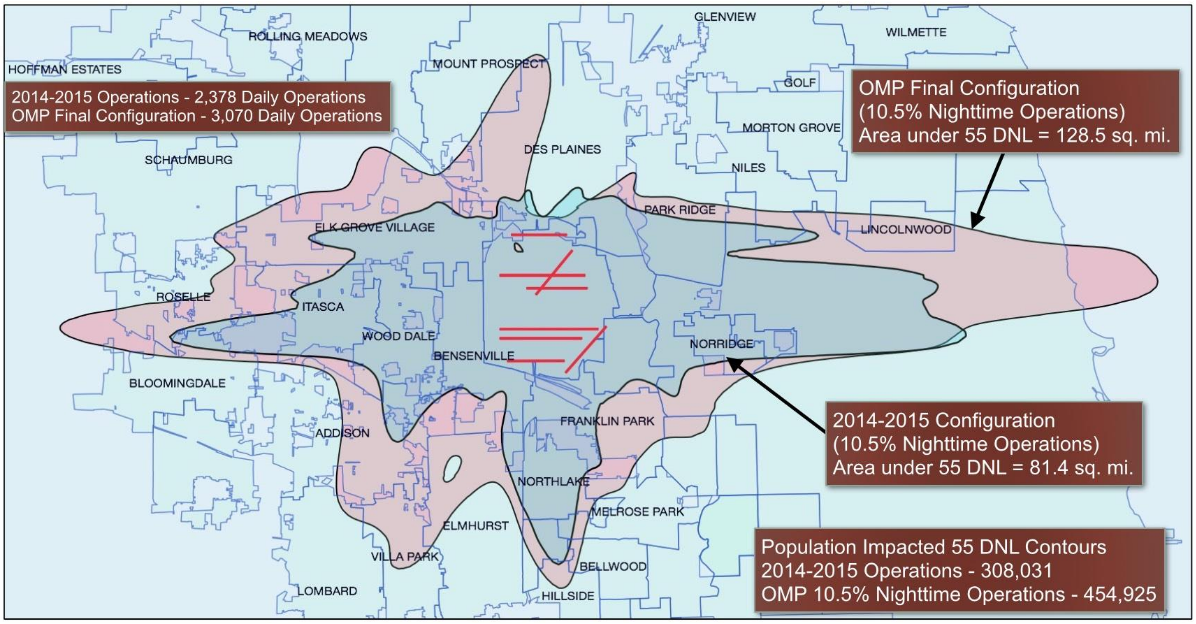


Figure 29: Comparison of 55 DNL Noise Contours for Full OMP Implementation and Today's ORD Condition (Using May 2014- April 2015 Fleet Mix Data).

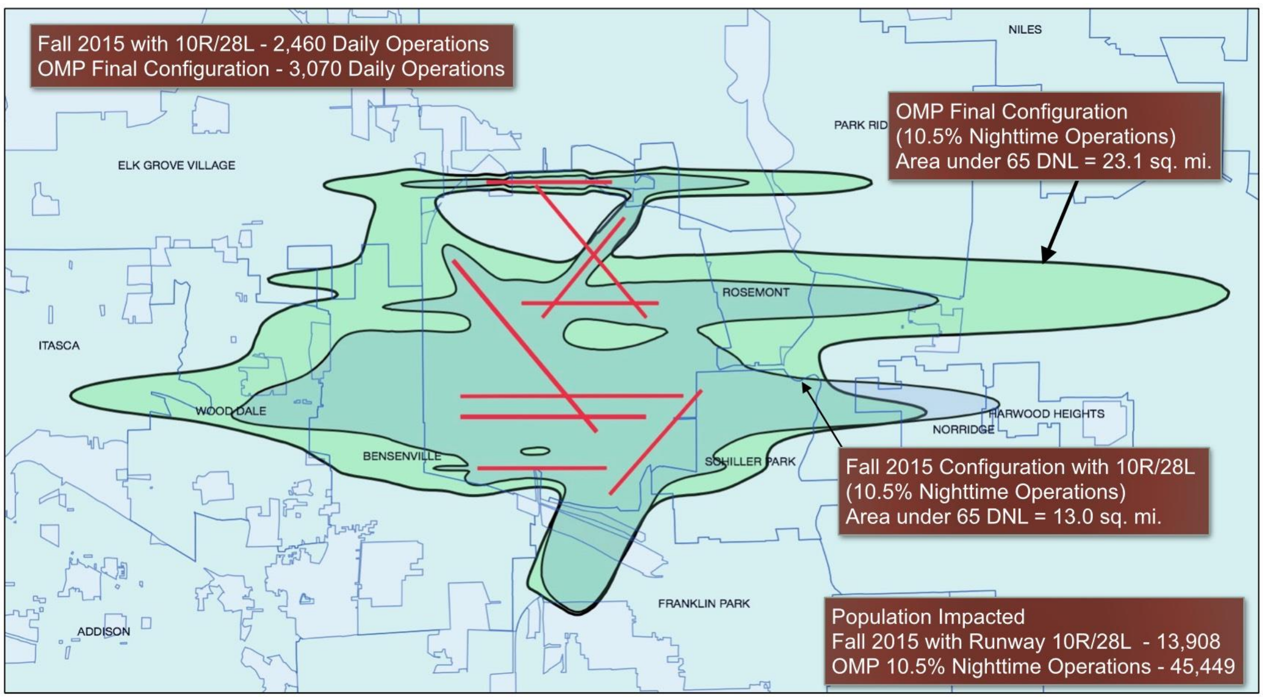


Figure 30: Comparison of 65 DNL Noise Contours for Full OMP Implementation and Fall 2015 Airport with Runway 10R/28L in Place (Using May 2014- April 2015 Fleet Mix Data).

A comparative analysis between the 65 DNL noise contours at full OMP implementation and the Fall 2015 ORD runway configuration with runway 10R/28L commissioned is shown in Figure 30. A comparison between the 55 DNL contours for the same conditions is shown in Figure 31.

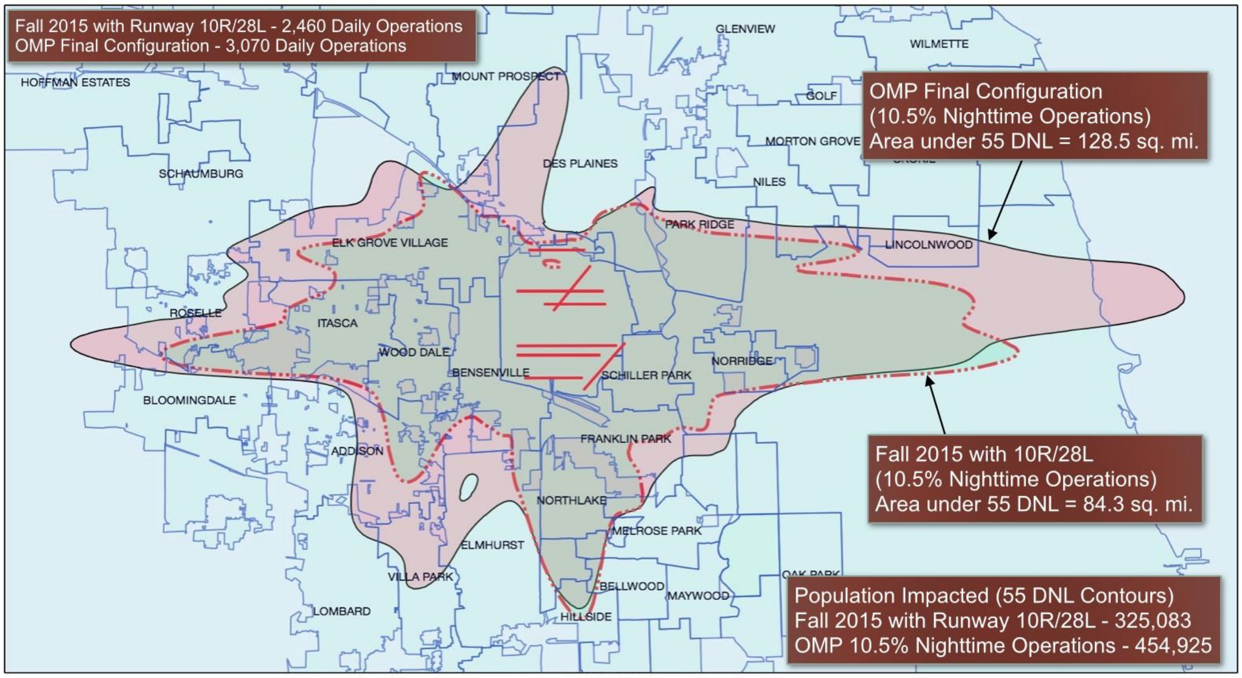


Figure 31: Comparison of 55 DNL Noise Contours for Full OMP Implementation and Fall 2015 Airport with Runway 10R/28L in (Using May 2014- April 2015 Fleet Mix Data).

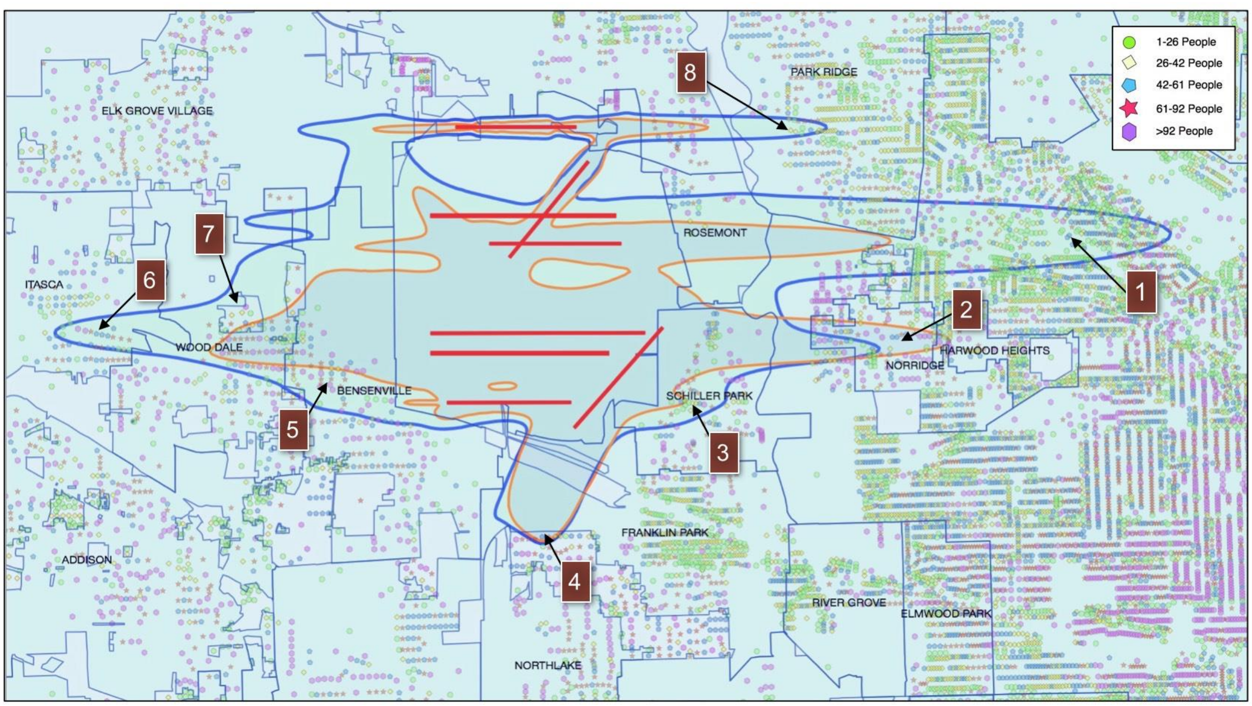


Figure 32: Comparison of 65 DNL Noise Contours for Full OMP Implementation and Fall 2015 Airport with Runway 10R/28L in Place. Population Data Points Shown in the Figure.

The effect of future 65 DNL noise contour impacts to population are shown in Figure 32. The figure compares the JDA noise contour solution for Fall 2015 with runway 10R/28L and the modified OMP solution with 10.5% nighttime operations and larger regional jets in the fleet mix. The graphic shows seven (7) impact areas where the future growth in the 65 DNL contour is expected to affect more people. Area 1 is the City of Chicago. This area will add 389 blocks to the 65 DNL contours compared to the Fall 2015 runway configuration. This area is the result of higher Northside operations with the addition of runway 9C/29C. Area 2 (Norridge) could add 35 blocks to the existing 65 DNL contours. This is the result of future additional operations on runways 10C/28C and 10L/28R.Area 3 (Schiller Park). Could add another 27 blocks to the 65 DNL contours. This is the result of future operation in runway 10R/28L. Area 4 is Northlake. This area will add 2-3 blocks in the 65 DNL contours. Heavy use of runway 22L is expected to contribute to this small increment in noise on the South side. Area 5 is an increase in the contour in Bensenville. This area will add 37 blocks to the 65 DNL contours at full implementation. Area 6 is Wood Dale. This area will add 47 blocks to the existing 65 DNL contours. The increase in population affected at Bensenville and Wood Dale is driven by operations on runways 10R/28L, 10C/28C and 10L/28R. Area 7 includes the Park Bridge. This area will add 10 blocks to the 65 DNL contours. The increase is associated with higher use of the runway 9L/27R in the future.

Recommendation

The OMP EIS noise analysis should revise assumptions about future fleet mix to include larger regional jets at ORD. The larger capacity aircraft would be consistent with the FAA forecast of faster growth in enplanements at the airport compared to flight operations.

Recommendation

The OMP EIS analysis should revise the number of nighttime operations used in the noise analysis for future airport conditions. Airline scheduling practices and network delays make it difficult to justify that ORD will ever have 5.6% percent nighttime operations in the future.

4.9 FORECASTS AND SENSITIVITY ANALYSIS

Airport demand cannot be predicted with great accuracy. Multiple factors make such prediction uncertain. These include: a) reliance on socio-economic factors that are uncertain (i.e., future GDP forecasts; b) use of service level variables that cannot be predicted accurately (i.e. air fares); c) individual mode choice behavior and airport selection are inherently difficult to predict; and, d) use of exogenous variables that are impossible to predict (i.e., terrorism, financial crises, etc.).

Historically, airport activity forecasts tend to deviate from reality by 21% in five years after the prediction is made (Friedman, 2004; Nishimura, 1999). Aviation forecasts tend to be off by 76% fifteen years into the future (Maldonado and DeNeufville, 1990). For this reason, airport forecasts consider multiple “futures”. Consideration of uncertainty has been well documented in the public literature (ACRP, 2012; DeNeufville and Odoni, 2013; Flyvbjerga et al., 2006). The Airport Cooperative Research Program (ACRP) offers five steps that airport planners can adopt in order to identify and more importantly, quantify uncertainty (ACRP 2012):

- Identify risk and uncertainty
- Quantify cumulative impacts
- Identify risk response strategies
- Evaluate response strategies
- Risk tracking and evaluation

If we consider that airport-level predictions are uncertain, then noise predictions follow a similar outcome because flight demand is one of the key elements to make a noise contour forecast. For this reason, it is important that when public agencies or airport authorities commission technical studies about noise impacts, the results include discussion and metrics that quantify the possible variations of the technical predictions. As a minimum, there should be recognition of the sources of uncertainty in the study.

The analysis presented in Section 2.8 about a revision of the assumptions made during the EIS study would be incomplete unless we provide some measure of the variability in the assumptions we changed in the original study. Here we enumerate some of the sources of uncertainty in the results presented in this study:

a) Flight demand is highly uncertain
b) Time of operations and future airline scheduling practices are difficult to forecast
c) Flight paths for a given flight vary from day to day, hence it is difficult to model one million flight paths with a few hundred or thousand tracks used in a noise study
d) Airline fleet projections have uncertainty

To understand the sensitivity of a noise contour forecast to item (b) above, we performed a sensitivity analysis of the noise contour area variability of the final OMP runway configuration against the number of nighttime operations. The results are presented in Figure 33. The figure indicates that, all other assumptions being equal, the noise contours for the future ORD airport change at a rate of 1.0 square miles for every one percent change in the number of nighttime operations. The dashed line shown in Figure 33 is a trend line for the values shown.

