FREQ Simulation and Ramp Meter/HOV Bypass Optimization for the Northwest Study Area: A Methodology for Determining Reasonable FREQ Volume Inputs

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March, 2005
Working Paper 05-02

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Abstract:

This paper examines the process used to determine the appropriate mainline and ramp volume inputs required for modeling existing conditions within a portion of the Northwest Area of the regional ramp HOV bypass study using FREQ12 PE.

The Northwest Area is comprised of the following expressway segments: (1) the Eisenhower (I-290) and IL 53 expressways, both inbound and outbound between Lake-Cook Road and a point just west of Austin Avenue; and (2) the Northwest Tollway (I-90), both inbound and outbound between IL Route 31 and the Cumberland Avenue bottleneck. This study focuses on segment (1).
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I. Purpose and Need

Purpose of overall project

Delays caused by traffic congestion on urban expressways are very costly to both individual drivers and the public at large, especially during morning and evening peak travel periods. These costs are manifested primarily as lost time and increased pollution in the form of tailpipe emissions. Congestion occurs on a daily basis on the Eisenhower Expressway (I-290) between Austin Ave. and Mannheim Rd., and on the Eisenhower Extension near the intersection of I-290 and I-90. To make matters worse, traffic volumes are forecast to increase in these areas and throughout the northeastern Illinois expressway system.

One of many possible responses to this worsening congestion problem is the implementation of a ramp-metering strategy. Ramp flow meters dynamically control the rate at which vehicles enter an expressway; they are used to mitigate merge conflicts with mainline traffic and to reduce traffic entering an expressway when incidents occur. When combined with High Occupancy Vehicle (HOV) bypass lanes, a ramp-metering strategy can also encourage the utilization of carpools and vanpools as an alternative to Single Occupancy Vehicles (SOVs).

By increasing the average speed of traffic on an expressway and encouraging carpools, vanpools and transit alternatives, properly configured ramp-flow meters can help reduce the aggregate volume of pollution emitted from automobile tailpipes. These potential benefits would be vital components of the overall effort to bring the Chicago region into compliance with the Clean Air Act Amendment of 1990 by benchmark year 2007.¹

Purpose of this study:

Simulation modeling is used to determine what the optimal ramp-metering strategy is, as well as how much benefit would be derived from its implementation. The general process involves the creation of three models. The first simulates existing conditions. The second simulates future conditions with no ramp-metering strategy — the “do-nothing” alternative. The third simulates future conditions with the implementation of the proposed ramp-metering strategy.

The purpose of modeling the existing condition is to ensure that the model is properly calibrated and accurately simulates observed traffic behavior in the study area. Measurements of total delay, congestion queue lengths and emissions are generated by the model and saved for comparison to future conditions. Once this is done, the traffic volumes forecast for the target year are input into the model and the same measurements are recorded. Finally, the ramp-metering data is input into the “future” model, resulting in a third set of measurements. The difference between the future condition with the ramp-metering strategy in place and the future “do-nothing” condition represents the overall benefit of the strategy.

¹ Dan Doenges, Chicago Area Transportation Study, Ramp HOV Milestone Report #1: State of the Practice (Chicago, IL).
In order to model current conditions, several inputs are required, including:

- Hourly mainline traffic volume entering the study area.
- Hourly mainline traffic volume exiting the study area.
- Hourly exit and entrance ramp volumes for each ramp within the study area.

This paper describes the process used to generate these three sets of data, and presents the results of a roughly calibrated FREQ analysis.

II. Background

Study relationship to regional transportation planning

The Shared Path 2030 Regional Transportation Plan supports the concept of a ramp-metering strategy including HOV bypass lanes to reduce congestion and increase Average Vehicle Occupancy (AVO). *Ramp HOV Milestone Report #1: State of the Practice* showed that ramp-metering strategies have been effective in improving traffic flow in various regions of the country. The report also noted that ramp flow meters with HOV bypass lanes are only effective as part of a system and *not* as stand-alone facilities. The CATS Ramp HOV Working Group selected three areas that would be particularly likely to benefit from the implementation of a ramp metering strategy. Two of those three areas are:

- North Area: Edens Expressway (I-94), including the Edens Spur from Irving Park Road on the Kennedy Expressway to Deerfield Road.

