Volume Studies

CIVL 4162/6162
Lesson Objectives

- Define critical parameters of interest in traffic volume studies
- Compute and interpret hourly, daily, weekly, and monthly adjustment factors
- Collect intersection traffic volume counts
- Describe origin-destination traffic volume studies
Why are Volume Studies Needed?

- Transportation planning/forecasts
- Assessing operations
- Impact analysis
- Determining need for traffic control, etc.

Traffic counts provide the primary measure of demand.
Parameters of Interest (1)

- Volume
- Rate of flow
- Demand
- Capacity
Parameters of Interest (2)

- **Volume**
  - The number of vehicles (or persons) passing a point during a specified time period which is usually one hour but need not be.

- **Rate of Flow**
  - The rate at which vehicles (or persons) pass a point during a specified time period less than an hour, expressed as an equivalent hourly rate.
Parameters of Interest (3)

• Demand
  - The number of vehicles (or persons) that desire to travel past a point during a specified time period (usually one hour).

• Capacity
  - The maximum rate at which vehicles can traverse a point or short segment during a specified time period.
Volume, Demand and Capacity

Illustration

\[ c = 4,000 \text{ vph} \]
\[ d = 3,800 \text{ vph} \]
\[ v = 3,800 \text{ vph} \]

\[ c = \text{capacity} \]
\[ d = \text{demand} \]
\[ v = \text{volume} \]
\[ \mathcal{\horseshoe} = \text{queueing area} \]

\[ c = 6,000 \text{ vph} \]
\[ d = 7,400 \text{ vph} \]
\[ v = 6,000 \text{ vph} \]
Demand Exceeding Capacity

- Capacity
- Demand
- Congestion
- Volume
Volume Pattern
Volume Patterns and Characteristics

- Traffic demand varies!
- Choosing design hour may be complex
- Very important to understand volume variation patterns
Bottleneck Effects

(a) True Demand

(b) Segment Capacities

(c) Observed Volumes
Observed Hourly Traffic Patterns

(a) Typical Variations for Rural Routes

Legend
- Wednesday
- Saturday
- Sunday
Observed Daily Variations

(b) Daily Variation in Volumes at Four Urban Locations
Volume Patterns and Characteristics

EXHIBIT 8-4. EXAMPLES OF DAILY TRAFFIC VARIATION BY TYPE OF ROUTE

--- Recreational access route MN 169, North-Central Lake Region, AADT 3,863, 2 lanes, 1981.
--- Suburban freeway, four freeways in Minneapolis-St. Paul, AADTs 75,000-130,000, 6-8 lanes, 1982.
--- Average day.

Source: Minnesota Department of Transportation.
Monthly VariationS

EXHIBIT 8-2. EXAMPLES OF MONTHLY TRAFFIC VOLUME VARIATIONS FOR A FREeway

Routes with Significant Recreational Traffic

Source: Minnesota Department of Transportation.
Peak Hour Volume

- Recreation Access Route MN 169
- Main Rural Route I-35
- Urban Circumferential Freeway I-494
- Urban Radial Freeway I-35E
# Peak Hour Volume

<table>
<thead>
<tr>
<th>Type of Facility</th>
<th>Percent of AADT Occurring in the Peak Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
</tr>
<tr>
<td>Recreational Access</td>
<td>30.0%</td>
</tr>
<tr>
<td>Main Rural</td>
<td>15.0%</td>
</tr>
<tr>
<td>Urban Circumferential Freeway</td>
<td>11.5%</td>
</tr>
<tr>
<td>Urban Radial Freeway</td>
<td>11.5%</td>
</tr>
</tbody>
</table>

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Within Peak Hour
Volume Studies

Manual counts
- Useful when data is needed quickly, duration of study is short, or scope is limited
- Useful when more detail is needed such as:
  - Vehicle occupancy
  - Pedestrians
  - Turning movements
  - Vehicle classifications

Automatic counts
- Useful when complex classifications not necessary*
- Useful when data is needed over an extended period of time
Intersection Traffic Volume Count

GRAPHIC SUMMARY OF VEHICLE MOVEMENTS
Intersection: McShane Blvd and Prassas Ave
Date: 20 May 97 Time/Day: Monday, 4-5 PM
Observer: R. Roess
City: Metrotech City