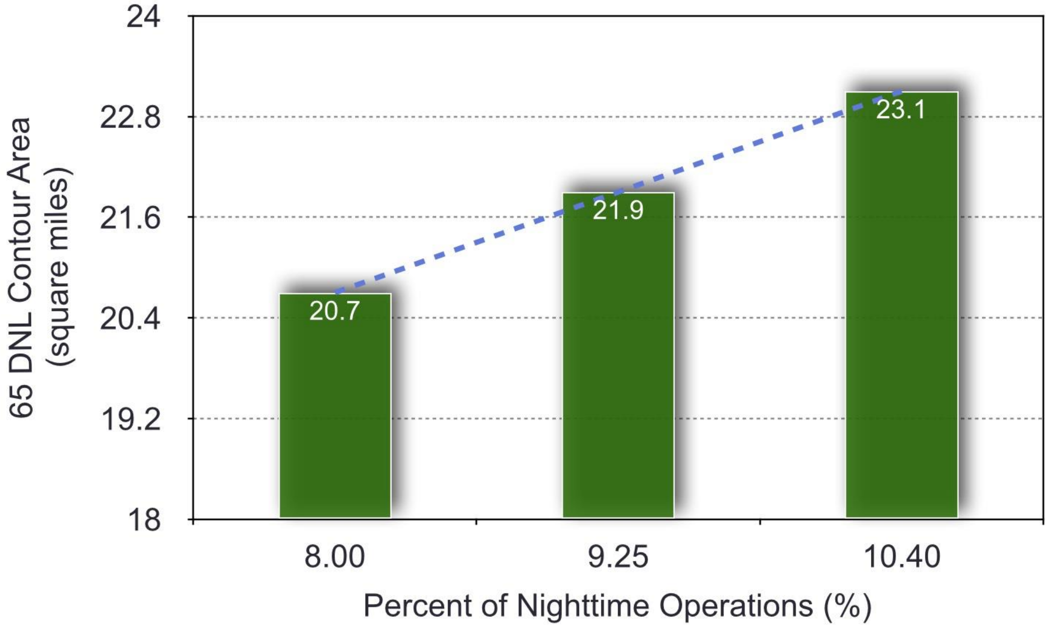


Figure 33: Variability of 65 DNL Noise Contour Areas as a Function of Nighttime Flight Events. O'Hare OMP Final Configuration. Constant Flight Demand (3070 Daily Flights).

Figure 34 offer some insight on the population affected as the number of nighttime operations changes. The figure indicates that, all other assumptions being equal, the number of people affected by the 65 DNL contours at ORD changes at a rate of 5,121 people for every one percent change in the number of nighttime operations.

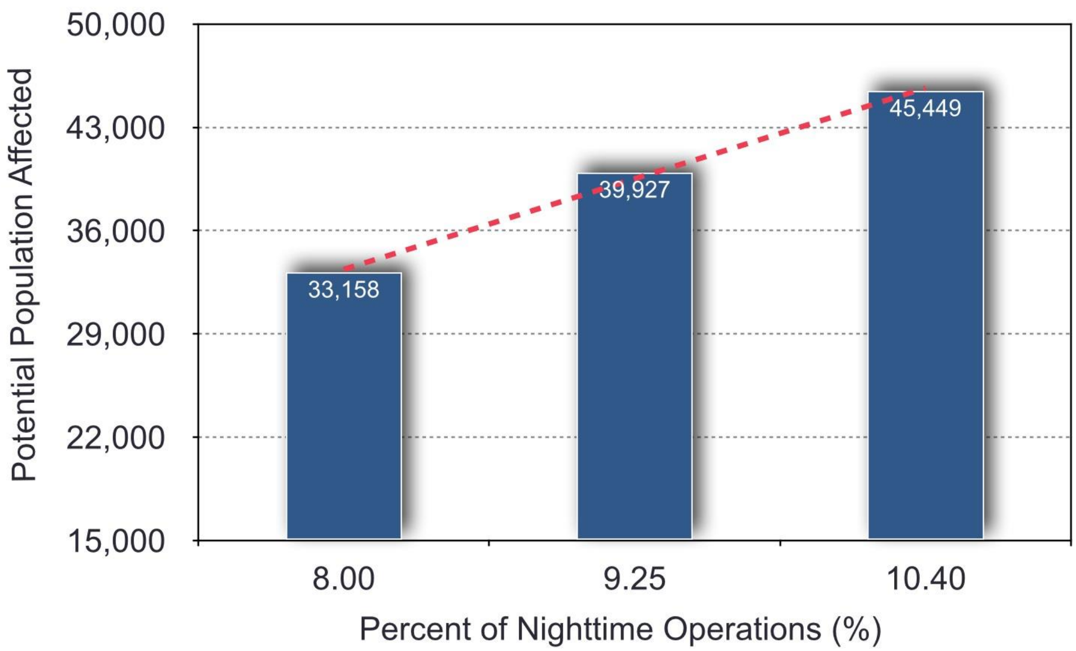


Figure 34: Potential Population Affected by 65 DNL Noise Contours for Variations in the Forecast of Nighttime Flight Events. O'Hare OMP Final Configuration. Census 2010 Data.

To understand the sensitivity of a noise contour forecast with respect to flight demand, we performed a sensitivity analysis of the noise contour area variability of the final OMP runway configuration against the number of nighttime operations and the number of daily flights. The results are presented in Figure 33. The figure indicates that, all other assumptions being equal, the noise contours for the future ORD airport change at a rate of 0.57 and 0.53 square miles for every 100 daily operations when the percent of nighttime operations is 10.5% and 9.25%, respectively.

Figure 34 offers insight on the population affected as the number of daily operations and nighttime operations change. The figure indicates that, all other assumptions being equal, the number of people affected by the 65 DNL contours at ORD changes at a rate of 2,460 people for every 100 daily flights added to the schedule if the percent of nighttime operations is 10.5%. The number decreases to 2,091 people for every 100 daily flights added to the schedule if using 9.25% nighttime operations.

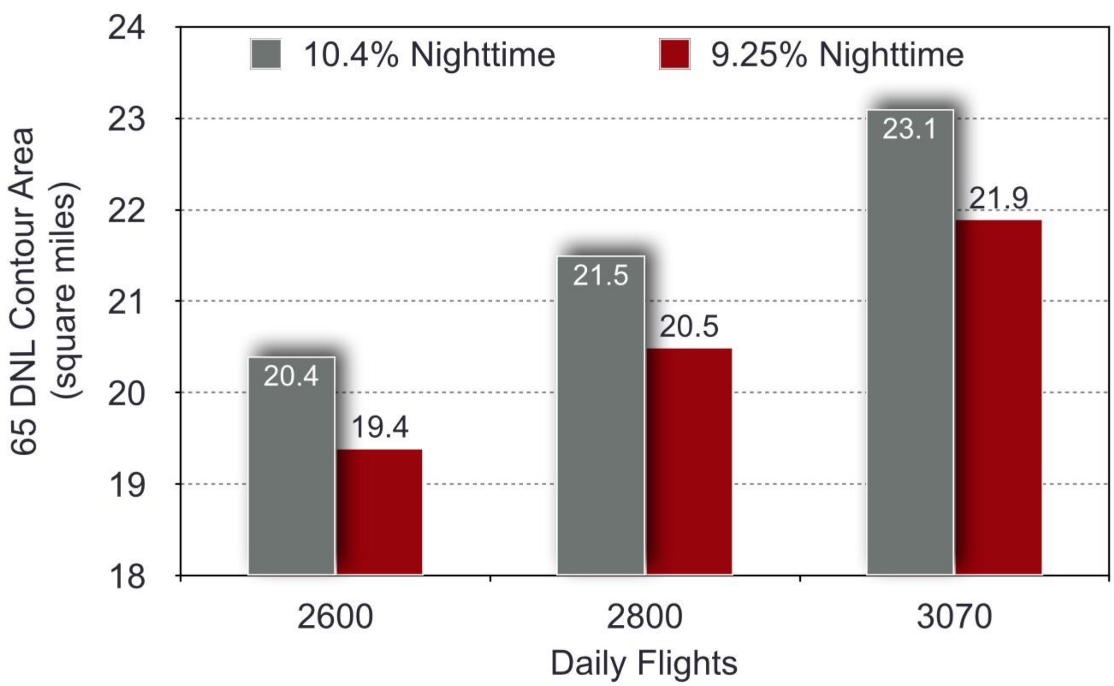


Figure 35: Variability of 65 DNL Noise Contour Areas as a Function of Daily Flight Demand and Nighttime Events. O'Hare OMP Final Configuration.

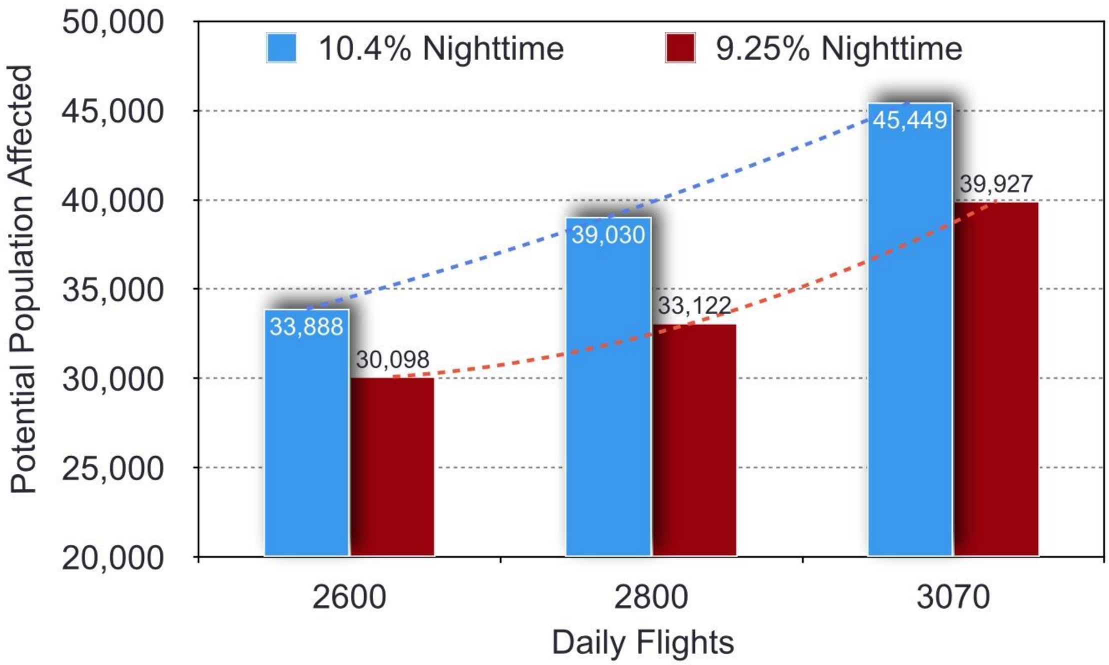


Figure 36: Potential Population Affected by 65 DNL Noise Contours for Variations in the Forecast of Daily Flights and Nighttime Flight Events . O'Hare OMP Final Configuration. Census 2010 Data.

Recommendation

Future analyses of ORD noise should include measures of variability in the results. This will help the public understand that airport demand and hence airport noise are very uncertain in the future.

Recommendation

Describe sources of uncertainty in the noise contour estimates.

5. COMMUNITY OVERFLIGHT ANALYSIS

This section presents a study of the overflight exposure for 78 communities around Chicago O'Hare International Airport. The study serves two purposes:

a) To verify perceptions of various communities in relation to noise exposure
b) To establish possible correlations between overflights and noise contour levels produced in the previous section.

5.1 METHODOLOGY

Using detailed flight track data provided by CDA and Flightaware, we performed a spatial analysis to estimate the number of flights that would affect each one of the communities around Chicago O'Hare International Airport. The analysis is presented graphically in Figure 37.

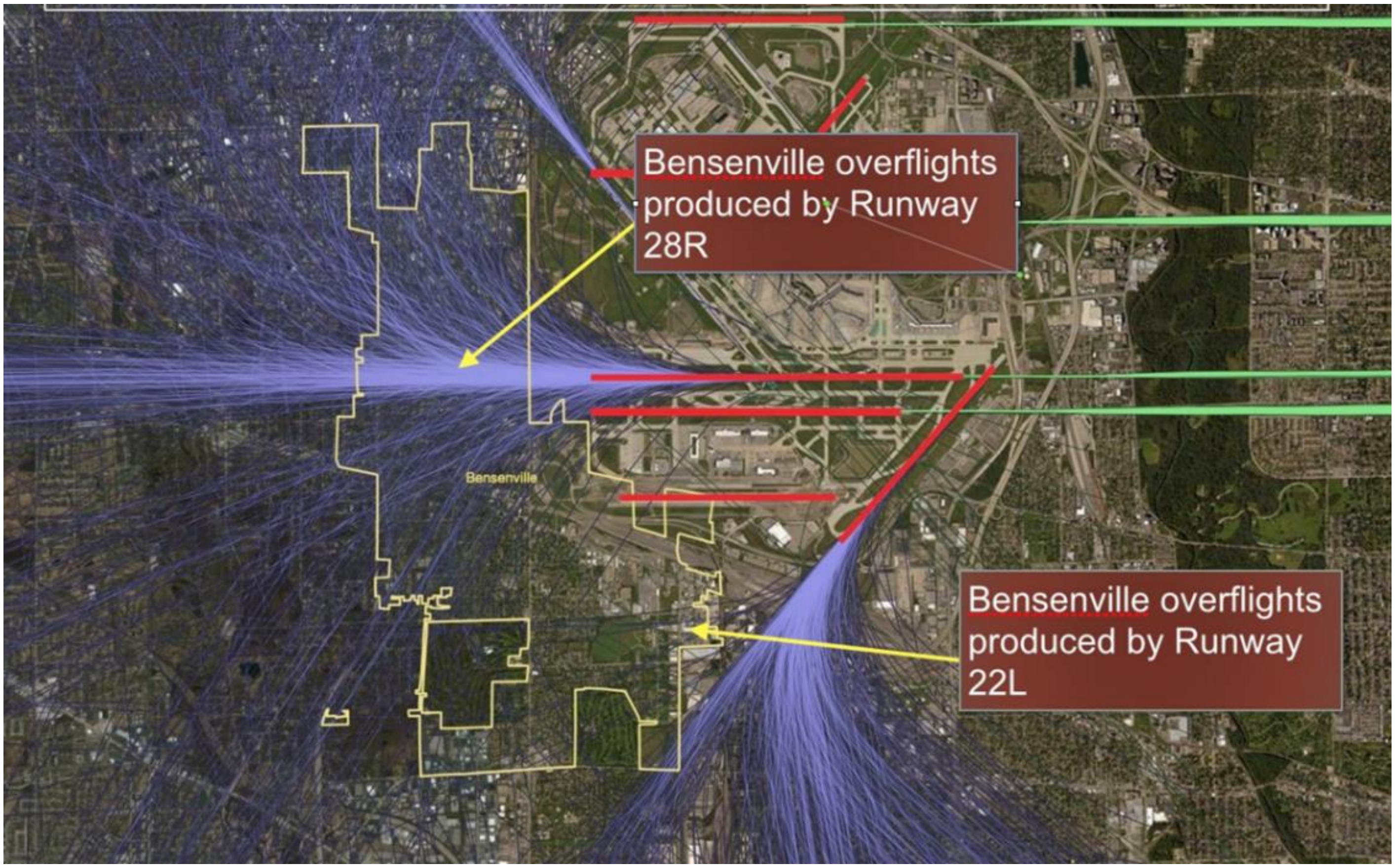


Figure 37: Graphic to Explain Spatial Analysis to Predict Overflight Operations Above Communities Surrounding Chicago O'Hare International Airport. ORD Flight Operations on May 1, 2014.

The graphic shows all the flights recorded in one day at ORD while operating in West flow configuration (May 1, 2014). The computer analysis uses the spatial geometry of each of the 78 towns around ORD and calculates the number of flights paths that overfly each of town. Figure 37 illustrates the overflights for the town of Bensenville just to the west of ORD. Departures from Runway 28R overfly the town in significant numbers. A few more departures from Runway 22L overfly the lower Southeast corner of the town.

The overflight analysis for SOC communities is presented in Figure 38. The graphic presents both real overflights and equivalent overflights. The equivalent number of overflights is the number of daytime overflights plus the nighttime overflights weighted by a factor of 10. The idea of equivalent overflights is to represent a metric used to estimate DNL levels (i.e., community noise analysis) where each nighttime operation is weighted 10 times more than a daytime flight.