- South Area: (Three Segments) – (1) the Dan Ryan Expressway (I-94) south of 35th Street, (2) the Bishop Ford Expressway (I-94) from the Dan Ryan Expressway south to the I-80 interchange and its continuation as the Calumet Expressway (I-394) to Beecher Road, and (3) I-57 from the Dan Ryan Expressway south to Peotone Road.

The third area — the Northwest Area — is described in the next section of this paper.

Northwest Study Area

The Northwest Study Area is comprised of the following two expressway segments: (1) the Eisenhower Expressway (I-290) from Austin Avenue through the IL Route 53 merge to Lake-Cook Road; and (2) the Northwest Tollway from Cumberland Avenue on the Kennedy Expressway to IL Route 31. **This paper focuses exclusively on segment (1) above.**
Scope of the study

This paper describes a process for determining reasonable hourly traffic volumes for each ramp within the study area. This work builds on the efforts of Monique Stinson and Dan Doenges to establish the overall structure of the study and to collect and organize the data. Actual ramp volumes vary from day to day, but the FREQ simulation tool requires single, whole-number ramp volumes in order to perform the analysis. Inbound and outbound volumes are determined for both AM and PM analysis periods. They are summarized below.

- Hourly traffic volumes for the inbound AM travel period (4 a.m. to noon)
- Hourly traffic volumes for the inbound PM travel period (noon to 8 p.m.)
- Hourly traffic volumes for the outbound AM travel period (4 a.m. to noon)
- Hourly traffic volumes for the outbound PM travel period (noon to 8 p.m.)

NW Area Expressway Traffic Balancing

Overview of FREQ model

The software package used to simulate traffic conditions and optimize ramp meter timing is FREQ version 12. FREQ is designed to simulate mainline, arterial, entrance and exit ramp traffic patterns based on real or forecasted input data. It is a macro-simulator, meaning that its inputs and outputs are stated in terms of large numbers of vehicles, average queue lengths, etc., as opposed to a micro-simulator which models the behaviors of individual cars and trucks. FREQ can perform two types of analyses: Priority Lane (PL) analysis for mainline HOV lanes and Priority Entry (PE) for entrance ramp HOV bypass lanes. The FREQ PE model used for this study requires the following inputs.

- Ramp, mainline and arterial lane capacities
- Number of lanes for ramp, mainline and arterials
- Location of entrance/exit ramps
- Free flow speed on the mainline and arterials
- Percentage of heavy trucks on each expressway segment
- Entrance/exit ramp vehicle mixture
  - Single occupancy
  - Dual occupancy
  - 3 person+ occupancy
  - Buses
- Average vehicle occupancy (for 3 person+ and buses)
- Entrance and exit ramp volumes
- Beginning and ending mainline volumes
- Arterial volumes
- Arterial signal progression (poor, good or none)
- Fuel consumption data
- Emissions data
This paper is concerned with determining the beginning and ending mainline and ramp volumes for current conditions. Arterial volumes will be addressed in a future phase of this study.

Other FREQ requirements

Since FREQ is a macro-simulation tool, it requires a discrete whole number for each ramp volume, as well as for the beginning and ending mainline volumes. It also requires that the volumes “balance.” This means that the ending mainline volume during a given time period must be equal to the beginning mainline volume, plus the volumes of all the entrance ramps minus the volumes of all the exit ramps (see equation below).

Equation #1: \[ ML_{END} = ML_{BEGIN} + \sum ENT - \sum EXIT \]

Where

- \( ML_{END} \) = mainline volume at the end of the study area
- \( ML_{BEGIN} \) = mainline volume at the beginning of the study area
- \( \sum ENT \) = sum of all entrance ramp volumes in the study area
- \( \sum EXIT \) = sum of all exit ramp volumes in the study area

Since actual traffic volumes for any given time period at any point on the expressway system vary, determining the single appropriate value (referred to as the “single-point” volume) for each ramp for each time period is an involved process. This process is described below for the Northwest Area.