[Diagram of traffic volume counts at an intersection]
Intersection Traffic Volume Count

12 HOUR COUNT
7 AM–7 PM
TUESDAY, APRIL 14, 1964
Limited Network Volume Studies

• Sampling techniques are used along with statistical manipulation to develop an hourly volume map for the network
• Requires identification of locations with similar demand patterns over time
• Uses control and coverage counts
Limited Network Volume Studies

- **Control count** - maintained throughout study period; selected locations are measured to identify demand variation patterns
- **Coverage count** - taken at all locations in study area for a portion of study period (samples)
- **Midblock counts**
Limited Network Volume Studies

Control Count
- One control for every 10-20 coverage locations
- Different control for each class of facility
- Different control for significantly different land-use type
- Used to establish volume patterns

Coverage Count
- These are sample locations which will be expanded with control information
- All network links should be counted at least once during study period
Control Count

1

2

A

3

4

5

6
# Networkwide Studies

## Table 9.3: Data and Computations for a One-Day Network Volume Study

<table>
<thead>
<tr>
<th>Control-Count Data Location A</th>
<th>Coverage-Count Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time (PM)</td>
<td>Count (vehs)</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>12–1</td>
<td>825</td>
</tr>
<tr>
<td>1–2</td>
<td>811</td>
</tr>
<tr>
<td>2–3</td>
<td>912</td>
</tr>
<tr>
<td>3–4</td>
<td>975</td>
</tr>
<tr>
<td>4–5</td>
<td>1,056</td>
</tr>
<tr>
<td>5–6</td>
<td>1,153</td>
</tr>
<tr>
<td>6–7</td>
<td>938</td>
</tr>
<tr>
<td>7–8</td>
<td>397</td>
</tr>
</tbody>
</table>

(a) Data from a One-Day Study

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### Time (PM) | Count (vehs) | Proportion of 8-Hour Total
--- | --- | ---
12–1 | 825 | $\frac{825}{7,067} = 0.117$
1–2 | 811 | $\frac{811}{7,067} = 0.115$
2–3 | 912 | $\frac{912}{7,067} = 0.129$
3–4 | 975 | $\frac{975}{7,067} = 0.138$
4–5 | 1,056 | $\frac{1,056}{7,067} = 0.149$
5–6 | 1,153 | $\frac{1,153}{7,067} = 0.163$
6–7 | 938 | $\frac{938}{7,067} = 0.133$
7–8 | 397 | $\frac{397}{7,067} = 0.056$

**Total** | **7,067** | **1.000**

(b) Computation of Hourly Volume Proportions From Control-Count Data

<table>
<thead>
<tr>
<th>Location</th>
<th>Time (PM)</th>
<th>Count (vehs)</th>
<th>Estimated 8-Hr Volume (vehs)</th>
<th>Estimated Peak Hour Volume (vehs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12–1</td>
<td>840</td>
<td>$\frac{840}{0.117} = 7,179$</td>
<td>$\times 0.163 = 1,170$</td>
</tr>
<tr>
<td>2</td>
<td>1–2</td>
<td>625</td>
<td>$\frac{625}{0.115} = 5,435$</td>
<td>$\times 0.163 = 886$</td>
</tr>
<tr>
<td>3</td>
<td>2–3</td>
<td>600</td>
<td>$\frac{600}{0.129} = 4,651$</td>
<td>$\times 0.163 = 758$</td>
</tr>
<tr>
<td>4</td>
<td>4–5</td>
<td>390</td>
<td>$\frac{390}{0.149} = 2,617$</td>
<td>$\times 0.163 = 427$</td>
</tr>
<tr>
<td>5</td>
<td>5–6</td>
<td>1,215</td>
<td>$\frac{1,215}{0.163} = 7,454$</td>
<td>$\times 0.163 = 1,215$</td>
</tr>
<tr>
<td>6</td>
<td>6–7</td>
<td>1,440</td>
<td>$\frac{1,440}{0.133} = 10,827$</td>
<td>$\times 0.163 = 1,765$</td>
</tr>
</tbody>
</table>