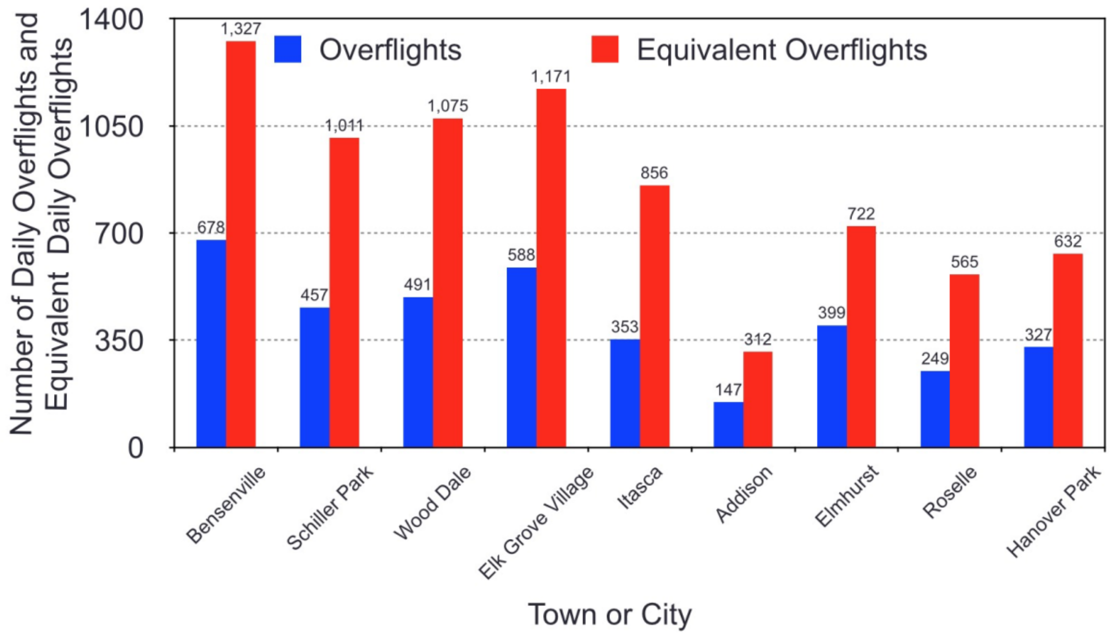


Figure 38: Average Overflight and Equivalent Overflight Operations for SOC Communities.

To illustrate the point, consider the village of Bensenville and refer to Figure 38. Bensenville has an average of 678 overflights per day (actual numbers are non-integers because they represent averages over 15 days). The average number of daytime overflights is 606 and nighttime overflights average 72. Converting the 72 nighttime events to equivalent daytime events yields 720 equivalent daytime events. When adding 606 real daytime overflights and 720 equivalent daytime overflights produces a total of 1,327 equivalent daytime overflights.

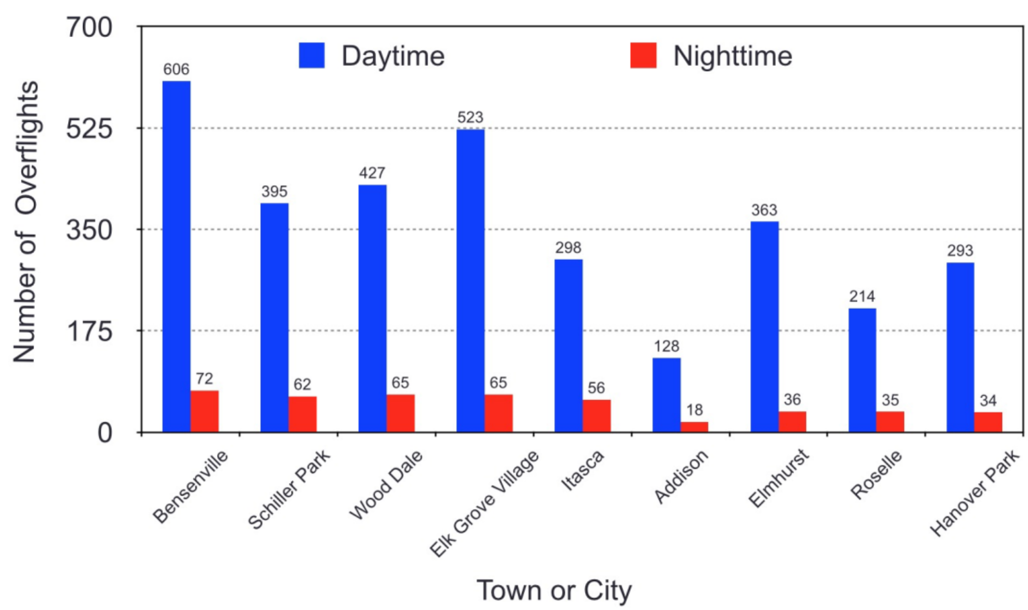


Figure 39: Average Daytime and Nighttime Overflight Operations for SOC Communities.

Figure 39 presents the overflight data for SOC communities without scaling. Using Elk Grove Village as example, there are on average 588 overflights per day with 523 occurring during the daytime period and 65 during the nighttime hours. Nighttime overflights are presented in Figure 40 for the same SOC communities.

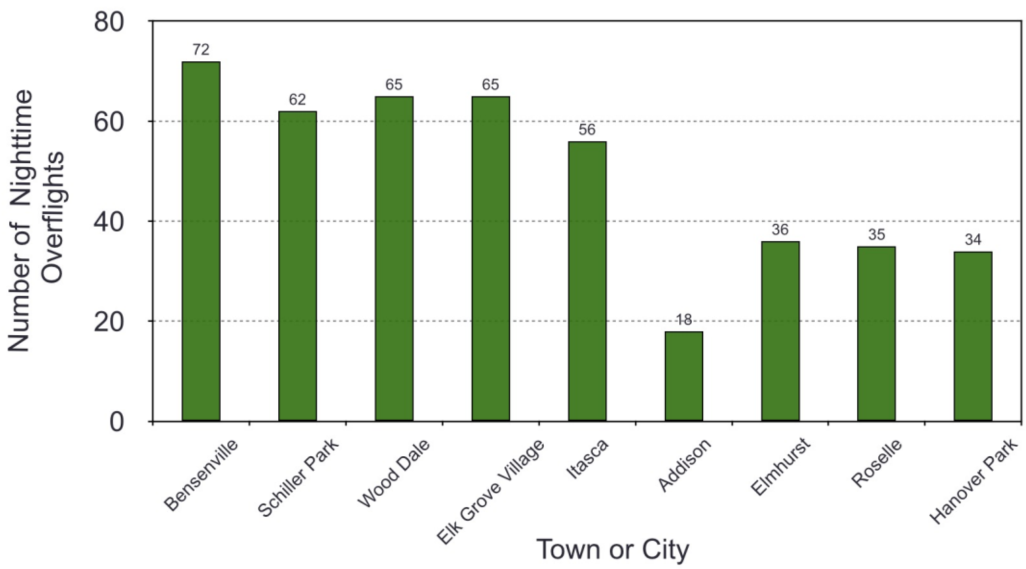


Figure 40: Number of Nighttime Overflights for SOC Communities.

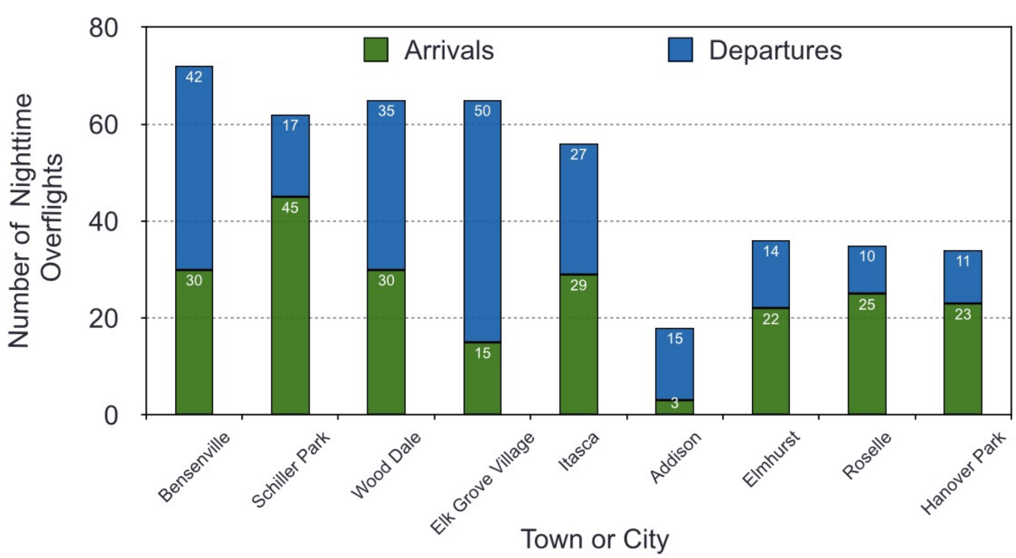


Figure 41: Number of Nighttime Overflights Departures and Arrivals for SOC Communities.

Figure 42 presents the number of nighttime arrival and departure overflights for SOC communities. It is evident that Bensenville, Elk Grove and Wood Dale are communities with the highest number of night overflight departures. Schiller Park, Bensenville and Elk Grove are the communities with highest number of night overflight arrival events.

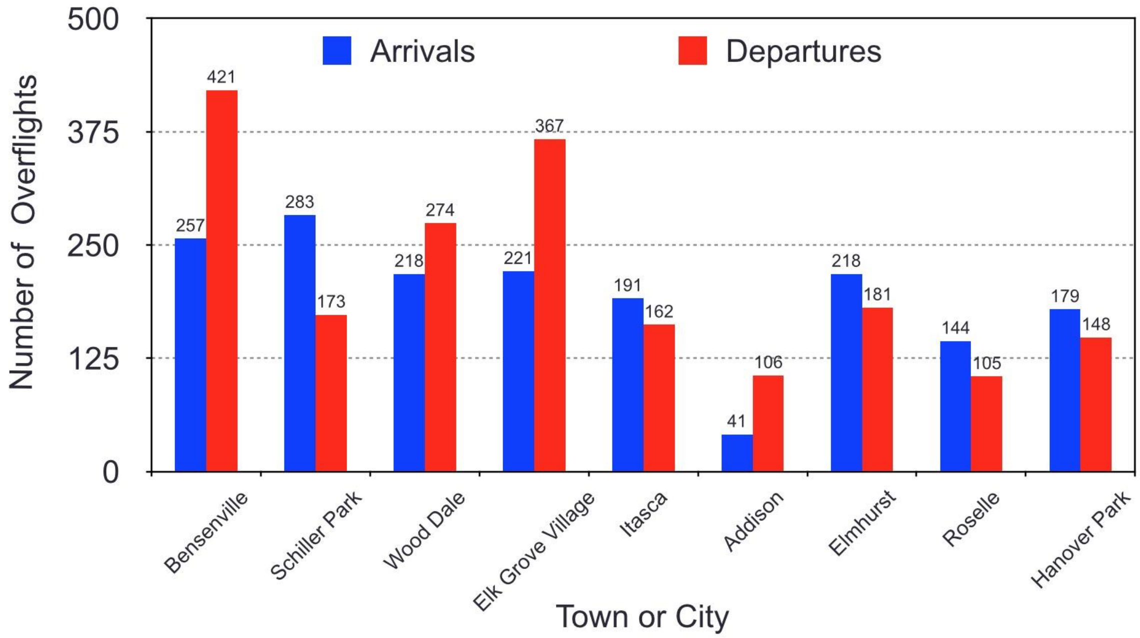


Figure 42: Average Arrival and Departure Overflight Operations for SOC Communities.

Figure 43 presents the same overflight analysis for communities located within 6.5 of Chicago O'Hare International Airport.

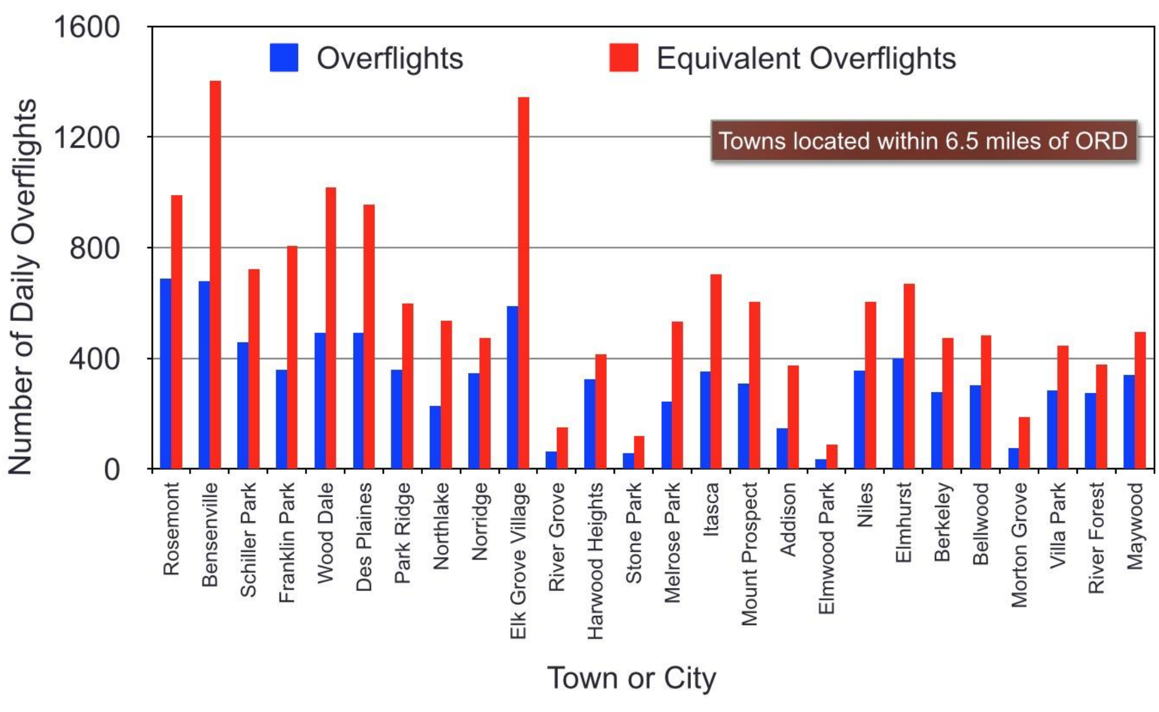


Figure 43: Average Overflight Operations for Towns Located Within 6.5 Miles from ORD.

Figure 44 presents the number of daytime and nighttime arrivals and departure overflights for communities located within 6.5 miles of Chicago O'Hare International Airport.

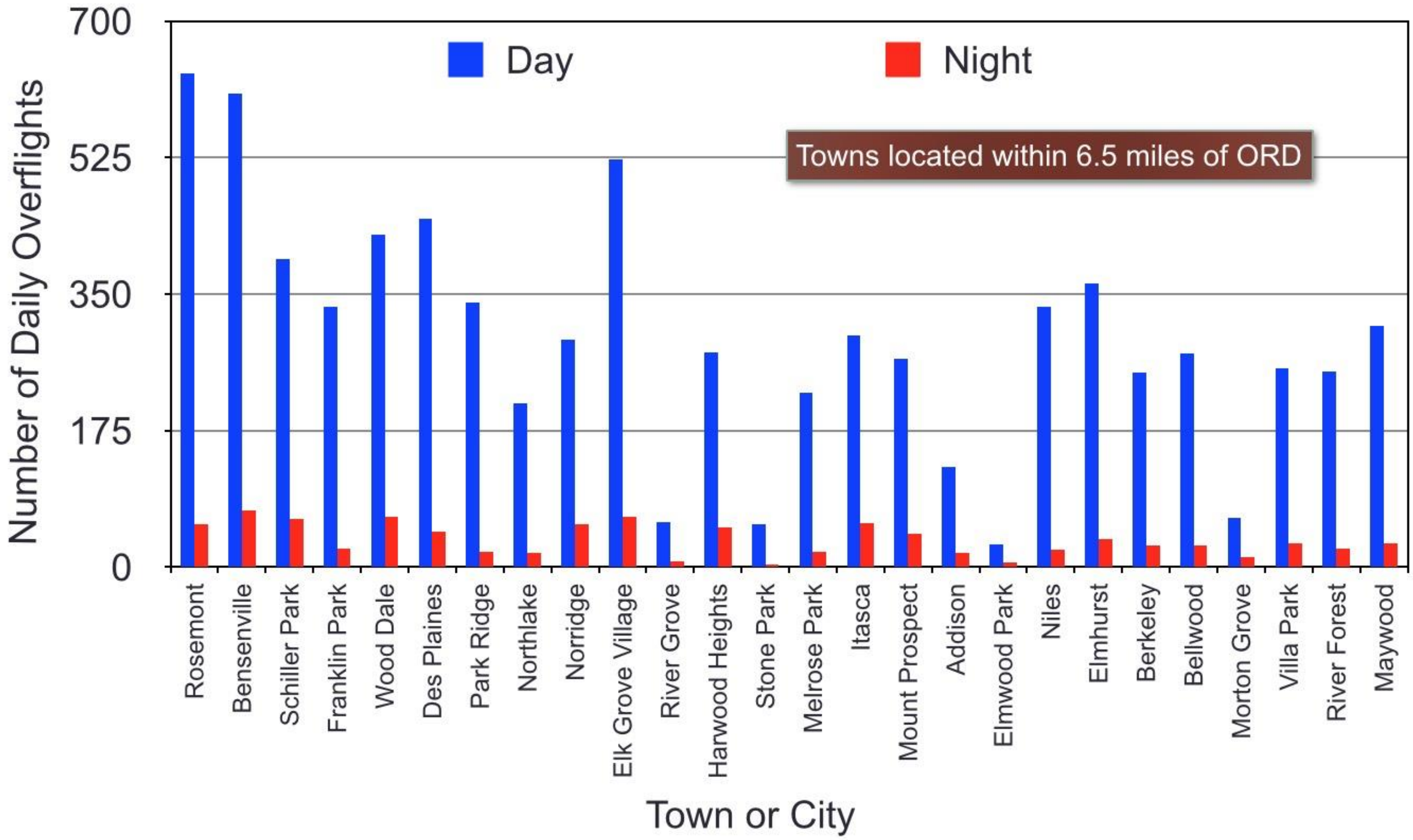


Figure 44: Average Daytime and Nighttime Overflight Operations for Towns Located Within 6.5 Miles from ORD.