Data collection

Raw traffic volume data are required in order to begin the process. These data are obtained from two primary sources. Each of them rely on under-pavement loop detectors located at every entrance and exit ramp, as well as at various points on the expressway mainlines themselves. The IDOT Traffic Systems Center (TSC) collects and stores these data and provides them in various report formats. The sources used for this study are as follows:

1. Hourly traffic volume data for Tuesday, March 5, 2002 as reported by the TSC. (Referred to as “Source 1” data)
2. Annual average daily traffic for each main line segment and entrance / exit ramp from the 2000 Travel Atlas. (Referred to as “Source 2” data)

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2 Traffic volume data from these loop detectors are continuously generated and collected by the TSC 24 hours a day, 365 days a year. Road construction and/or mechanical/electrical failure occasionally result in gaps in the data. For the study area, there were a number of ramps (18 of 66 inbound and 22 of 66 outbound) where no data was available for the March 5, 2002 date.
3 In the Chicago region, spring and fall are standard data collection seasons because people travel more in the summer and less in the winter and because major road construction projects are either over or have not started yet. Traffic volumes are more predictable on midweek days than they are on either Monday or Friday. Therefore, Tuesday, Wednesday and Thursday are often the best days to select traffic volumes for study purposes.
4 Travel Atlas data is based on the TSC’s loop detector data, but is massaged into average daily traffic numbers. In order to be used, these data need to be disaggregated into hourly slices.
5 Referred to as Source 3 data in the spreadsheet.
Traffic volumes from these data sources were input into four spreadsheets for analysis — one each for Inbound AM (IBAM), Inbound PM (IBPM), Outbound AM (OBAM) and Outbound PM (OBPM) trips.

Process

The process used to determine the balanced, single point volume data for each ramp was as follows.6

1. Set baseline volume data;
2. Determine control points7 and associated mainline traffic volumes for each time slice;
3. Select the first control point and time slice to balance;
4. Adjust traffic volumes of the ramps located before the selected control point so that the adjusted mainline volume equals the mainline volume determined in step 2 above;
5. Go to step 3 for the next control point and continue until complete.

Each of these steps is described in detail below.

Set baseline volume data

“Source 1” data is used as the baseline when available. However, 21 of 65 inbound and 22 of 64 outbound ramp loop detectors were not functioning properly on March 5, 2002. So, in order to fill in these missing pieces, “Source 2” data was used. The difficulty with “Source 2” data is that it is in the form of Average Daily Traffic and must be converted to specific hourly traffic volumes. To derive these hourly volumes for a “March Tuesday” the data is first multiplied by a monthly factor8, then by a day-of-the-week factor,9 and finally by an hourly factor.

The multiplication by the hourly factor is complicated further by the fact that there is only one point within the Northwest Area where the hourly variation of traffic factor is provided — at the intersection of Church Road and the Eisenhower Extension.10 The true hourly factor is quite different, depending on which expressway segment is studied. To account for this difference, hourly factors are derived in this study for four other points along the study section: Dundee Road, the Northwest Tollway (I-90), the North-South Tollway (I-355) and 9th Street. Hourly traffic volumes are then calculated using the hourly factors from the point nearest to the ramp in question.

To derive the hourly factors, the “Source 1” hourly mainline volumes are simply converted to ratios. For example, if 22,703 cars are detected at the Dundee three-lane cross section of IL Route 53 during the course of the entire day and 1,927 of them are detected during the 7-8 a.m. time period, the hourly factor for that time period is 1,927 divided by 22,703 or 0.08488.

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6 Note: the process is described for IBAM trips only, but the other three sets of trips are analyzed the same way.
7 A control point is a location within the study area where the mainline volume derived by adding and subtracting ramp volumes is set equal to the “actual” mainline volume from “Source 1.”
8 Taken from Exhibit 4.1-A in the 1995 Travel Atlas, page 137.
9 Taken from Exhibit 4.2-A in the 1995 Travel Atlas, page 138.
10 See Exhibit 4.4-Da in the 1995 Travel Atlas, page 143.
Determine control points and their associated mainline traffic volumes for each time slice

Four control points were selected for both the inbound and the outbound trips.\textsuperscript{11}

The inbound control points are:

- The three-lane cross section just downstream from the Dundee Road exit ramp.
- The six-lane cross section (three local, three express) just downstream from the eastbound I-90 exit ramp.
- The three-lane cross section just downstream from the eastbound North Avenue entrance ramp.
- The three-lane cross section just downstream from the Harlem Avenue entrance ramp.

