HOV Lanes in Twin Cities

Research on Possible Addition to HOV Lanes in the Twin Cities Metro Area

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Introduction

The Federal Highway Administration (FHWA) defines High Occupancy Vehicle (HOV) lanes as “lanes where only high-occupancy vehicles are allowed to operate, which include exclusive bus lanes and bus ways (1).” It also says that HOV facilities “move significantly more people during congested periods, even if the number of vehicles that use the HOV lane is lower than on the adjoining general purpose lanes.” In the USA and Canada there is currently 2,500 miles of HOV lanes. They were implemented for the first time in Virginia in the 1970’s. This was a failure and the HOV lanes were converted back to mixed-use lanes. HOV lanes were again started in California and this time they were successful.

*There are six main types of HOV lanes:*

1. HOV 2+: Minimum of two people in vehicle.
2. HOV 3+: Minimum of three people in vehicle.
4. Exclusive Bus Way and Bus Lane: Cheap and efficient mass transit.
5. Bus, Taxi, and Van pools: Lanes for bus, taxi or van pools.
6. HOV/Toll (HOT) Lanes: Allows carpools to use for free or at discount.

*Geometric Classification of HOV lanes:*

1. Concurrent Flow: Leftmost lane is dedicated as HOV lane, and is cheapest.
2. Barrier-separated: HOV lane is separated from rest of the lanes by a barrier.
   a. Fixed Flow: HOV lane only flows in one direction.
   b. Reversible Flow: The same HOV lane is reversed depending on flow.
3. Contraflow: Uses lane from opposing traffic as HOV lane.
4. Shoulder Lane: Shoulder is used as HOV lane.
The Minnesota Department of Transportation (MNDot) currently has two separate stretches of HOV lanes.

- **East Bound:** CR 101 South Junction to I-94 (10.4 miles)
- **West Bound:** I-94 to Carlson Parkway (8.8 miles)
- **North Bound:** Burnsville to 86th Street, Bloomington (5.7 miles)
- **South Bound:** 66th Street Richfield to HWY 13 Burnsville (7.5 miles)

Fig 1.1 HOV Lanes in Minnesota
Minneapolis experiences quite a large amount of traffic during the morning and evening rush-hour. In addition to the HOV lanes Minneapolis operates more than 70 HOV ramp meter bypasses and 100 miles of freeway where the shoulder is utilized by transit vehicles. The public transportation in the Minneapolis area is getting better but there are quite a large number of people who commute from the suburbs surrounding Minneapolis. We may be able to reduce this traffic by providing for HOV lanes for commuters. The objective is to “provide faster, more reliable travel for those who rideshare or use transit, and to transport more people in fewer vehicles” (MnDot, 1-1). This study will plot a scaled diagram of the volume flowing in the interstate and highway network around the Twin Cities Metropolitan area. Based on this visual data we will identify if there are other locations/stretches of the interstate network around Minneapolis where HOV lanes can be implemented.

**Methodology**

MNDOT has placed a network of stations and detectors in the road network around the Twin Cities Metro Area. These detectors collect traffic information which is then uploaded to a server. For the purpose of this project I have the location of these stations and also the data for the year 2005.
Stations:

A station is the location of either a single or multiple detectors located under the asphalt of the road. The location schematic of detector and station is shown below.

Each time a vehicle passes over the detector, it records it and uploads the data to a server. Stations and detectors are related by a file which lists the detectors that are present in a particular station. The station data also consists of the co-ordinates of each station. This will allow us to plot the stations on a map, and know which detectors fall under a particular station. There are 1020 stations in the data.

Fig. 1.2 Detector and Station Convention
Table 1.1 Sample Table of Station Number with Co-ordinates

<table>
<thead>
<tr>
<th>STATION_NO</th>
<th>NORTING</th>
<th>EASTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>4978827</td>
<td>478705.3</td>
</tr>
<tr>
<td>3</td>
<td>4978779</td>
<td>478762.7</td>
</tr>
<tr>
<td>4</td>
<td>4977999</td>
<td>478622.2</td>
</tr>
<tr>
<td>5</td>
<td>4977617</td>
<td>478396.7</td>
</tr>
<tr>
<td>6</td>
<td>4977025</td>
<td>478304.5</td>
</tr>
<tr>
<td>7</td>
<td>4976301</td>
<td>478304.6</td>
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<td>8</td>
<td>4975644</td>
<td>478304.3</td>
</tr>
<tr>
<td>9</td>
<td>4974905</td>
<td>478301.4</td>
</tr>
<tr>
<td>10</td>
<td>4974101</td>
<td>478295.8</td>
</tr>
<tr>
<td>11</td>
<td>4973351</td>
<td>478292.2</td>
</tr>
<tr>
<td>12</td>
<td>4972686</td>
<td>478279.3</td>
</tr>
<tr>
<td>13</td>
<td>4967429</td>
<td>476420.3</td>
</tr>
</tbody>
</table>

Data:

Each detector records and uploads the data. This raw data is in MNDot's *.traffic format. For the purpose of this project, data for the year 2005 was chosen, and had already been extracted and simplified. This data was now present to us in the form of a *.csv file containing station id’s on the first column. The other columns contained the hourly volume of each station.