Figures 45 and 46 present the overflight analysis results for towns located between 6.6 and 9.6 miles of the geometric center of the airport. Appendices 9-11 contain the overflight statistics for all 78 communities. Each table in Appendices 9-11 includes distance from the geometric center of each community to the Airport Reference Point (ARP). Note that the City of Chicago is located in Appendix 11. Because of its large size and location in relation to the airport, there are an average of 2,308 overflights in the city per day. In recent times, the number of complaints from residents of the City of Chicago has increased. This points out to the need of reviewing the adequacy of establishing the 65 DNL contours as the threshold of annoyance to communities.

Figure 45: Average Nighttime Arrival and Departure Overflight Operations for Towns Located Within 6.5 Miles from ORD.

Figure 46: Daytime Arrival and Departure Overflight Operations for Towns Located Within 6.5 Miles from ORD.

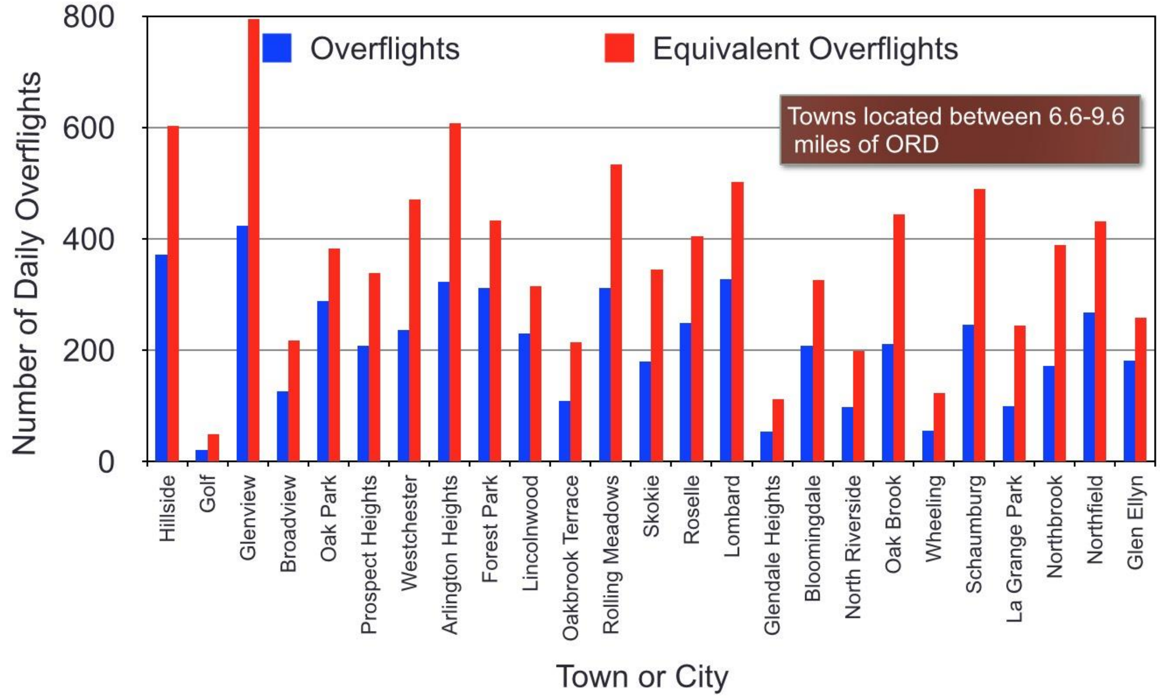


Figure 47: Overflight Operations for Towns Located Between 6.6 and 9.6 Miles from ORD.

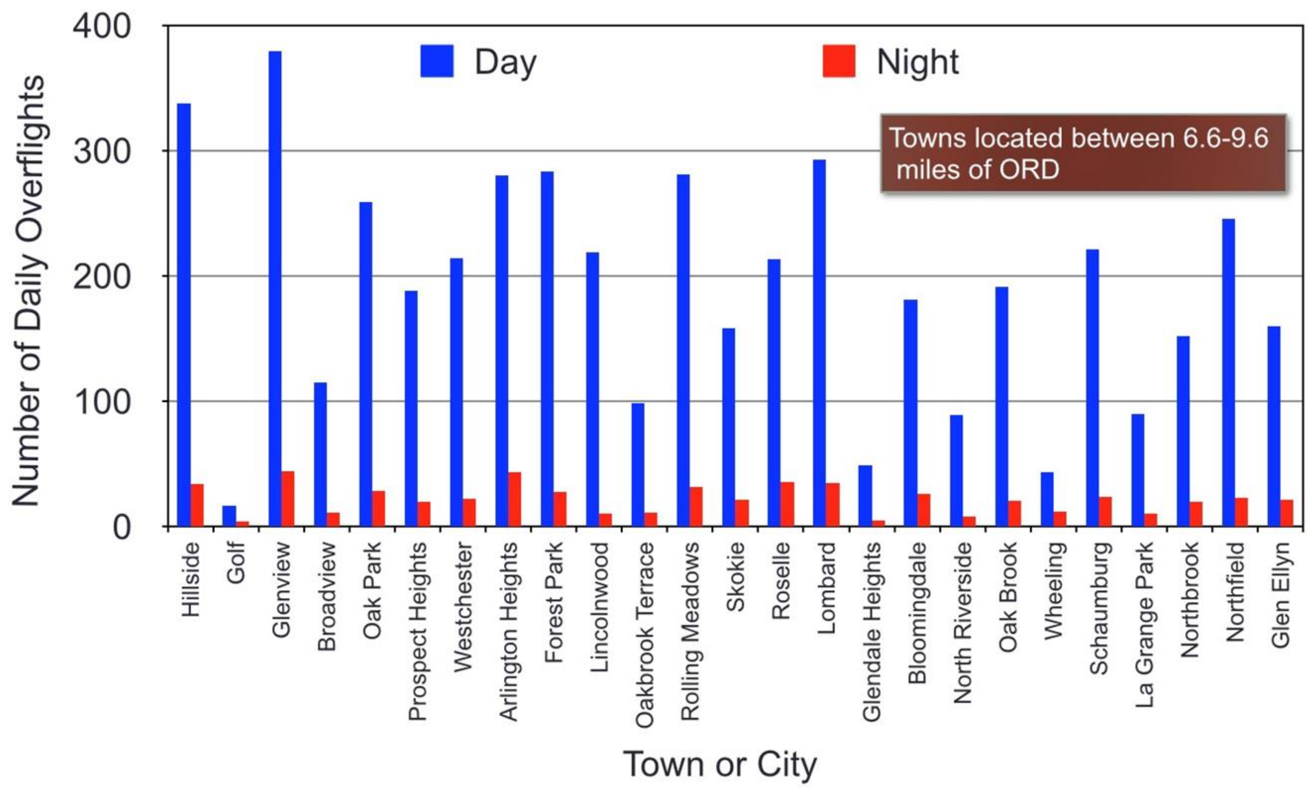


Figure 48: Daytime and Nighttime Overflight Operations for Towns Located Between 6.6 and 9.6 Miles from ORD.

6. STUDY OF ORD ANMS MONITORING SYSTEM DATA

This section presents a qualitative study of the day-night average sound levels recorded by the Chicago O'Hare Airport Monitoring System (ANMS). The ANMS system comprises 32 sensors around Chicago O'Hare International Airport. The analysis presented in this section serves two purposes:

c) To verify perceptions of various communities in relation to noise exposure over time
d) To establish possible correlations between overflights, noise contour levels produced in Section 2 and the recorded DNL values at 32 remote stations in the vicinity of the airport.

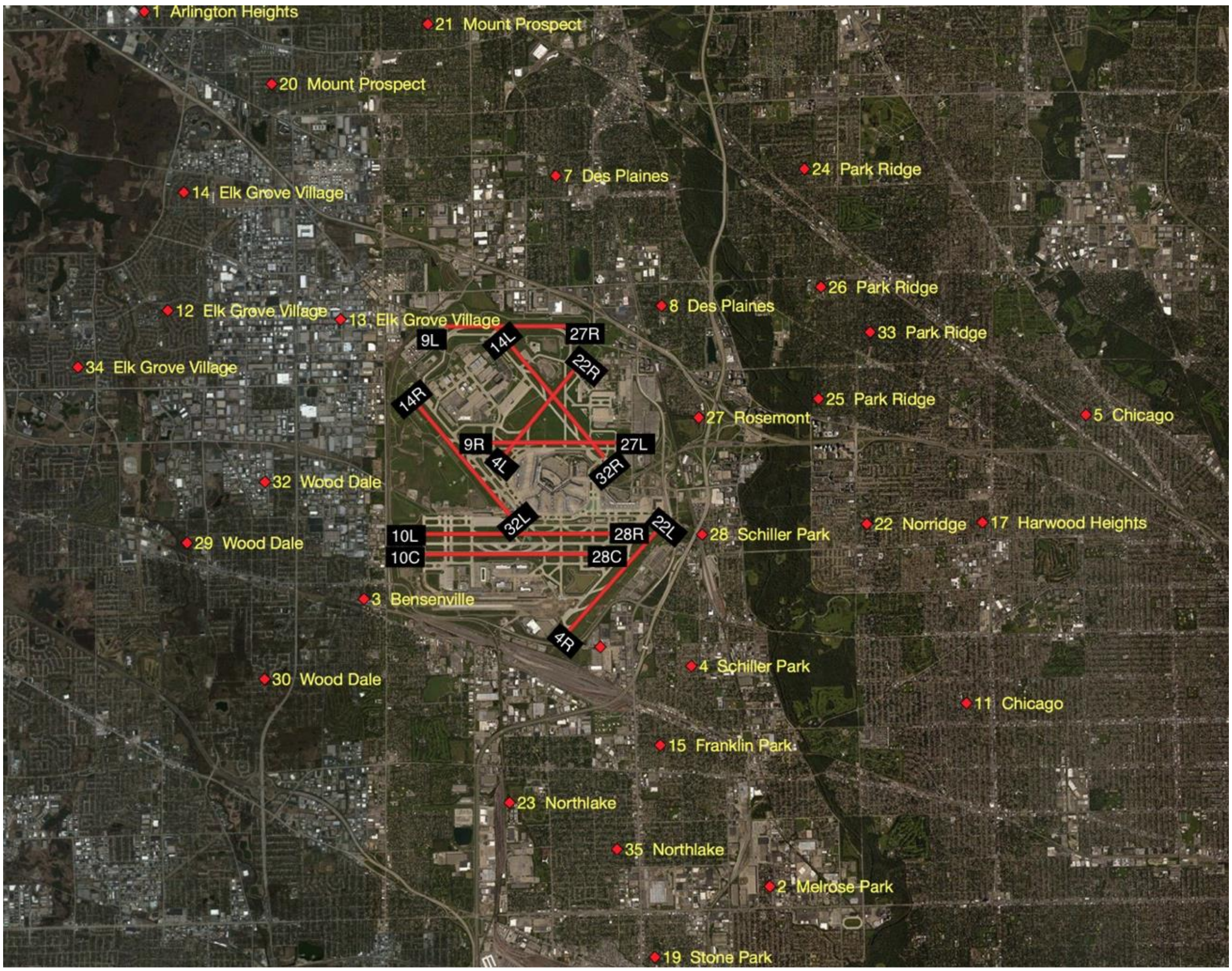


Figure 49: ORD Airport Noise Monitoring Locations.

6.1 AIRPORT OPERATIONS AND REMOTE MONITOR DNL LEVELS

The analysis presented in this section attempts to explain the relationship between the historical DNL trends collected by the Chicago O'Hare International Airport Noise Monitoring System (ANMS) and the trends in runway operations at the airport. The transformation of O'Hare from a six runway (3 runway orientations) airport to an eight runway system (6 East-West parallel plus two Northeast-Southwest) has changed flight patterns that directly affect day-night average sound levels for communities surrounding the airport.

Two important events since October 2013 have affected the DNL levels experienced by communities around ORD: a) the opening of runway 10C/28C and b) the implementation of Converging Runway Operations (CRO) in April 2014. The first event shifted arrival operations from runway 28R (called runway 28 before the opening of runway 28C) to runway 28C. Runway 28C became an arrival runway and runway 28R became a departure runway. This is illustrated in Figure 52. Note that before the opening of runway 28C, runway 28R handled and average of 223 daily arrivals. After the opening of runway 28C, the average daily arrivals on runway 28R decreased to less than 20 with 63% of those arrivals occurring during the nighttime hours. Figure 52 shows the arrival traffic shift from runway 28R to runway 28C. Since its opening, runway 28C handled an average of 269 arrivals per day.

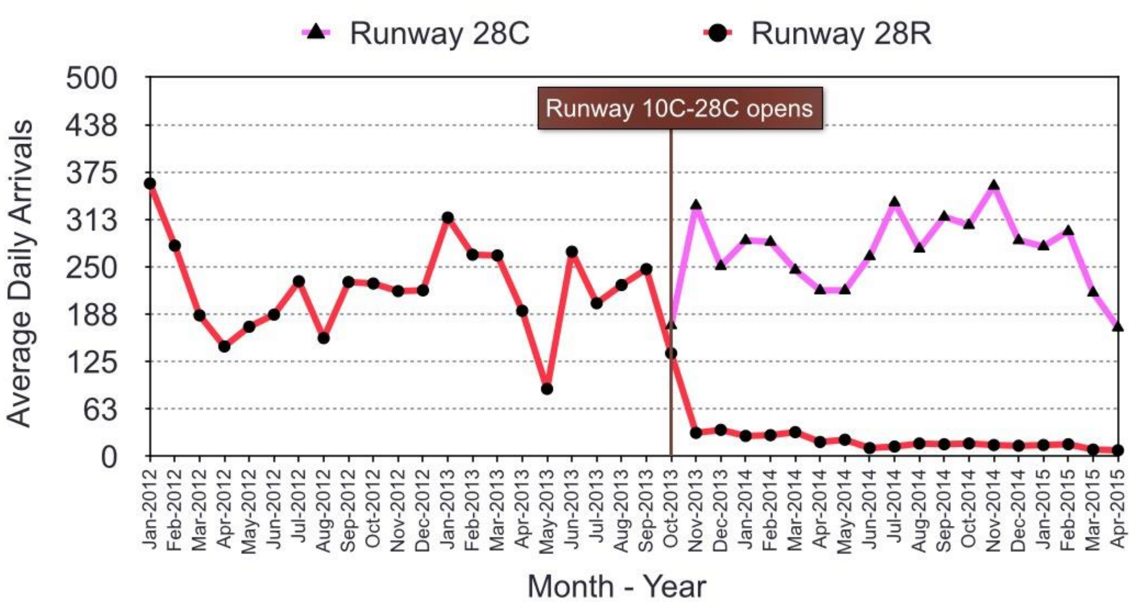


Figure 50: Historical Trend of Arrivals to Runways 28R and 28C at Chicago O'Hare International Airport. Before October 2013, Runway 28R was Labeled Runway 28.

In 2014, the Federal Aviation Administration developed new guidance for converging runway operations nationwide after a series of runway incursions at Las Vegas

International Airport. The ruling affected several large hub airports including Chicago O'Hare. The rule in place at ORD limits the simultaneous use of runways 27R and 27L for arrivals and runway 32L for departures. The rule applies to runways with distance between thresholds separated by one mile or less. This rule protects against an event where an arrival on runway 27L executes a missed approach and flies a converging course that intersects a departure using runway 32L.