\textsuperscript{11} While it is possible to use just two control points — one at the beginning and one at the end — four are used in this study. This is done because the study area is quite long (approximately 25 miles), and if it were not divided into sections, the ramp adjustments would be rationalized along its entire length. By dividing the study area into sections and balancing them individually, the ramp adjustments are concentrated within the sections where the data indicate there is an imbalance. This method provides for a closer match between the model and the observed conditions.
Figure #2
Locations of Inbound Control Points
The outbound control points are:

- The three-lane cross section just downstream from the Austin Avenue entrance ramp.
- The two-lane cross section just downstream from the I-88 exit.
- The four-lane cross section just downstream from the Biesterfield entrance ramp.
- The three-lane cross section just downstream from the Dundee exit ramp.
Figure #3
Locations of Outbound Control Points
Select the first control point and time slice to balance

To balance the system, start with the first control point in the direction of travel and the first time slice. For the IBAM trip, this is the three-lane cross section just past the Dundee Road exit ramp during the 4-5 a.m. time interval.

To illustrate the process used to adjust ramp volumes, the balancing of the IBAM trip between Lake-Cook Road and the Northwest Tollway during the 7-8 a.m. interval is described in detail in the following section. The same process was used for all other time intervals for both inbound and outbound trips.

Adjust ramp volumes

Source 1 volumes are used for each entrance and exit ramp. For the ramps that have no Source 1 data available, Source 2 data is used. Starting with the mainline volume at the previous control point (or the mainline volume at the beginning of the study area if this is the first iteration), add the baseline volume for each of the entrance ramps and subtract the baseline volume for each of the exit ramps and compare the results to the Source 1 volume at the control point. The difference between these two volumes equals the total ramp volume adjustment needed to balance the system (see Table 1 below).
### Table 1: Original Data

<table>
<thead>
<tr>
<th>Inbound AM Trips</th>
<th>Source 3</th>
<th>Source 1 Actual Hourly Ramp Volume on 3/5/02 (from loops)</th>
<th>Source 1 Actual Hourly Mainline Volume on 3/5/02 (from loops)</th>
<th>Selected Comparison Ramp Volume</th>
<th>Final Ramp Volume (for input to FREQ)</th>
<th>Difference Between Final RV and Actual RV</th>
<th>Percent Difference</th>
<th>Final Mainline Volume</th>
<th>Difference Between Final MLV and Actual MLV</th>
</tr>
</thead>
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<tr>
<td>Start</td>
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<td>0</td>
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<td>0</td>
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<td>0</td>
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<td>WB Lake Cook Rd. On</td>
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<td>1472</td>
<td>1472</td>
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<td>0</td>
<td>0.0%</td>
<td>0</td>
<td>1472</td>
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<td>EB Lake Cook Rd. Off</td>
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<td>0</td>
<td>0.0%</td>
<td>2886</td>
<td>-118</td>
</tr>
<tr>
<td>Dundee Rd. Off</td>
<td>1273</td>
<td>476</td>
<td>476</td>
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<td>0.0%</td>
<td>3362</td>
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</tr>
<tr>
<td>JFS 12/Rand Rd. On</td>
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<td>970</td>
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<td>0.0%</td>
<td>4322</td>
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<td>WB Palatine Rd. Off</td>
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<td>EB Palatine Rd. Off</td>
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<td>46</td>
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<td>0</td>
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<td>906</td>
<td>906</td>
<td>906</td>
<td>0</td>
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<td>0.0%</td>
<td>4876</td>
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</tr>
<tr>
<td>JFS 14/Northwest Hwy. Off</td>
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<td>454</td>
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<td>JFS 14/Northwest Hwy. On</td>
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<td>5224</td>
<td>0</td>
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<td>WB Euclid Ave. Off</td>
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<td>WB Euclid Ave. On</td>
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<td>EB Euclid Ave. Off</td>
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<td>-357</td>
<td>-335</td>
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<td>0</td>
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<td>4856</td>
<td>0</td>
</tr>
<tr>
<td>IL 62/Algonquin Rd. Off</td>
<td>-907</td>
<td>-682</td>
<td>-682</td>
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<td>0.0%</td>
<td>6976</td>
<td>0</td>
</tr>
<tr>
<td>IL 62/Algonquin Rd. On</td>
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<td>0</td>
<td>0.0%</td>
<td>7136</td>
<td>0</td>
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<tr>
<td>WB I-90 Off</td>
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<td>-894</td>
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<td>0</td>
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<td>WB I-90 On</td>
<td>1316</td>
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<td>761</td>
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<td>7003</td>
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<td>0.0%</td>
<td>4973</td>
<td>-1873</td>
</tr>
</tbody>
</table>