(c) Expansion of Hourly Counts

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### Daily Variation Factor

**Table 9.7: Calibration of Daily Variation Factors**

<table>
<thead>
<tr>
<th>Day</th>
<th>Yearly Average Volume for Day (vehs/day)</th>
<th>Daily Adjustment Factor (DF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>1820</td>
<td>$\frac{1430}{1820} = 0.79$</td>
</tr>
<tr>
<td>Tuesday</td>
<td>1588</td>
<td>$\frac{1430}{1588} = 0.90$</td>
</tr>
<tr>
<td>Wednesday</td>
<td>1406</td>
<td>$\frac{1430}{1406} = 1.02$</td>
</tr>
<tr>
<td>Thursday</td>
<td>1300</td>
<td>$\frac{1430}{1300} = 1.10$</td>
</tr>
<tr>
<td>Friday</td>
<td>1289</td>
<td>$\frac{1430}{1289} = 1.11$</td>
</tr>
<tr>
<td>Saturday</td>
<td>1275</td>
<td>$\frac{1430}{1275} = 1.12$</td>
</tr>
<tr>
<td>Sunday</td>
<td>1332</td>
<td>$\frac{1430}{1332} = 1.07$</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>10,010</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Estimated AADT</strong></td>
<td><strong>1,430</strong></td>
<td></td>
</tr>
</tbody>
</table>
Weekly Variation Factor (2)

![Graph showing weekly variation factor over time. The graph plots the ratio of AADT to monthly ADT against months from January to December. Peaks and troughs indicate variations in traffic volume throughout the year.]
### Daily and Monthly Adjustment Factors

<table>
<thead>
<tr>
<th>Day</th>
<th>Factor</th>
<th>Month</th>
<th>Factor</th>
<th>Month</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>1.072</td>
<td>January</td>
<td>1.215</td>
<td>July</td>
<td>0.913</td>
</tr>
<tr>
<td>Tuesday</td>
<td>1.121</td>
<td>February</td>
<td>1.191</td>
<td>August</td>
<td>0.882</td>
</tr>
<tr>
<td>Wednesday</td>
<td>1.108</td>
<td>March</td>
<td>1.100</td>
<td>September</td>
<td>0.884</td>
</tr>
<tr>
<td>Thursday</td>
<td>1.098</td>
<td>April</td>
<td>0.992</td>
<td>October</td>
<td>0.931</td>
</tr>
<tr>
<td>Friday</td>
<td>1.015</td>
<td>May</td>
<td>0.949</td>
<td>November</td>
<td>1.026</td>
</tr>
<tr>
<td>Saturday</td>
<td>0.899</td>
<td>June</td>
<td>0.918</td>
<td>December</td>
<td>1.114</td>
</tr>
<tr>
<td>Sunday</td>
<td>0.789</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 9.11: Typical Daily and Monthly Variation Factors for a Contiguous Area on a State Highway System
Network wide AADT

- AADT = $V_{24ij} \times Df_i \times MF_j$
  - AADT: Average annual daily traffic
  - $V_{24ij}$: 24-hour volume for day $i$, in month $j$
  - $Df_i$: Daily adjustment factor for day $i$
  - $V_{24ij} \times Df_i \times MF_j$: Monthly adjustment factor for month $j$
Vehicle Miles Travelled

- $VMT_{365} = AADT \times L \times 365$

- Annual vehicle miles travelled over the segment
- AADT for the segment (veh/day)
- Length of the segment
Manual Counts

http://jamartech.com
Figure 1 – Manual Count Checklist

- Project:________________________________________________________
- Count Location:________________________________________________
- Date:___________________________________________________________
- Time of Count:__________________________________________________

___ 1. Check data collection equipment for proper operation and calibration
___ 2. Label the field equipment as needed
___ 3. Bring necessary accessory equipment (Batteries, flashlight, etc)
___ 4. Stopwatch
___ 5. Bring data collection forms and fill in as much data as possible before leaving the office.
___ 6. Extra pens and paper for taking notes
___ 7. Clipboard or writing surface
___ 8. Business cards of the engineer to contact and be prepared to answer the question “What are you doing here?”
___ 9. A map to the site
___ 10. Weather condition equipment (Sunscren, umbrella, jacket or warm coat)
___ 11. Safety equipment (Flags, Signs, safety vests, or other reflective materials)
Manual Counts