Table 1.2 Sample Station Number with Total Hourly Volume

<table>
<thead>
<tr>
<th>Station</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1094</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1095</td>
<td>603</td>
<td>594</td>
<td>295</td>
<td>188</td>
<td>161</td>
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<tr>
<td>1096</td>
<td>647</td>
<td>655</td>
<td>308</td>
<td>212</td>
<td>194</td>
</tr>
<tr>
<td>910</td>
<td>942</td>
<td>883</td>
<td>432</td>
<td>280</td>
<td>245</td>
</tr>
<tr>
<td>916</td>
<td>781</td>
<td>842</td>
<td>569</td>
<td>348</td>
<td>229</td>
</tr>
<tr>
<td>1097</td>
<td>549</td>
<td>593</td>
<td>407</td>
<td>253</td>
<td>181</td>
</tr>
<tr>
<td>870</td>
<td>413</td>
<td>405</td>
<td>178</td>
<td>140</td>
<td>130</td>
</tr>
</tbody>
</table>

Table 1.2 Sample Station Number with Total Hourly Volume
According to the Texas Department of Transportation “freeway corridors with average daily traffic of at least 25,000 vehicles per lane should be considered as an HOV lane candidate. Corridors with heavy peak-period demands are usually prioritized for HOV lane deployment”.

Based on this condition I chose two different scenarios to analyze the data. The first would be based on the total daily volume per lane. The second one would consider average hourly volume during the rush hour time frame.

*Total Daily Volume per Lane*

Total daily volume is the number of vehicles that passes through a particular station during a twenty-four hour period. For this purpose a program was written in MatLab, which would give an average daily volume for the whole year (see Appendix 1). The program took in the available files with volume data as input and added up all the volume for each station. This was in turn averaged out with the number of days, which would give us the total number of cars passing through that station (i.e. volume per hour). To get the volume per lane, the volume at each station was averaged out by the number of detectors for each particular station to give the Daily Traffic Volume per Lane. This was saved as a *.csv file.

<table>
<thead>
<tr>
<th>Station</th>
<th>Daily Traffic Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>1094</td>
<td>0</td>
</tr>
<tr>
<td>1095</td>
<td>16521.5</td>
</tr>
<tr>
<td>1096</td>
<td>12796</td>
</tr>
<tr>
<td>910</td>
<td>15462.66</td>
</tr>
<tr>
<td>916</td>
<td>15653.33</td>
</tr>
<tr>
<td>1097</td>
<td>12703.66</td>
</tr>
<tr>
<td>870</td>
<td>10323.5</td>
</tr>
<tr>
<td>871</td>
<td>8019</td>
</tr>
<tr>
<td>872</td>
<td>13170</td>
</tr>
<tr>
<td>873</td>
<td>12355.5</td>
</tr>
<tr>
<td>874</td>
<td>12439</td>
</tr>
</tbody>
</table>

*Table 1.3 Sample Average Daily Traffic Volume per Lane*
Average Peak Hour Volume per Lane

Graphs with traffic volume plotted against each hour were drawn out from the available data fig. 1.1. The spike in traffic volume is noticeable from 6 a.m. to 9 a.m. and from 3 p.m. to 7 p.m. This was taken to be our rush hour time frame. Random weekday data was picked out from the available sample data and an average volume for each hour for each station was computed. Only the data for the morning and evening rush hour was kept. The rest was deleted. Then an average volume for the morning rush hour was calculated and average volume for the evening rush hour was also calculated. The average volume was obtained for each station. This volume was then averaged out to the number of detectors at each station to get hourly volume per lane. This was saved as a *.csv file.

**Fig 1.3 Daily Traffic Volumes versus Time for multiple stations**
Table 1.4 Daily Rush Hour - Hourly Volume

A map of Minnesota was created in TransCAD using available ccdata. The Interstate Highway system was added on as a layer. The stations were plotted with their x,y co-ordinates and a little help from ArcMap. These data were then imported from their respective *.csv files and joined with the station data, using join and selecting the station as the field. We can get three separate figures for ADT per Lane >=25,000 (appendix 4), average morning rush hour traffic >=800 (appendix 5), and average evening rush hour volume >=800 (appendix 6).
Fig 1.4 Locations of Stations around Twin Cities Metro Area
Results

From the ADT/Lane diagram we see that there is a section of HWY 169, I-94, I-694, MN-5 and I-35W that are known to have more than 25,000 vehicles per day per lane (appendix 4). These sections are heavy traffic roads which do not have any HOV lanes dedicated in them.