### Description of Table Columns

- **Column 1**: On/Off Ramp Description
- **Column 2**: Source 2 ADT Volume
- **Column 3**: Source 1 Actual Hourly Ramp Volume
- **Column 4**: Source 1 Actual Hourly Mainline Volumes
- **Column 5**: Selected Comparison Ramp Volume
- **Column 6**: Final Ramp Volume
- **Column 7**: Difference Between Final and Actual
- **Column 8**: Percent Difference
- **Column 9**: Final Mainline Volume
- **Column 10**: Diff. Between Final and Actual ML Vols

**Location of Ramp**
- **Adjusted Travel Atlas Volume Data**
- **Actual Loop Detector Volumes 3/5/02**
- **Actual Loop Detector Volumes 3/5/02**
- **Base Volume used (S1 or S3) as a starting point. This is saved here in order to calculate proportional adjustment later.**
- **The values in this column are adjusted to “balance” the system. This will be the input volume for FREQ analysis.**
- **As the data is modified in column 6, this column keeps track of the difference between the adjusted volume and the original base volume.**
- **This column displays the numeric difference shown in column 7 as a percentage.**
- **This keeps a running tally of the mainline volume by adding and subtracting the ramp volumes in column 6.**
- **Shows how far off the system is from “balancing.” Will equal zero at the control point when the system is balanced.**
Note that the last cell in the last column equals zero when this segment is balanced. This table shows that a total of 1,873 vehicles must be added to entrance ramp volumes or subtracted from exit ramp volumes in order for this part of the system to balance.

At this point, a decision is made whether or not to substitute Source 2 data for Source 1 data for each ramp. This is done using a trial and error method. It is desirable to balance the system with a minimum of manual adjustments. If using Source 2 data for a given ramp can reduce the overall excess or deficit of vehicles at the interim control point over the entire analysis period, the substitution is made. For the purposes of consistency, once a substitution is made it would apply to all of the time slices for the inbound or outbound trips for that ramp. Substitutions are made only if they bring the overall system, including all time slices, closer to balance. In this example, substitutions were made for the following ramps:

- Dundee Road On
- US 12/Rand Road On
- Westbound Palatine Road Off
- Westbound I-90 Off
- Westbound I-90 On
- Eastbound I-90 Off

These substitutions and their effects are shown in Table 2 below.

### Table 2: Substitution of Selected Source 2 Data

<table>
<thead>
<tr>
<th>Inbound AM Trips</th>
<th>Source 3 ADT volume adjusted by time of day factor</th>
<th>Source 1 Actual Hourly Ramp Volume on 3/5/02 (from loops)</th>
<th>Source 1 Actual Hourly Mainline Volume on 3/5/02 (from loops)</th>
<th>Selected Comparison Ramp Volume</th>
<th>Final Ramp Volume (for input to FREQ)</th>
<th>Difference Between Final RV and Actual RV</th>
<th>Percent Difference</th>
<th>Final Mainline Volume</th>
<th>Difference Between Final MLV and Actual MLV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dundee Rd. Off</td>
<td>105</td>
<td>-58</td>
<td>3004</td>
<td>-58</td>
<td>-58</td>
<td>0</td>
<td>0.0%</td>
<td>2886</td>
<td>118</td>
</tr>
<tr>
<td>Dundee Rd. On</td>
<td>1273</td>
<td>476</td>
<td>1273</td>
<td>1273</td>
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<td>0.0%</td>
<td>4159</td>
<td></td>
<td></td>
</tr>
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<td>US 12/Rand Rd. On</td>
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<td></td>
<td></td>
</tr>
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<td>EB Palatine Rd. Off</td>
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<td>-335</td>
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<td>7188</td>
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<td>-223</td>
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<tr>
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<td>510</td>
<td>510</td>
<td>510</td>
<td>510</td>
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<td>7875</td>
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<tr>
<td>EB Euclid Ave. On</td>
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<td>858</td>
<td>663</td>
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<td>0</td>
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<td>9483</td>
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</tr>
<tr>
<td>IL 62/Algonquin Rd. Off</td>
<td>-60</td>
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<td>8060</td>
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</tr>
<tr>
<td>IL 62/Algonquin Rd. On</td>
<td>1032</td>
<td>846</td>
<td>1032</td>
<td>846</td>
<td>0</td>
<td>0.0%</td>
<td>9448</td>
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</tr>
<tr>
<td>WB I-90 Off</td>
<td>-1052</td>
<td>-984</td>
<td>-1052</td>
<td>-984</td>
<td>0</td>
<td>0.0%</td>
<td>9356</td>
<td></td>
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<tr>
<td>WB I-90 On</td>
<td>1318</td>
<td>761</td>
<td>1318</td>
<td>761</td>
<td>0</td>
<td>0.0%</td>
<td>9074</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EB I-90 Off</td>
<td>-1428</td>
<td>-2035</td>
<td>-1428</td>
<td>-2035</td>
<td>0</td>
<td>0.0%</td>
<td>8246</td>
<td>1400</td>
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</table>
The result of these substitutions is that instead of needing to add 1,873 vehicles, it is now necessary to subtract 1,400 vehicles in order to balance this segment. This is done so that the ramp volumes from Source 1 data are adjusted by no more than 10%. The ramp volumes derived from Source 2 data can be adjusted by more than 10% if necessary. These requirements reflect a preference for actual traffic counts from loop detectors over data derived from average daily traffic numbers.