After the implementation of the Converging Runway Operations (CRO) rule, the airport lost an important departure runway (32L) and perhaps more specifically, lost about one third of its departure capacity in the summer of 2014. The loss in departure capacity was also exacerbated by maintenance actions on runway 32L in 2014. Figure 51 shows the shift in departure operations from runways 32L and 32R over time. Before the CRO rule, runway 32L handled an average of 401 departures per day. This represented one third of the departure capacity of the airport. Today, the runway handles an average of 15 departures per day with 61% of those during the nighttime hours.

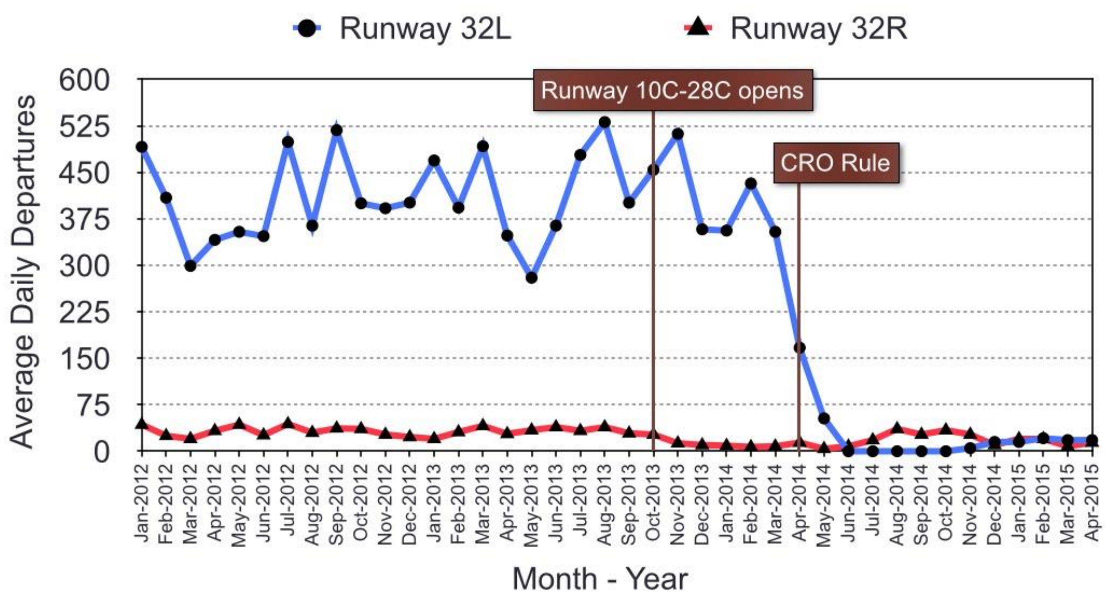


Figure 51: Historical Trend of Departures from Runways 32L and 32R at Chicago O'Hare International Airport. Before the implementation of the CRO Rule, Runway 32L was an Important Departure Runway.

The shift in runway operations stated above changed the flight patterns over communities in the vicinity of the airport. Examination of historical trends of remote noise monitors provide an important assessment of how the community noise levels have changed as result of runway operational changes. Figure 54 shows the location of eight permanent noise monitor stations in the Northwest and West quadrant at ORD. The figure also shows the typical flight paths that would have been observed in a West flow day at ORD before the implementation of the CRO rule with many departures using runway 32L. Before CRO operations, West flow operations used runways 32L, 28R and 22L for departures.

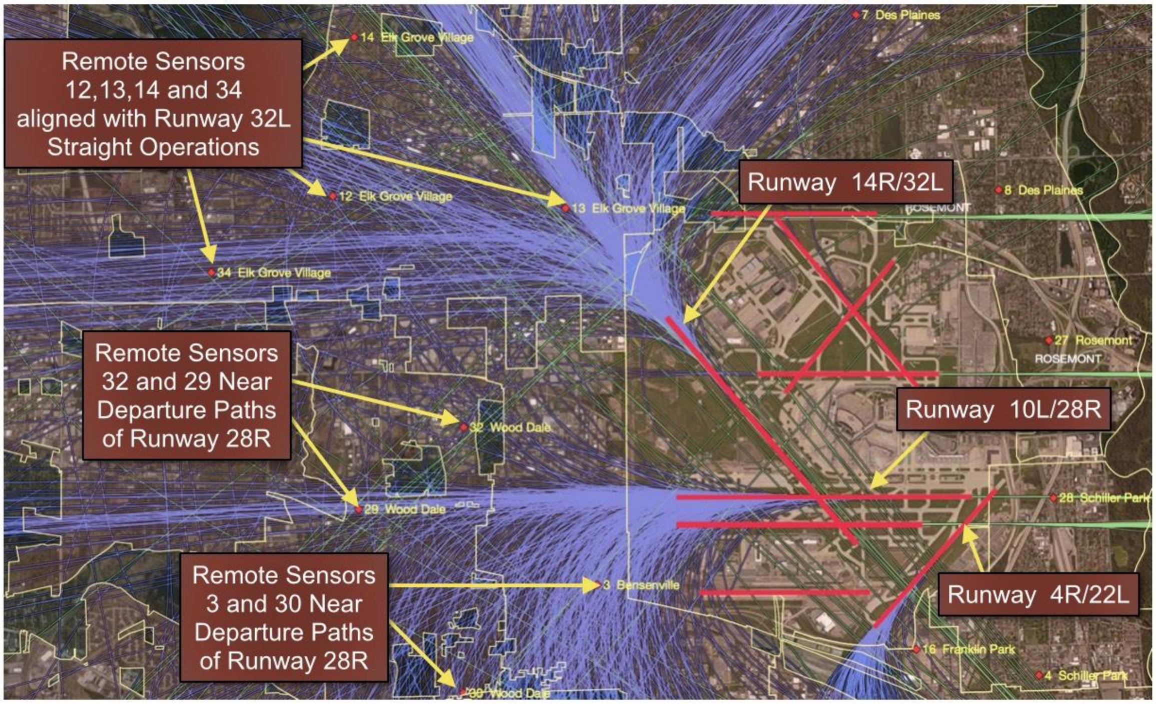


Figure 52: Chicago O'Hare International Airport Remote Monitors on the West and Northwest Quadrant. Typical West Flow Day Before CRO Rule. Blue Lines Represent Departures. Green Lines Represent Arrivals.

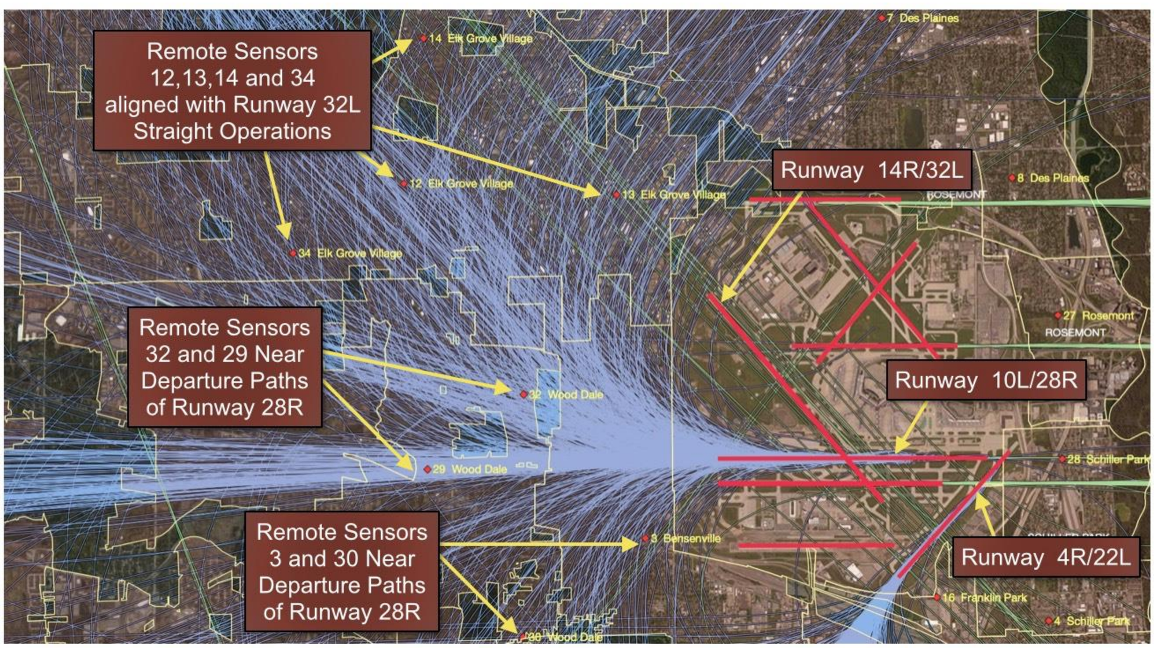


Figure 53: Chicago O'Hare International Airport Remote Monitors on the West and Northwest Quadrant. Remote Sensors are Part of the Airport Noise Monitoring System. Typical West Flow Day After CRO Rule. Blue Lines are Departures. Green Lines are Arrivals.

Figure 53 shows the departure patterns after the implementation of the CRO rule. In the graphic, we see that runway 32L is no longer used for departures. From a practical point, all departures were shifted to runways 28R and 22L. The shift in departure operations is shown in Figure 54. The figure shows the historical trend of departure operations for runways 22L, 28R and 28C. After the commissioning of runway 28C, runway 28R has had an average of 510 departures per day. This places a significant overflight burden on communities to the West of the airport during West flow operations. Communities like Bensenville and Wood Dale have been exposed to more overflights. Communities such as Elk Grove have benefited from that shift. This is demonstrated in Figure 55. Without significant operations on runway 32L, Elk Grove Remote Sensor 33 DNL values have dropped from over 70 dB to 64 dB today. This is a very significant drop (6 dB) considering that the DNL scale is logarithmic. Note that Remote Sensor 13 is aligned with runway 32L and located 1.6 miles from the threshold of runway 14R (or the departing end of runway 32L).

The situation is reversed for Wood Dale remote sensor # 32. Before the opening of runway 28C and CRO rule, this remote location averaged 62 dB DNL levels. Today, this sensor registers DNL levels near 68 dB. It is important to state that an increase in 3 dB represents twice the power than the baseline noise level. The community of Wood Dale has two other sensors (# 30 and #29). Sensor # 29 is aligned with runway 10L/28R and located 3.5 miles from the runway end, has registered an increase of 2.6 dB in the DNL levels since runway 10C/28C was commissioned. This is illustrated in Figure 57.

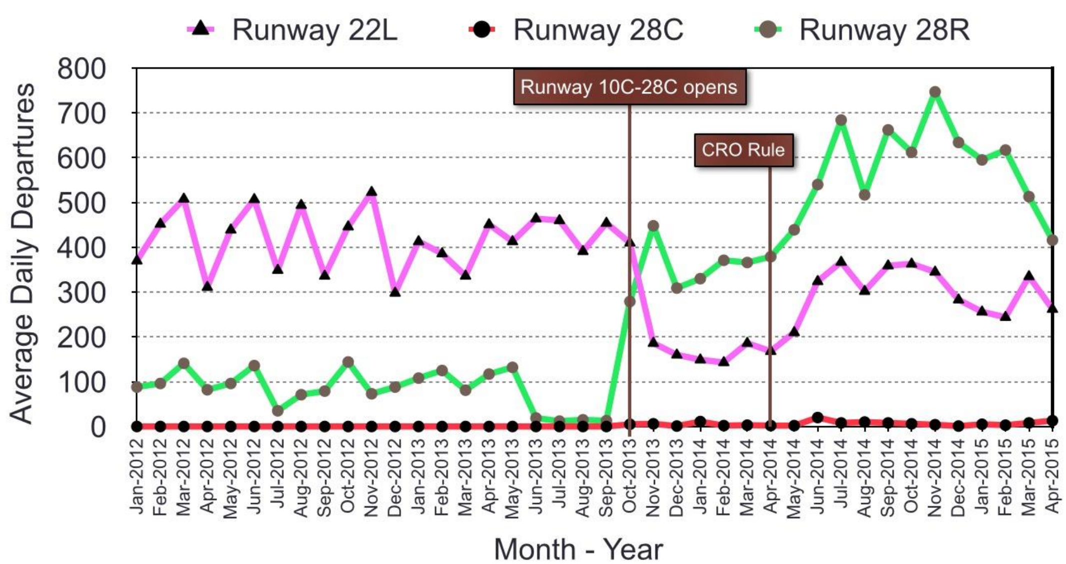


Figure 54: Historical Trend of Departures from Runways 22L, 28C and 28R at Chicago O'Hare International Airport. After the Opening of Runway 28C and After Implementation of the CRO Rule, Runway 28R Became the Key Departure Runway at the Airport.

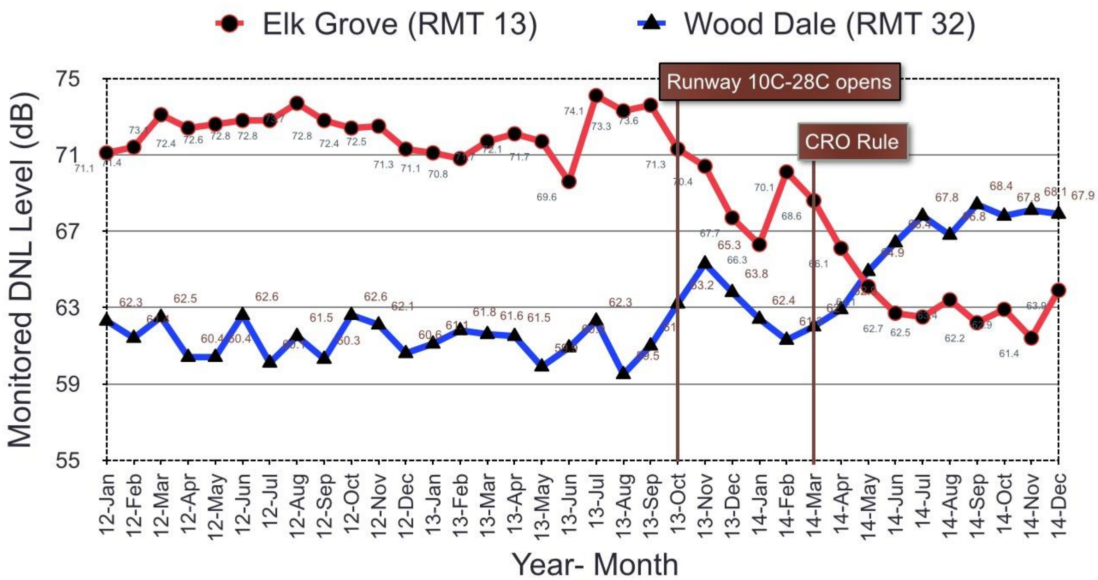


Figure 55: Historical Trend of Remote Monitor DNL Levels at Elk Grove (RMT # 13) and Wood Dale (RMT # 32).

The community of Bensenville near remote monitor # 3 has experienced a significant increase in noise since the commissioning of runway 10C/28C. This is shown in Figure 58. Remote monitor # 3 is located 1.1 miles from the end of runway threshold 10C and at a bearing of 220 degrees. At this location, DNL level values have increase from 59 dB before opening of runway 10C/28C to 65 dB today. This constitutes a very significant change for residents in that area.

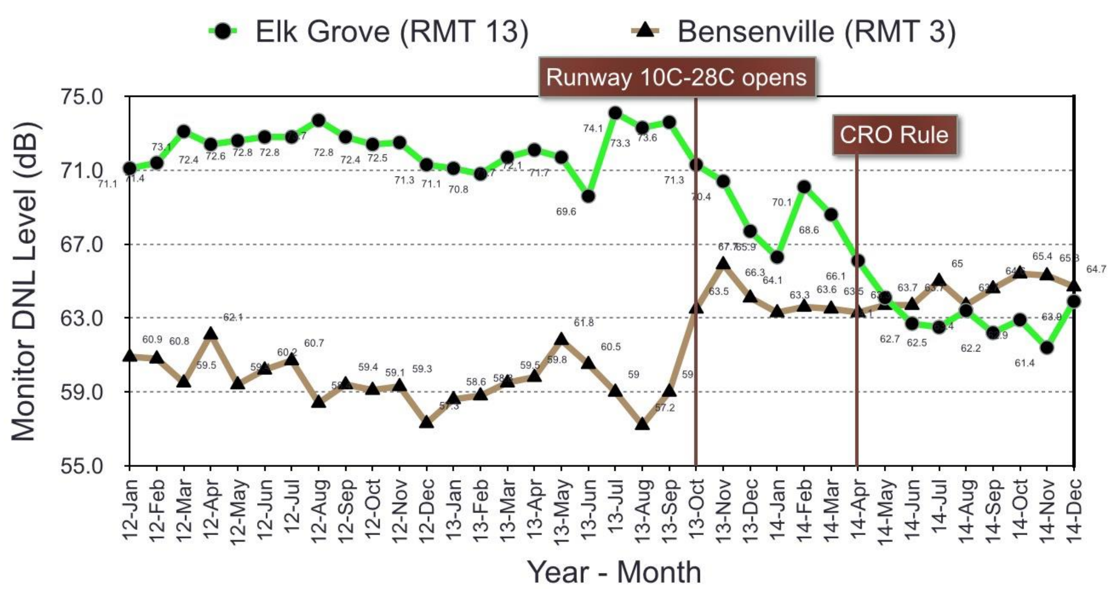


Figure 56: Historical Trend of Remote Monitor DNL Levels at Elk Grove (RMT # 13) and Bensenville (RMT # 3).