The two diagrams for the hourly volume for the morning rush hour and the evening rush hour show that almost all stations have more than 800 vehicles per hour per lane traffic through them (appendix 5 & 6).
**Recommendations & Conclusion**

We cannot base our recommendation just by looking at one diagram and comparing it with the location of existing HOV lanes in Minnesota. If we look at the ADT/Lane data then this gives us new sections of roads that may benefit from addition of HOV lanes (green dots). The section of US-169 just below intersection with I-394, I-35W and I-94 through the center of Minneapolis, I-694 on the north-east section, the section of I-494 on the southern side, and the intersection of MN803A and US61, they all seem to have heavy traffic and they may be good locations to have additional HOV lanes.

However if we look at the morning and evening rush hour volumes, it is illogical to have HOV lanes through such a large network. We can compare the two diagrams and come up with what may be good locations for HOV lanes (*appendix 7*).

The red outlined parts are the sections with current HOV dedications. I have proposed sections for future HOV consideration by outlining them in black ink. The shaded ones indicate roads that my benefit by having HOV lanes throughout the day, instead of just during the rush hour because these seem to have heavy traffic throughout the year. The sections marked out as possible HOV candidates consistently have a large amount of traffic flowing through them during the peak hour. These sections may benefit by having HOV lanes designated on them during the rush hour (6-9 am and 3-8 pm).

Further research and studies is required before an actual implementation of these HOV lanes. There are some other data analyses that need to be considered for further study. The current volume data does not include any flow due to current HOV lanes. Random samples of volunteers have to be chosen and studies have to be carried out on their car-pooling and driving behavior. Studies have to be carried out on traffic volume impact before and possible implementation of HOV lanes. This will tell us the effectiveness of HOV lanes in reducing traffic jams. Effect of future HOV lanes on traffic should be
properly studied. A benefit-cost analysis should be performed to analyze the economical viability of the lanes. This study only looks at the volume data, but we need to obtain data on the trip distribution to and network assignment to know which roads around the metro area are the most frequently used ones and how is the traffic distributed. Sometimes data can mislead a research. We need to speak with people who use the metro network and obtain feedback from them. We should ask them about the roads that they use on a daily basis and which sections are the ones that have the heaviest traffic. This should not be a guiding principle rather a check to make sure that we are recommending the right roads for HOV implementation.

Overall, I think this current project and data analysis was useful in providing an understanding of HOV lanes implementation around the Twin Cities Metro Area. It serves as a starting point to base future research on. This research gives us a simple way to analyze traffic and recommend possible roads for HOV lanes. Though there are other factors that need to be considered to make it comprehensive, I think this is a good starting point.
References


Appendices

%To take all the volume matrix as input and add the volume for each station. Then divide by the number of days in that year to get a *.csv file with the Total Volume for that Year for each station
%input -> all volume CSV files
%output -> CSV file containing stations with Total Yearly Volume

clear all
%this part takes in all the volume matrix and input and after storing each
%matrix in memory it will just keep adding the all the volume. The total
%volume FOR THE WHOLE YEAR will based on each station will be stored in TDV matrix
number_of_days=0;
TDV= [99, 2];
Filenumber=20050101;
while filenumber<=20051231
    i=2;j=2;
    filename=int2str(filenumber);
    %TDV = Total Daily Volume
    Volume_matrix = csvread(['volume_'.filename,'.csv']);
    [Volume_i,Volume_j]=size(Volume_matrix);
    while i<=Volume_i
        TDV(i,1)=Volume_matrix(i,1);
        while j<=Volume_j
            Volume_matrix(i,j);
            TDV(i,2)=Volume_matrix(i,j)+TDV(i,2);
            j=j+1;
        end
        j=2;
        i=i+1;
    end
    clear Volume_matrix;
    filenumber=filenumber+1;
end
%changes the filenumber when month changes
if filenumber == 20050132
    filenumber = 20050201;
elseif filenumber==20050229
    filenumber = 20050301;
elseif filenumber==20050332
    filenumber = 20050401;
elseif filenumber==20050431
    filenumber=20050501;
elseif filenumber==20050532
    filenumber=20050601;
elseif filenumber==20050631
    filenumber=20050701;
elseif filenumber==20050732
    filenumber=20050801;
elseif filenumber==20050832
    filenumber=20050901;
elseif filenumber == 20050931
    filenumber=20051001;
elseif filenumber==20051032
    filenumber=20051101;
elseif filenumber==20051131
    filenumber=20051201;
end
%gives the number of data used, which is the number of days for the year
number_of_days=number_of_days+1;
end
%TDV matrix contains the volume for the whole year. Dividing it by number_of_days will give the Total Volume per Day
x=1;
while x<=Volume_i
    TDV(x,2)=TDV(x,2)/number_of_days;
    x=x+1;
end
csvwrite('total_daily_volume.csv',TDV);