Vehicle Turn Movement Count
Four-Approach Field Sheet

North/South Street

East/West Street

Time

To

Date

Day

Weather

Observer

P = Passenger cars, minivans, two-axle trucks, motor cycles and station wagons
T = Trucks, multi-axle vehicle, city bus or school bus

North
# Manual Counts

## Tabular Summary of Vehicle Counts

<table>
<thead>
<tr>
<th>Time Begins</th>
<th>from North</th>
<th>from South</th>
<th>TOTAL North/South</th>
<th>from East</th>
<th>from West</th>
<th>TOTAL East/West</th>
<th>TOTAL ALL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R S L TOTAL</td>
<td>R S L TOTAL</td>
<td>R S L TOTAL</td>
<td>R S L TOTAL</td>
<td>R S L TOTAL</td>
<td>R S L TOTAL</td>
<td>R S L TOTAL</td>
</tr>
</tbody>
</table>

Observer: __________________ Date: ________________ Day: ___________ City: ___________ 

Intersection of: __________________ AND __________________

R=Right Turn  S=Straight  L=Left Turn
Field Considerations

- Everyone should be familiar with count procedure/labels/equipment
- Must have enough members in field to adequately record, provide relief, and to address safety concerns
- Be prepared!!!
Field Considerations

- Observer locations (manual studies)
- Count location (automatic studies)
- Be sure to secure equipment for automatic counts
- Install equipment during very low volume time periods
- Safety vests!
Count Periods

- 2 hours, peak period
- 4 hours, am/pm peak period
- 6 hours, am/midday/pm peak periods
- 12 hours daytime (7am-7pm)
- 24 hours, week, month, etc. (automatic)
# Count Periods

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Typical Peak Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>7:00-9:00 am weekday</td>
</tr>
<tr>
<td></td>
<td>4:00-6:00 pm weekday</td>
</tr>
<tr>
<td>Regional Shopping center</td>
<td>5:00-6:00 pm weekday</td>
</tr>
<tr>
<td></td>
<td>2:30-3:30 pm Saturday</td>
</tr>
<tr>
<td></td>
<td>12:30-1:30 pm Saturday</td>
</tr>
<tr>
<td>Office</td>
<td>7:00-9:00 am weekday</td>
</tr>
<tr>
<td></td>
<td>4:00-6:00 pm weekday</td>
</tr>
<tr>
<td>Industrial</td>
<td>Varies</td>
</tr>
<tr>
<td>Recreational</td>
<td>Varies</td>
</tr>
<tr>
<td>Hospital</td>
<td>Varies based on shift changes</td>
</tr>
<tr>
<td>School</td>
<td>Varies based on school release times</td>
</tr>
</tbody>
</table>
Intersection Studies

- Typical 4-leg intersection has 12 separate movements
- Vehicles usually counted as they depart the intersection, but cannot do this when \( D > Q_{\text{cap}} \)
- Must record queue size

\[
V_{ai} = V_{di} + N_{qi} - N_{qi-1}
\]

\( V_{ai} \) = arrival volume in period \( i \), vehs
\( V_{di} \) = departure volume in period \( i \), vehs
\( N_{qi} \) = number of queued vehs at end of period \( i \), vehs
\( N_{qi-1} \) = number of queued vehs at end of period \( i - 1 \), vehs
## Intersection Studies

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Total Departure Count (veh)</th>
<th>Queue Length (veh)</th>
<th>Arrival Volume (veh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4:00-4:15 pm</td>
<td>50</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>4:15-4:30</td>
<td>55</td>
<td>0</td>
<td>55</td>
</tr>
<tr>
<td>4:30-4:45</td>
<td>62</td>
<td>5</td>
<td>62 + 5 = 67</td>
</tr>
<tr>
<td>4:45-5:00</td>
<td>65</td>
<td>10</td>
<td>65 + 10 - 5 = 70</td>
</tr>
<tr>
<td>5:00-5:15</td>
<td>60</td>
<td>12</td>
<td>60 + 12 - 10 = 62</td>
</tr>
<tr>
<td>5:15-5:30</td>
<td>60</td>
<td>5</td>
<td>60 + 5 - 12 = 53</td>
</tr>
<tr>
<td>5:30-5:45</td>
<td>62</td>
<td>0</td>
<td>62 - 5 = 57</td>
</tr>
<tr>
<td>5:45-6:00</td>
<td>55</td>
<td>0</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Total = 469</td>
<td></td>
<td>Total = 469</td>
</tr>
</tbody>
</table>
Statewide Programs