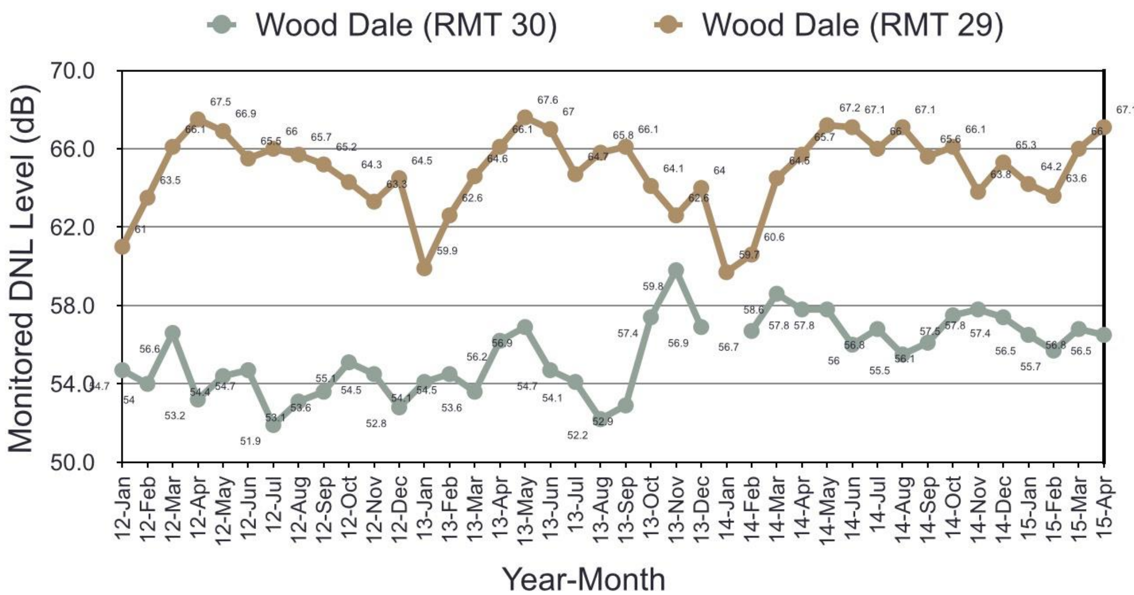


Figure 57: Historical Trend of Remote Monitor DNL Levels at Wood Dale (RMT # 30) and Bensenville (RMT # 29).

Figure 58 shows the departure patterns for runway 10L under East flow operations. The figure also includes West flow arrivals on runway 28C. Two sensors located at Schiller Park are annotated in the figure. Remote sensor # 28 is aligned to runway 10L/28R whereas remote sensor # 4 is located 1.7 miles to the South of runway 10L/28R. Before the opening of runway 10C/28C arrivals and departures used to fly directly above sensor # 28. Now, these operations fly parallel offset tracks which have resulted in reduction of 2.3 dB DNL levels at the site. This is illustrated in the Figure 59.

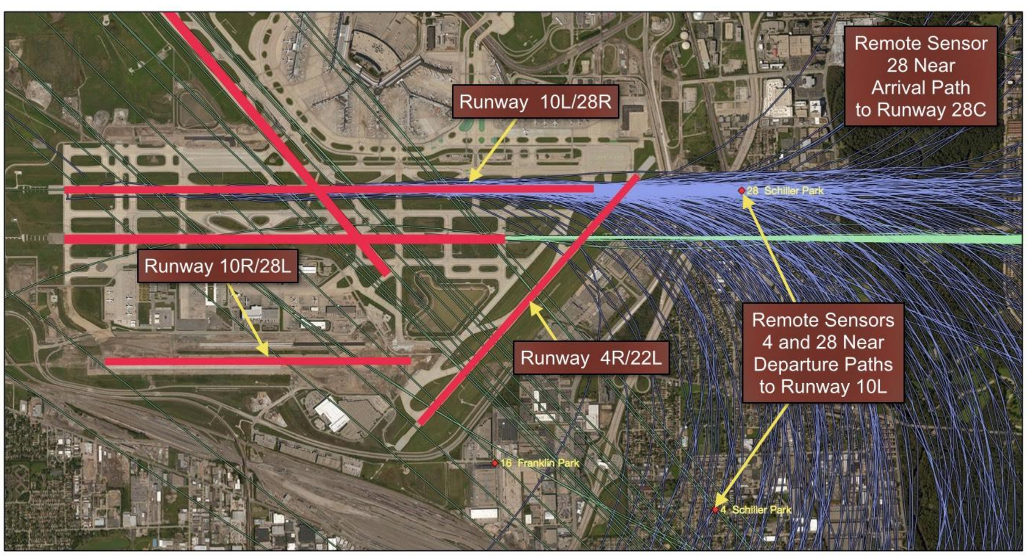


Figure 58: Chicago O'Hare International Airport Remote Monitors at Schiller Park. West Flow Arrivals (in green) and East Flow departures (in blue).

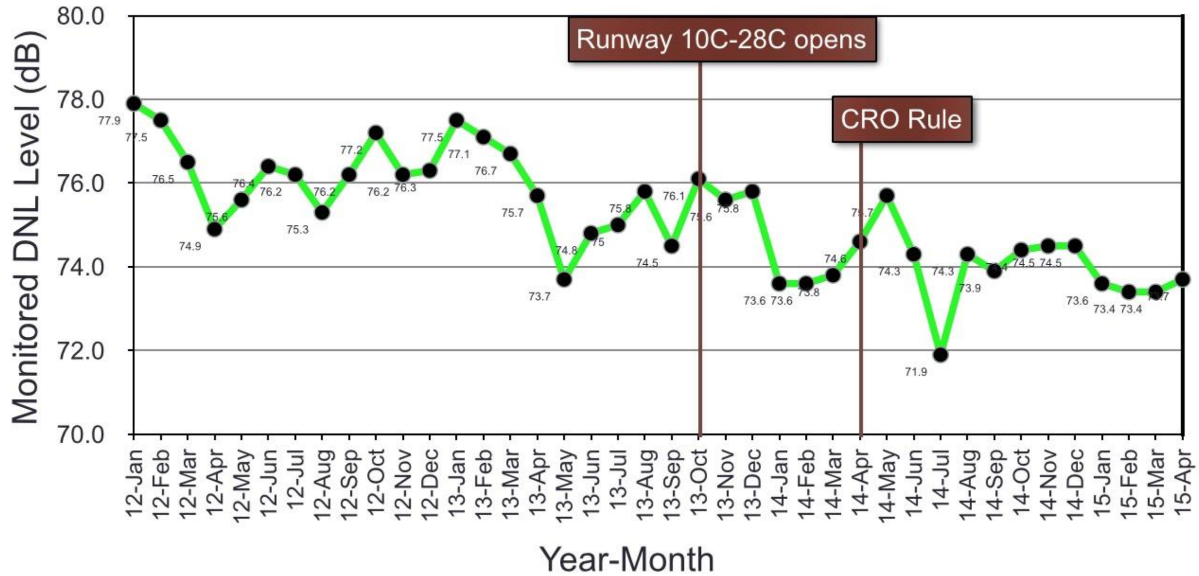


Figure 59: Historical Trend of DNL Values at Remote Monitor at Schiller Park (RMT 28).

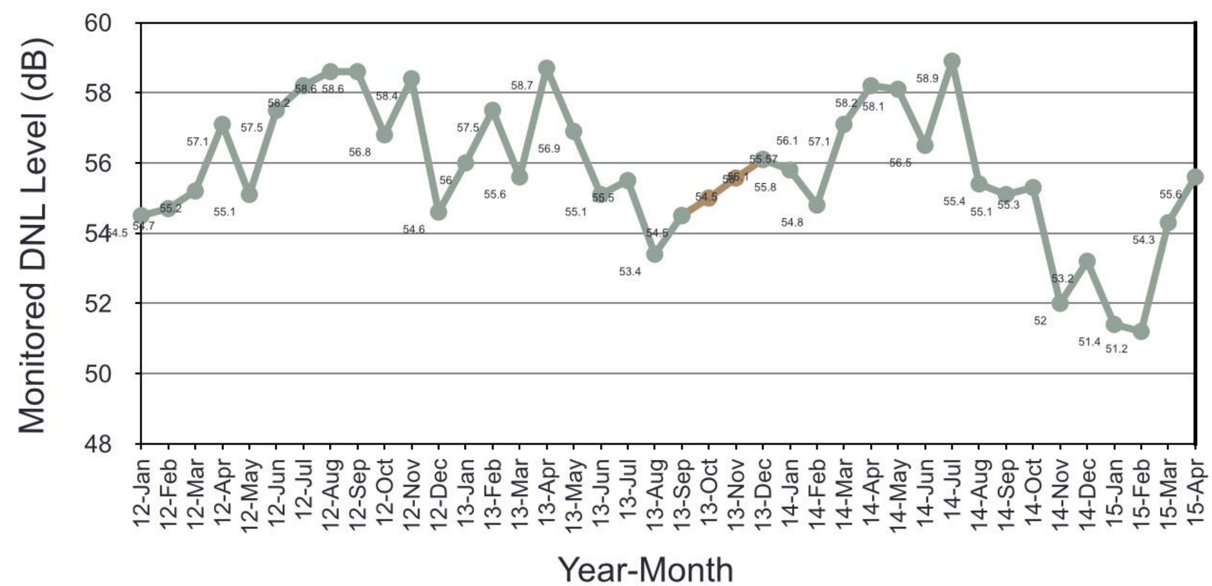


Figure 60: Historical Trend of DNL Values at Remote Monitor at Schiller Park (RMT 4).

7. EVALUATION OF SOME FLY QUIET STRATEGIES

This section discusses the potential impact of some of the Fly Quiet (FQ) paper recommendations made by JDA Technology Solutions. The quantification of all 19 recommendations made in the FQ paper is not possible within the scope of this work. However, we present some examples to demonstrate that some mitigation strategies are possible.

JDA FQ-2: The CDA should leave a third runway open during Fly Quiet hours, including at least one diagonal runway, to disperse airport noise effects and to reduce flying distances over communities.

This recommendation provides relief to communities by rotating runways used during the nighttime period. Providing ORD Tower with added flexibility to assign an extra runway every night could have some benefits for some communities. Figure 61 illustrates an example of shifting nighttime operations from runway 32R to runway 32L. The graphic shows two 55 DNL contours with the same level of airport activity. The difference in the noise contours shown is the shift of 12 nighttime operations from runway 32R to runway 32L. Further analysis could demonstrate small to modest benefits for some communities if a third runway is available for nighttime operations.

Another way to understand the benefit of having a third runway open during Fly Quiet hours can be explained using Figure 60The figure represents the number of nighttime overflights for selected communities around ORD today. If a third runway is available during Fly Quiet hours, some communities would experience nights with little or no overflight traffic. Depending upon which runway is added to the rotation, Bensenville could see reductions in the number of nighttime events from 72 to perhaps 3-5 in the nights where runway 28R would not be part of the active runways during the nighttime hours. It is important to note that because ORD has some long flights, heavy aircraft may still require using the longest runway in the airfield.

Recommendation

In coordination with FAA Air Traffic Control specialists, CDA should undertake a careful examination and quantification of noise patterns as a result of Flight Quiet Recommendation # 2.

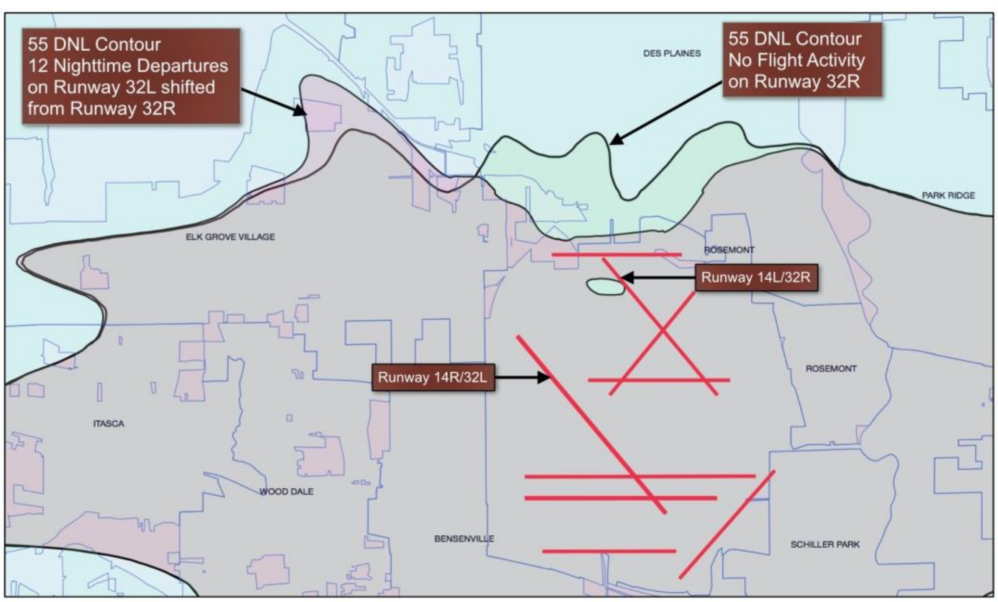


Figure 61: Effect of Runway Activity Shift in 55 DNL Contour.

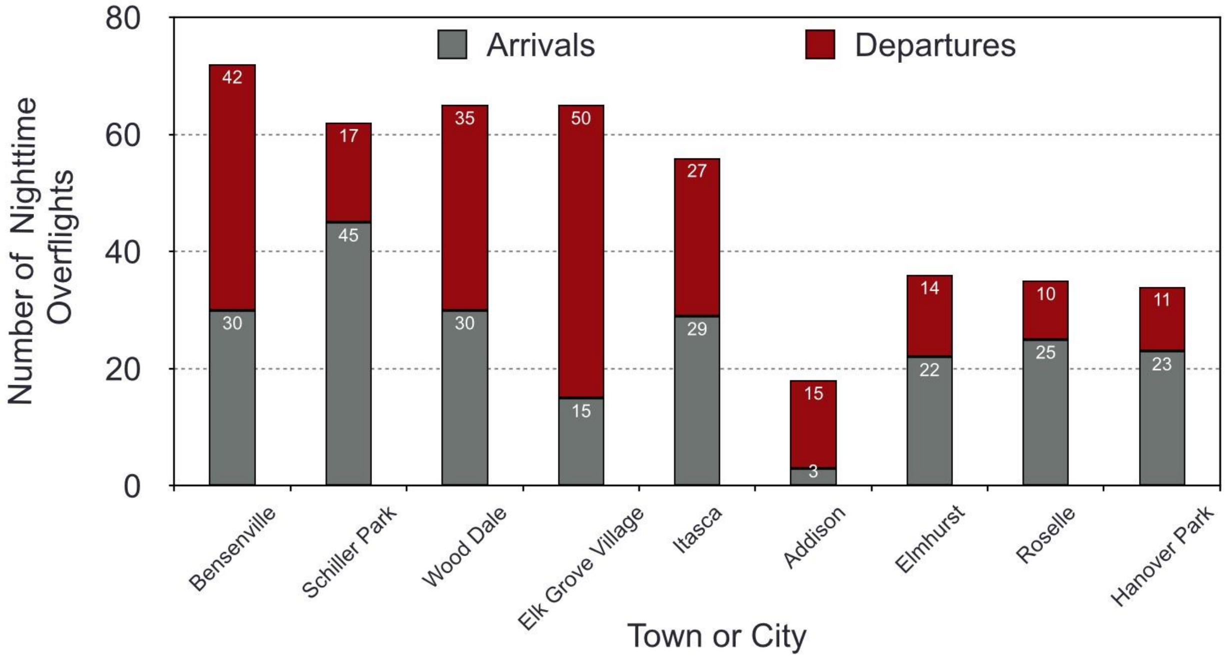


Figure 62: Number of Nighttime Overflights Departures and Arrivals for SOC Communities.