Next, the volumes on each ramp are adjusted by just under 10% so that the mainline volume is reduced. These results are shown below in Table 3.

**Table 3:**
*After Adjusting Ramp Volumes by 10%*

<table>
<thead>
<tr>
<th>Inbound AM Trips</th>
<th>Source 3 ADT volume adjusted by time of day factor</th>
<th>Source 1 Actual Hourly Ramp Volume on 3/5/02 (from loops)</th>
<th>Source 1 Actual Hourly Mainline Volume on 3/5/02 (from loops)</th>
<th>Selected Comparison Ramp Volume</th>
<th>Final Ramp Volume (for input to FREQ)</th>
<th>Difference Between Final RV and Actual RV</th>
<th>Percent Difference</th>
<th>Final Mainline Volume</th>
<th>Difference Between Final MLV and Actual MLV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>WB Lake Cook Rd. On</td>
<td>1472</td>
<td>1472</td>
<td>1531</td>
<td>59</td>
<td>4.0%</td>
<td>1531</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>EB Lake Cook Rd. On</td>
<td>1472</td>
<td>1472</td>
<td>1531</td>
<td>59</td>
<td>4.0%</td>
<td>1531</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dundee Rd. Off</td>
<td>-109</td>
<td>-109</td>
<td>478</td>
<td>0</td>
<td>0.0%</td>
<td>478</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Dundee Rd. On</td>
<td>327</td>
<td>327</td>
<td>1531</td>
<td>59</td>
<td>4.0%</td>
<td>1531</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>IL 12/Rand Rd. On</td>
<td>1111</td>
<td>1111</td>
<td>1000</td>
<td>0</td>
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<td>1000</td>
<td>0</td>
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<tr>
<td>WB Palatine Rd. Off</td>
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<td>747</td>
<td>0</td>
<td>0.0%</td>
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<td>0</td>
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<tr>
<td>EB Palatine Rd. On</td>
<td>325</td>
<td>325</td>
<td>747</td>
<td>0</td>
<td>0.0%</td>
<td>747</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>US 14/Northwest Hwy On</td>
<td>122</td>
<td>122</td>
<td>401</td>
<td>0</td>
<td>0.0%</td>
<td>401</td>
<td>0</td>
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</tr>
<tr>
<td>US 14/Northwest Hwy On</td>
<td>122</td>
<td>122</td>
<td>401</td>
<td>0</td>
<td>0.0%</td>
<td>401</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>WB Euclid Ave. Off</td>
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<td>25</td>
<td>9.9%</td>
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<td>0</td>
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<tr>
<td>EB Euclid Ave. Off</td>
<td>230</td>
<td>230</td>
<td>148</td>
<td>13</td>
<td>8.8%</td>
<td>241</td>
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<tr>
<td>EB Euclid Ave. On</td>
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<td>-161</td>
<td>-12</td>
<td>7.5%</td>
<td>-153</td>
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<tr>
<td>WB I-90 Off</td>
<td>-1092</td>
<td>-1092</td>
<td>-1201</td>
<td>-109</td>
<td>8.8%</td>
<td>-1201</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>WB I-90 On</td>
<td>1318</td>
<td>1318</td>
<td>1189</td>
<td>92</td>
<td>7.9%</td>
<td>1189</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>EB I-90 Off</td>
<td>-1428</td>
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<td>-1570</td>
<td>-142</td>
<td>9.2%</td>
<td>-1570</td>
<td>0</td>
<td>0</td>
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</table>

The 10% ramp volume adjustments bring this segment much closer to balance (from 1,400 to 226 excess vehicles). To complete the balancing process for this segment, the remaining 226 extra vehicles on the mainline are removed from the ramps where Source 2 data was used. Each ramp is adjusted by roughly equal percentages. See Table 4 below.

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12 Note: The first control point is located on the mainline just downstream from the Dundee Rd. exit ramp. For this study, the Source 2 data provided for the beginning of the expressway were divided equally between the westbound and eastbound Lake-Cook Rd. entrance ramps. These ramps were then adjusted so that their sum was made to equal the mainline volume at the first control point. The Dundee Rd. exit volume was left unchanged since it has a much lower volume. Therefore, a small percentage adjustment would have a negligible effect on this ramp volume (about 3 vehicles per hour in this case), so, for ease of calculation, it was ignored.
This process is repeated 96 times (16 hourly time slices x 3 inbound segments x 3 outbound segments) until the entire system is in balance.

**IV. Findings**

By applying the systematic process outlined in this paper, reasonable single-point ramp volumes can be derived from loop detector data. The process consists of four steps, two of which are iterated until the entire section is balanced for the analysis period in question. The process is as follows:

1. Set baseline volume data.
2. Determine control points and their associated mainline traffic volumes for each time slice.
3. Select the first control point and time slice to balance.
4. Adjust traffic volumes of the ramps located before the selected control point so that the adjusted mainline volume equals the mainline volume determined in step 2 above.
5. Go to step 3 for the next control point and continue until complete.

The keys to the process are (1) determining the appropriate control points and (2) using a reasonable algorithm to make ramp volume adjustments.

At a minimum, there should be a control point at both the beginning and the end of the study area. If the area to be studied is large and/or connects with other freeways, additional intermediate control points may be established near these freeway interchanges.
The ramp volume adjustment algorithm used in this study adjusts all ramps by a maximum of 10%. Additional adjustments, where required, are made only to the ramps where Source 2 base data were used. In either case, the adjustments are made in such a manner that the ratio of adjusted ramp volume to base ramp volume is the same for all ramps in the section. If the average adjustment is greater than 10%, the excess is distributed equally among the ramps using Source 2 base data.

The magnitude of the ramp volume adjustments is summarized as follows.

Overall
- 92% ramp time slices adjusted less than 10%
- 4% ramp time slices adjusted less than 20%
- 3% ramp time slices adjusted less than 30%
- 1% ramp time slices adjusted less than 40%
- 0% ramp time slices adjusted more than 40%

IBAM
- 88% ramp time slices adjusted less than 10%
- 7% ramp time slices adjusted less than 20%
- 2% ramp time slices adjusted less than 30%
- 3% ramp time slices adjusted less than 40%
- 0% ramp time slices adjusted more than 40%

IBPM
- 99% ramp time slices adjusted less than 10%
- 1% ramp time slices adjusted less than 20%
- 0% ramp time slices adjusted less than 30%
- 0% ramp time slices adjusted less than 40%
- 0% ramp time slices adjusted more than 40%

OBAM
- 93% ramp time slices adjusted less than 10%
- 3% ramp time slices adjusted less than 20%
- 4% ramp time slices adjusted less than 30%
- 0% ramp time slices adjusted less than 40%
- 0% ramp time slices adjusted more than 40%

OBPM
- 87% ramp time slices adjusted less than 10%
- 7% ramp time slices adjusted less than 20%
- 6% ramp time slices adjusted less than 30%
- 0% ramp time slices adjusted less than 40%
- 0% ramp time slices adjusted more than 40%
V. Further Analysis

The most important areas for further analysis within the Northwest study area are as follows:

1. Perform floating car studies and use the resulting data to calibrate the FREQ model.13
2. Develop a micro-simulation model of the Hillside Strangler area in order to analyze its complex geometry and traffic flow more effectively.
3. Input forecasted traffic volumes into the model to determine future conditions under the “do nothing” alternative.
4. Create a FREQ model with the proposed Ramp/HOV bypass configurations and run it to determine future conditions with the improvements.

VI. Conclusion

The primary purpose of this paper is to describe the process used to develop FREQ ramp volume inputs for the Northwest area. This process can be generally applied with minor modifications to many freeway projects. It could be especially helpful when working with large study areas that are missing a significant number of ramp volume data points.

13 The single-point ramp volumes derived using the process outlined in this paper have been input into a FREQ model of the Northwest Area.