JDA FQ-7: The SOC, CDA, ONCC, other impacted communities, impacted Chicago neighborhoods, local state and Federal officials, community organizations such as FAIR and FAA coordinate to assess departure flight paths from ORD's newest runways and preferred runway usage, to determine the best runway configurations and departure headings for noise abatement and include these within the Fly Quiet Program Manual.

The complexity of the airspace around ORD is a challenge. However, observed departure paths for most runways involve multiple departure headings that show large flight track dispersions. The use of Area Navigation (RNAV) coupled with lower Required Navigation Performance (RNP) available in today's commercial aircraft could provide more accurate flight tracks at the airport. Both of these technologies constitute the so-called Performance Based Navigation that FAA is deploying at airports nationwide as part of the Next Generation Air Transportation System (NextGen).

Figure 63 illustrates all departure paths from runways 9R and 10L (i.e., East flow) for one day at ORD. Note the large dispersion in the flight paths out of two runways in the same day. Operationally we recognize that distinct departure headings provide advantages to ATC to expedite departures from the same runway. However, the flight track dispersion could be reduced to mitigate noise for some communities. Other airports have implemented RNAV departure procedures with substantial reductions in the dispersion patterns while overflying communities. Atlanta and Denver are two airports that have implemented RNAV procedures with some degree of success. Our recommendation is also consistent with recommendation JDA FQ-10 made in a companion paper. That recommendation proposed a reevaluation of RNAV arrival and departure procedures to determine whether amendments or new procedures could be designed and implemented to provide additional noise benefits.

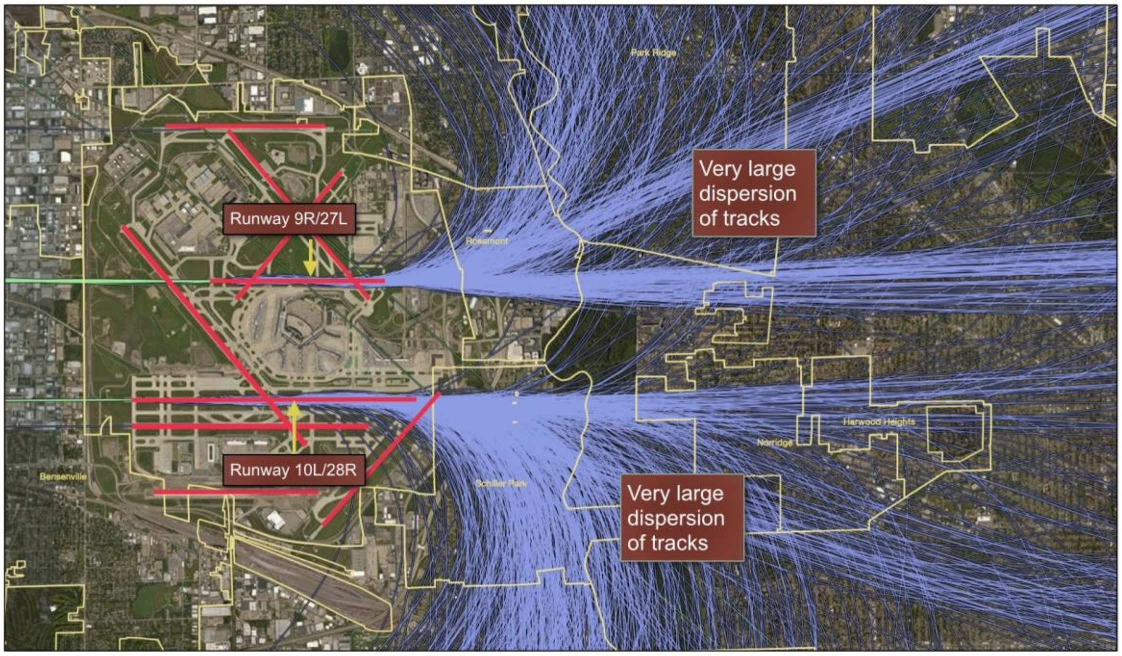


Figure 63: Typical Departure Flight Tracks for One Day of East Flow Operations. Departures from Runways 9R and 10L Shown in Blue.

Recommendation

In coordination with FAA Air Traffic Control specialists, CDA should undertake a careful examination of existing and future runway flight tracks and quantify their noise impact. We recommend the development of a "Playbook" of runway strategies for ORD that from its inception considers noise as an important design element.

JDA FQ-8: All of the current recommended departure headings should be assessed to determine whether they are actually achieving the goal of directing flights over less-populated areas and revised as required to minimize population impacted by noise on a rotating basis every evening to the extent practical. The CDA should utilize a computer driven model to best determine how to distribute fights over the region on an objective basis to minimize the impact on any particular community. Take-offs should be evenly disbursed over the entire population.

The CDA should utilize a computer driven model to best determine how to distribute fights over the region on an objective bases to minimize the impact on any particular community. Take-offs should be evenly disbursed over the entire population.

The high dispersion in departure tracks at ORD is one of the many factors that contribute to the noise problem at the airport. Figure 61 illustrates all departure paths from runway 28R (i.e., West flow) and overflying Bensenville in a single day. Note the large dispersion in the flight paths out of the runways in the same day. The resulting flight patterns expose more people to "lower" annual noise but a question that perhaps needs further investigation is whether such dispersion contribute to more complaints.

Recommendation

In coordination with FAA Air Traffic Control specialists, CDA should undertake a careful examination of runway flight headings and quantify their noise impact on communities. The results of this analysis should be part of the "Playbook" of runway strategies for ORD advocated in our previous recommendation.

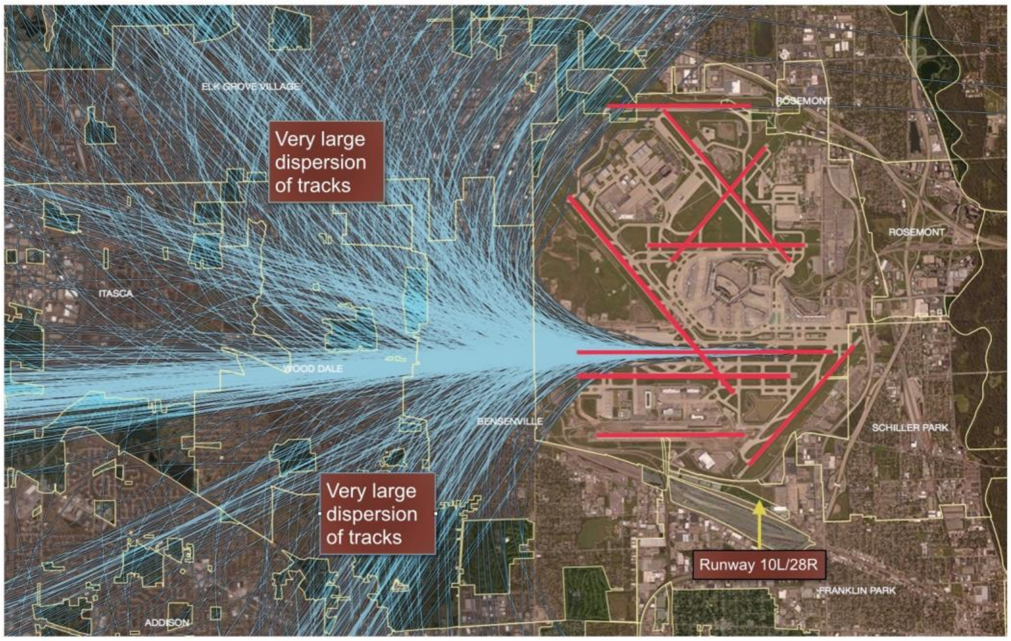


Figure 64: Typical Departure Flight Tracks Overflying Bensenville in West Flow Operations. 813 Departures from Runway 28R Shown in Blue.

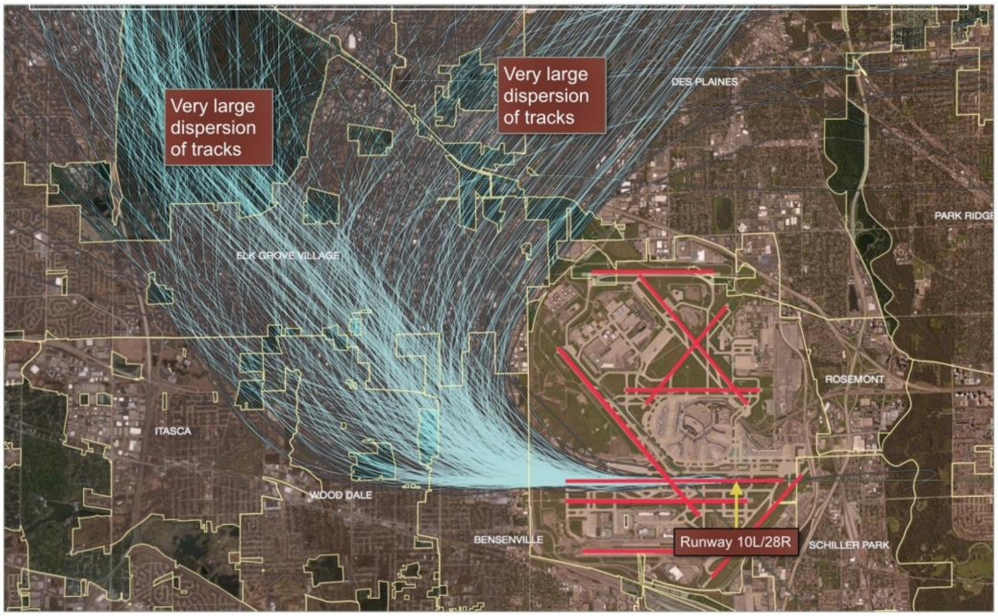


Figure 65: Flights Tracks for Runway 28R Departures Overflying Elk Grove. 425 Flight Tracks Shown.

JDA FQ-19: The FAA (O'Hare Tower) should refrain from using intersection departures during Fly Quiet hours.

Analysis of intersecting departures using both Noise-Power-Distance (NPD) in the INM database and also using simulated departures from runway 28R model were performed to evaluate the benefit of limiting intersection departures at night. An intersection departure offset of 3,700 feet (i.e., further to departure threshold) increases the single flyover metric noise level to an observer located 2 nm from the runway departure threshold by 1.4-1.5 decibels. Avoiding intersecting departures could provide a small relief to communities located within 3-4 nm of the airport. Intersection departures are common at ORD from runway 28R. Intersection departures are generally conducted from taxiway MM located 3,700 feet from the departure threshold 28R.

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Appendix 1: Days of Flight Track Data Collected.

Date (Year-Month-Day)	Configuration (Arrival | Departure Runways)	Remarks	Daily Operations
2013-10-05	*27L, 27R, 28C | 22L, 28R, 32L*	*West flow*	*1919*
2013-10-06	*27L, 27R, 28C | 22L, 28R, 32L*	*West flow*	*2465*
2013-10-07	*10, 14R, 22R | 9R, 10, 14L, 22L*	*East flow*	*2575*
2013-10-08	*10, 14R, 22R | 9R, 10, 14L, 22L*	*East flow*	*2585*
2013-12-09	*27L, 27R, 28C | 22L, 28R, 32L, 32R*	*West flow*	*2239*
2013-12-10	*27L, 27R, 28C | 22L, 28R, 32L, 32R*	*West flow*	*2244*
2014-02-07	*27L, 27R, 28C | 22L, 28R, 32L*	*West flow*	*2309*
2014-02-08	*27L, 27R, 28C | 22L, 28R, 32L*	*West flow*	*1668*
2014-02-16	*9L, 9R, 10C | 4L, 9R, 10L, 22L*	*East flow*	*2189*
2014-02-17	*9L, 9R, 10C | 4L, 9R, 10L, 22L*	*East flow*	*1377*
2014-03-01	*27L, 27R, 28C | 28C, 28R, 32L, 32R*	*West flow*	*1799*
2014-03-02	*27L, 27R, 28C | 28C, 28R, 32L, 32R*	*West flow*	*2062*
2014-03-06	*27L, 27R, 28C | 22L, 28R, 32L*	*West flow*	*2497*
2014-03-07	*27L, 27R, 28C | 22L, 28R, 32L*	*West flow*	*2474*
2014-04-25	*27L, 27R, 28C | 22L, 28R and 9L, 9R, 10C | 9R, 10L*	*Both*	*2543*
2014-04-26	*27L, 27R, 28C | 22L, 28R and 9L, 9R, 10C | 9R, 10L*	*Both*	*1959*
2014-04-30	*27L, 27R, 28C | 22L, 28R*	*West flow*	*2469*
2014-05-01	*27L, 27R, 28C | 22L, 28R*	*West flow*	*2587*
2014-05-27	*9L, 9R, 10C | 4L, 9R, 10L*	*East flow*	*2381*
2014-05-28	*9L, 9R, 10C | 4L, 9R, 10L*	*East flow*	*2627*
2014-06-23	*27L, 27R, 28C | 22L, 28R*	*West flow*	*2552*
2014-06-24	*27L, 27R, 28C | 22L, 28R*	*West flow*	*2643*
2014-07-09	*27L, 27R, 28C | 22L, 28R and 9L, 9R, 10C | 9R, 10L, 22L*	*West flow*	*2755*
2014-07-10	*27L, 27R, 28C | 22L, 28R and 9L, 9R, 10C | 9R, 10L, 22L*	*West flow*	*2742*
2014-08-14	*9L, 9R, 10C | 9R, 10L*	*West flow*	*2755*

2014-08-15	*9L, 9R, 10C | 9R, 10L*	*East flow*	*2732*
2014-09-07	*27L, 27R, 28C | 22L, 28R*	*West flow*	*2507*
2014-09-08	*27L, 27R, 28C | 22L, 28R*	*West flow*	*2687*
2014-09-20	*9L, 9R, 10C | 9R, 10L*	*East flow*	*2001*

Appendix 2: May 2014 – April 2015 ORD Fleet Mix Derived from CDA and Flightaware Flight Track Data.

INM Aircraft Model	Percent Daytime Operations (%)	Percent Nighttime Operations (%)	Percent All Operations (%)
EMB145	31.83	34.36	32.10
737800	12.52	15.07	12.79
CRJ9-ER	11.57	8.78	11.27
EMB170	11.01	7.20	10.61
CL601	7.31	0.98	6.64
A320-232	5.46	6.02	5.52
A319-131	3.49	4.12	3.55
737700	2.16	3.46	2.29
MD83	2.14	1.14	2.03
757PW	1.78	2.04	1.81
MD82	1.75	1.51	1.72
767300	1.37	0.31	1.26
777200	1.14	1.03	1.13
747400	0.93	2.74	1.12
A321-232	0.95	1.56	1.02
777300	0.81	1.85	0.92
GASEPV	0.52	0.19	0.49
A380-841	0.31	1.21	0.40
CL600	0.40	0.08	0.37
MD11GE	0.21	1.66	0.37
A340-211	0.32	0.73	0.36
A330-343	0.40	0.00	0.36
A330-301	0.30	0.39	0.31
717200	0.31	0.03	0.28
A300-622R	0.01	2.22	0.25

CNA560	0.23	0.18	0.23
MU3001	0.17	0.21	0.17
GIV	0.13	0.08	0.13
CNA500	0.13	0.08	0.12
CNA750	0.14	0.00	0.12
CIT3	0.12	0.00	0.11
767CF6	0.02	0.58	0.08
CNA441	0.03	0.05	0.04
LEAR35	0.01	0.11	0.02
7373B2	0.02	0.00	0.01
747R21	0.01	0.05	0.01
GASEPF	0.01	0.00	0.01
767400	0.00	0.00	0.00

Appendix 3: Baseline 2002 EIS ORD Fleet Mix Used for Noise Analysis.

Aircraft	Percent Daytime Operations (%)	Percent Nighttime Operations (%)	Percent All Operations (%) [1]
CL601	11.20	9.46	11.06
MD82	10.00	7.51	9.81
EMB145	9.29	7.25	9.14
737300	8.94	3.76	8.54
A320-232	6.61	5.54	6.53
F10065	6.77	2.49	6.45
757PW	5.79	6.35	5.83
737500	5.44	2.40	5.21
A319-131	4.30	7.03	4.51
EMB135	4.35	2.80	4.23
737800	3.78	3.81	3.79
MD83	3.46	2.62	3.39
767300	1.91	2.52	1.96
BAE146	1.69	0.82	1.62
A320-211	1.43	2.71	1.53
DO328	1.59	0.29	1.49
757RR	1.37	2.94	1.49
777200	1.31	0.93	1.28
DC93LW	0.88	1.13	0.90
747R21	0.63	3.51	0.85
BEC190	0.80	0.60	0.78
BAE300	0.65	0.37	0.63
7373B2	0.61	0.50	0.60
747400	0.51	1.44	0.58

[1] Table shows operations by aircraft with more than 0.05% of the total fleet mix. The analysis considered a total of 104 distinct INM aircraft.

MD88	0.56	0.71	0.57
737400	0.56	0.42	0.55
777300	0.56	0.08	0.52
DC95HW	0.47	0.29	0.46
727EM2	0.25	2.04	0.39
A340-211	0.29	0.33	0.29
LEAR35	0.30	0.25	0.29
CNA500	0.28	0.21	0.27
GASEPF	0.27	0.15	0.26
DC1010	0.10	2.12	0.26
CL600	0.25	0.15	0.24
767CF6	0.23	0.05	0.22
MD81	0.19	0.15	0.19
737700	0.18	0.25	0.19
74720B	0.07	1.49	0.18
737N17	0.18	0.01	0.16
MD11GE	0.08	1.11	0.16
MD9025	0.16	0.00	0.15
DC1030	0.06	1.09	0.14
DC870	0.03	1.39	0.13
737N9	0.14	0.04	0.13
A300B4-203	0.02	1.43	0.13
GASEPV	0.12	0.07	0.12
DHC6	0.12	0.09	0.12
A330-301	0.12	0.02	0.11
DC86BT	0.00	1.39	0.11
A300-622R	0.00	1.35	0.11
A310-304	0.06	0.71	0.11
SF340	0.10	0.12	0.10

MU3001	0.10	0.04	0.09
CIT3	0.09	0.05	0.08
BEC58P	0.08	0.11	0.08
MD11PW	0.06	0.25	0.08
A321-232	0.03	0.60	0.08
CNA441	0.08	0.05	0.08
GIV	0.07	0.06	0.07
74720A	0.04	0.40	0.07
7472G2	0.02	0.68	0.07
727EM1	0.02	0.49	0.06

Appendix 4: Phase II EIS Fleet Mix Used in the Noise Analysis.

Aircraft	Percent Daytime Operations (%)	Percent Nighttime Operations (%)	Percent All Operations (%)
CL601	21.85	10.92	21.05
MD82	13.07	10.60	12.89
A319-131	12.67	11.66	12.59
EMB145	12.35	6.69	11.94
A320-232	6.12	5.96	6.11
737300	5.07	2.55	4.89
737800	4.78	5.98	4.87
MD83	4.53	3.66	4.46
757PW	4.16	2.65	4.05
767300	2.02	4.62	2.21
A320-211	1.60	3.75	1.76
777200	1.17	0.54	1.12
DC93LW	0.93	1.37	0.97
777300	0.80	0.47	0.77
LEAR35	0.70	1.04	0.72
737500	0.72	0.25	0.69
747400	0.60	1.66	0.67
MD88	0.66	0.17	0.62
7373B2	0.55	0.73	0.57
A340-211	0.52	0.95	0.55
747R21	0.26	3.26	0.48
CNA750	0.46	0.77	0.48
CIT3	0.45	0.02	0.41
737400	0.43	0.16	0.41
A300-622R	0.06	3.97	0.35

DC95HW	0.32	0.60	0.35
CL600	0.33	0.49	0.35
74720B	0.08	2.72	0.28
GIV	0.30	0.02	0.28
HS125	0.25	0.57	0.28
MD11GE	0.04	2.84	0.24
MU3001	0.22	0.00	0.21
737N17	0.21	0.14	0.21
GASEPF	0.22	0.00	0.21
MD9025	0.22	0.05	0.21
A330-301	0.19	0.00	0.17
CNA500	0.19	0.00	0.17
MD81	0.14	0.32	0.16
A330-343	0.15	0.00	0.14
DC870	0.00	1.89	0.14
DC86BT	0.00	1.89	0.14
GASEPV	0.15	0.00	0.14
CNA560	0.15	0.00	0.14
727EM2	0.00	1.18	0.09
A310-304	0.04	0.47	0.07
737700	0.04	0.47	0.07
767400	0.07	0.00	0.07
CNA441	0.04	0.47	0.07
DC1010	0.04	0.49	0.07
7472G2	0.03	0.27	0.05
727Q9	0.00	0.47	0.03
GIIB	0.04	0.00	0.03
727EM1	0.00	0.24	0.02

Appendix 5. ORD 2014-2015 Fleet Mix Used in the Noise Analysis.

Aircraft	Percent Daytime Operations (%)	Percent Nighttime Operations (%)	Percent All Operations (%)
EMB145	42.77	35.64	42.01
737800	12.52	15.07	12.79
CRJ9-ER	10.82	8.48	10.57
EMB170	8.14	7.20	8.04
A320-232	5.46	6.02	5.52
A319-131	3.49	4.12	3.55
737700	2.16	3.46	2.29
MD83	2.14	1.14	2.03
757PW	1.78	2.04	1.81
MD82	1.75	1.51	1.72
767300	1.37	0.31	1.26
777200	1.14	1.03	1.13
747400	0.93	2.74	1.12
A321-232	0.95	1.56	1.02
777300	0.81	1.85	0.92
GASEPV	0.52	0.19	0.49
A380-841	0.31	1.21	0.40
CL600	0.40	0.08	0.37
MD11GE	0.21	1.66	0.37
A340-211	0.32	0.73	0.36
A330-343	0.40	0.00	0.36
A330-301	0.30	0.39	0.31
717200	0.31	0.03	0.28
A300-622R	0.01	2.22	0.25
CNA560	0.23	0.18	0.23
MU3001	0.17	0.21	0.17

GIV	0.13	0.08	0.13
CNA500	0.13	0.08	0.12
CNA750	0.14	0.00	0.12
CIT3	0.12	0.00	0.11
767CF6	0.02	0.58	0.08
CNA441	0.03	0.05	0.04
LEAR35	0.01	0.11	0.02
7373B2	0.02	0.00	0.01
747R21	0.01	0.05	0.01
GASEPF	0.01	0.00	0.01
767400	0.00	0.00	0.00

Appendix 6. ORD Fleet Mix Used in the Noise Analysis with Runway 10R/28L.

Aircraft	Percent Daytime Operations (%)	Percent Nighttime Operations (%)	Percent All Operations (%)
EMB145	42.93	35.55	42.19
EMB170	18.94	15.68	18.61
737800	12.54	14.99	12.78
A320-232	5.48	6.01	5.53
A319-131	3.50	4.07	3.56
737700	2.19	3.41	2.31
MD83	2.11	1.12	2.01
757PW	1.80	2.00	1.82
MD82	1.74	1.53	1.72
767300	1.37	0.32	1.27
777200	1.10	1.04	1.10
747400	0.87	2.83	1.07
A321-232	0.95	1.57	1.01
777300	0.76	1.84	0.87
GASEPV	0.51	0.17	0.47
A380-841	0.28	1.28	0.38
CL600	0.41	0.08	0.38
A340-211	0.30	0.77	0.35
A330-343	0.38	0.00	0.35
MD11GE	0.20	1.65	0.35
A330-301	0.29	0.38	0.30
717200	0.31	0.04	0.28
CNA560	0.24	0.20	0.24
A300-622R	0.01	2.23	0.23
MU3001	0.17	0.22	0.17
GIV	0.13	0.10	0.13

CNA750	0.14	0.00	0.13
CNA500	0.13	0.08	0.12
CIT3	0.12	0.00	0.11
767CF6	0.01	0.60	0.07
CNA441	0.04	0.06	0.04
7373B2	0.02	0.00	0.02
LEAR35	0.01	0.11	0.02
747R21	0.01	0.06	0.01
GASEPF	0.01	0.00	0.01
767400	0.00	0.00	0.00

Appendix 7. Chicago O'Hare Modernization Program EIS Fleet Mix.

Aircraft	Percent Daytime Operations (%)	Percent Nighttime Operations (%)	Percent All Operations (%)
CL601	25.26	7.40	24.27
737800	22.65	17.07	22.34
A319-131	11.91	10.56	11.83
A320-232	10.66	7.33	8
EMB145	9.29	1.66	8.87
A320-211	3.98	7.39	4.17
A321-232	3.74	2.37	3.66
767300	2.36	10.89	2.84
777200	1.42	1.73	1.44
747400	0.64	4.22	0.84
A340-211	0.80	1.13	0.82
737700	0.84	0.57	0.82
LEAR35	0.70	1.13	0.73
777300	0.72	0.57	0.71
717200	0.47	1.13	0.50
CNA750	0.43	0.57	0.44
A300-622R	0.07	6.79	0.44
CIT3	0.40	0.00	0.38
CL600	0.37	0.57	0.38
74720A	0.20	2.90	0.35
MD82	0.35	0.38	0.35
MD11GE	0.07	3.96	0.28
GIV	0.30	0.00	0.28
LEAR25	0.23	0.57	0.25
CNA500	0.20	0.00	0.19
GASEPF	0.20	0.00	0.19

MU3001	0.20	0.00	0.19
A330-343	0.20	0.00	0.19
CNA560E	0.20	0.00	0.19
A330-301	0.20	0.00	0.19
MD81	0.17	0.19	0.17
MD83	0.17	0.19	0.17
74720B	0.05	1.84	0.15
767400	0.13	0.00	0.13
767CF6	0.00	2.26	0.13
A310-304	0.03	1.70	0.13
A380-841	0.13	0.00	0.13
GASEPV	0.13	0.00	0.13
757PW	0.00	1.13	0.06
757RR	0.00	1.13	0.06
7373B2	0.07	0.00	0.06
CNA441	0.03	0.57	0.06
747200	0.01	0.13	0.02

Appendix 8. Chicago O'Hare Fleet Mix for Modified OMP Analysis.

Aircraft	Percent Daytime Operations (%)	Percent Nighttime Operations (%)	**Percent All Operations (%)**
737800	22.60	17.18	22.04
EMB170	13.11	3.87	12.15
A319-131	11.88	10.63	11.75
CL601	11.95	2.85	11.00
A320-232	10.64	7.38	10.30
CRJ9-ER	4.82	0.87	4.41
EMB145	4.82	0.87	4.41
A320-211	3.97	7.43	4.33
A321-232	3.73	2.39	3.59
767300	2.36	10.97	3.26
777200	1.42	1.74	1.45
747400	0.64	4.25	1.02
A340-211	0.80	1.14	0.84
737700	0.83	0.57	0.81
A300-622R	0.07	6.83	0.77
LEAR35	0.70	1.14	0.75
777300	0.71	0.57	0.70
717200	0.47	1.14	0.54
747R21	0.20	2.92	0.48
MD11GE	0.07	3.99	0.48
CNA750	0.43	0.57	0.45
CL600	0.37	0.57	0.39
CIT3	0.40	0.00	0.36
MD82	0.34	0.38	0.35
GIV	0.30	0.00	0.27
HS125	0.23	0.57	0.27

74720B	0.05	1.85	0.24
767CF6	0.00	2.28	0.24
A310-304	0.03	1.71	0.21
CNA500	0.20	0.00	0.18
MU3001	0.20	0.00	0.18
GASEPF	0.20	0.00	0.18
A330-343	0.20	0.00	0.18
CNA560	0.20	0.00	0.18
A330-301	0.20	0.00	0.18
MD81	0.17	0.19	0.17
MD83	0.17	0.19	0.17
767400	0.13	0.00	0.12
A380-841	0.13	0.00	0.12
GASEPV	0.13	0.00	0.12
757PW	0.00	1.14	0.12
757RR	0.00	1.14	0.12
CNA441	0.03	0.57	0.09
7373B2	0.07	0.00	0.06
7472G2	0.01	0.14	0.02

Appendix 9. Overflight Statistics for Towns Located within 6.5 miles of the Airport.

Town	Flights	Day Arrivals	Day Departures	Night Arrivals	Night Departures	Daytime Total	Nighttime Total	Distance to ORD (nm)
Rosemont	688	430	204	39	15	633	54	1.6
Bensenville	678	227	379	30	42	606	72	1.9
Schiller Park	457	239	156	45	17	395	62	2.1
Franklin Park	357	74	259	2	21	334	24	2.9
Wood Dale	491	188	239	30	35	427	65	3.4
Des Plaines	491	229	218	15	29	446	45	3.5
Park Ridge	359	207	132	7	13	340	19	3.6
Northlake	229	46	164	3	16	210	19	3.7
Norridge	347	213	80	44	10	292	55	3.8
Elk Grove Village	588	207	317	14	50	523	65	4.5
River Grove	64	19	38	2	5	57	7	4.6
Harwood Heights	325	208	66	43	7	275	51	4.7
Stone Park	58	13	41	1	2	55	3	4.8
Melrose Park	243	58	166	5	14	224	19	4.9
Itasca	353	162	135	29	27	298	56	5.0
Mount Prospect	309	145	122	21	21	267	43	5.1
Addison	147	38	90	3	16	128	18	5.2
Elmwood Park	35	10	19	2	4	29	6	5.3
Niles	356	204	129	8	14	334	22	5.3
Elmhurst	399	196	167	22	14	363	36	5.3
Berkeley	277	137	112	17	11	249	28	5.6
Bellwood	302	161	113	18	9	274	28	6.0
Morton Grove	76	23	41	4	8	64	12	6.2
Villa Park	284	161	93	20	10	254	30	6.4

River Forest	274	175	76	19	5	250	24	6.4
Maywood	339	193	116	23	7	309	30	6.5

Appendix 10. Overflight Statistics for Towns Located between 6.6 and 9.6 miles of the Airport.

Town	Flights	Day Arrivals	Day Departures	Night Arrivals	Night Departures	Daytime Total	Nighttime Total	Distance to ORD (nm)
Hillside	371	201	137	21	13	337	34	6.9
Golf	20	6	10	2	2	16	4	7.2
Glenview	423	193	186	21	23	379	44	7.4
Broadview	126	59	56	6	5	115	11	7.6
Oak Park	287	186	74	23	5	259	28	7.6
Prospect Heights	208	124	64	11	9	188	20	7.6
Westchester	235	91	123	8	13	214	22	7.7
Arlington Heights	323	158	122	23	20	280	43	7.7
Forest Park	311	191	92	22	6	284	28	7.7
Lincolnwood	229	157	61	7	3	219	11	7.8
Oakbrook Terrace	109	49	49	4	7	98	11	7.9
Rolling Meadows	312	156	125	19	13	281	32	8.0
Skokie	179	90	68	9	12	158	21	8.0
Roselle	249	119	95	26	10	214	35	8.0
Lombard	327	194	99	24	11	293	35	8.1
Glendale Heights	54	18	31	2	3	49	5	8.3
Bloomingdale	207	100	81	20	6	181	26	8.6
North Riverside	97	31	58	3	5	89	8	8.7
Oak Brook	211	74	117	7	14	191	20	8.8
Wheeling	55	24	19	6	6	43	12	8.8
Schaumburg	245	101	120	9	15	221	24	8.8
La Grange Park	100	19	71	2	8	89	10	9.0
Northbrook	171	45	107	6	13	152	19	9.3

Northfield	268	153	92	13	9	245	23	9.4
Glen Ellyn	182	113	47	16	5	160	22	9.6

Appendix 11. Overflight Statistics for Towns Whose Geometric Center is Located farther than 9.6 miles of the Airport.

Town	Flights	Day Arrivals	Day Departures	Night Arrivals	Night Departures	Daytime Total	Nighttime Total	Distance to ORD (nm)
Berwyn	95	36	51	5	4	87	8	9.7
Brookfield	78	15	56	2	5	71	7	9.7
Riverside	45	13	28	1	3	41	4	9.8
Wilmette	124	62	46	9	7	108	16	9.9
Evanston	187	97	67	12	11	164	23	10.1
Palatine	350	174	145	20	10	319	31	10.3
Cicero	117	56	50	8	3	106	11	10.5
La Grange	83	15	59	1	8	74	9	10.6
Hanover Park	327	156	138	23	11	293	34	10.6
Carol Stream	106	52	46	5	3	98	8	10.7
Winnetka	238	140	78	11	9	218	20	10.7
Lyons	52	10	37	1	3	47	5	10.8
Kenilworth	133	88	36	7	2	124	10	10.8
Western Springs	79	14	56	1	8	70	9	10.9
Hinsdale	86	16	60	2	9	76	10	11.1
Clarendon Hills	44	8	31	1	4	40	5	11.2
Stickney	50	12	33	1	3	45	5	11.3
Glencoe	138	59	68	5	7	126	12	11.3
Westmont	75	14	52	3	6	66	9	11.4
Deerfield	35	7	23	1	4	30	5	11.6
McCook	89	18	64	1	6	82	8	11.6
Buffalo Grove	30	11	11	5	3	22	8	11.6
Riverwoods	6	1	3	0	1	4	1	11.6
Chicago	2308	1022	1052	121	114	2074	235	11.7

Inverness	122	70	39	10	2	109	12	11.8
Forest View	22	4	16	1	2	20	3	11.9
Wheaton	187	123	45	17	3	168	20	11.9