- Involves entire state highway system in continuous study period
- AADT/ADT [http://ww3.tdot.state.tn.us/trafficHistory/](http://ww3.tdot.state.tn.us/trafficHistory/)
- Vehicle-miles traveled
- Usually every 2 mile state hwy segment is included in coverage count each year
- Develop AADT estimate for each coverage location annually
- Control locations may be permanent; data collected over entire year
Specialized Counting Studies

- Origin and destination counts
  - Weaving areas
  - Freeway studies
  - Major activity centers

- Cordon counts
  - Estimate vehicle and person accumulation within the cordon
  - Used to supplement O-D studies or for trend analysis

- Screen-line
  - Record travel from one area to another
  - Used to adjust results of O-D studies

For specialized counts, must have more than just count data.
Types of Volume Studies

- Intersection counts (duration depends on the purpose, 15-minute intervals or shorter, turning volumes)
- Pedestrian counts (duration depends on the purpose, 5-minute intervals or longer)
- Cordon counts (one weekday + travelers’ survey)
- Screen line counts (hourly counts for a weekday)
- Area wide counts
  - Control counts (hourly counts with permanent stations)
  - Coverage counts (hourly counts for one or two days)
Origin-Destination Counts

- License plate studies
  - Recording license plates at entry and exit
- Postcard studies
  - Handing out color coded post cards at entry points and collecting them at exit
- Interview studies
  - Stopping vehicles and interviewing them about trip details
O-D Counts Example
# O-D Counts Example (2)

**Table 9.12:** Sample Expansion of Origin and Destination Data

<table>
<thead>
<tr>
<th>Destination Station</th>
<th>Origin Station</th>
<th></th>
<th></th>
<th></th>
<th>T&lt;sub&gt;j&lt;/sub&gt;</th>
<th>V&lt;sub&gt;j&lt;/sub&gt;</th>
<th>F&lt;sub&gt;j&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>50</td>
<td>8</td>
<td>20</td>
<td>17</td>
<td>95</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>10</td>
<td>65</td>
<td>21</td>
<td>10</td>
<td>106</td>
<td>310</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>15</td>
<td>12</td>
<td>38</td>
<td>15</td>
<td>80</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>13</td>
<td>14</td>
<td>18</td>
<td>42</td>
<td>87</td>
<td>375</td>
</tr>
<tr>
<td>T&lt;sub&gt;i&lt;/sub&gt;</td>
<td>88</td>
<td>99</td>
<td>97</td>
<td>84</td>
<td>368</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V&lt;sub&gt;i&lt;/sub&gt;</td>
<td>210</td>
<td>200</td>
<td>325</td>
<td>400</td>
<td></td>
<td></td>
<td>1135</td>
</tr>
<tr>
<td>F&lt;sub&gt;i&lt;/sub&gt;</td>
<td>2.39</td>
<td>2.02</td>
<td>3.35</td>
<td>4.76</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(a) Field Data and Factors for Iteration 0

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O-D Counts Example (3)

\[ T_{ijN} = T_{ijN-1} \left( \frac{F_i + F_j}{2} \right) \]

- Fi: Adjustment factor for origin i
- Fj: Adjustment factor for origin j
- \( T_{ijN} \): Number of trips from station i to station j after Nth iteration
- Ti: Sum of matched trips from station i
- Tj: Sum of matched trips from station j
- Vi: Observed total volume at Station i
- Vj: Observed total volume at Station j
### O-D Counts Example (4)

<table>
<thead>
<tr>
<th>Destination Station</th>
<th>Origin Station</th>
<th>( T_j )</th>
<th>( V_j )</th>
<th>( F_j )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>125</td>
<td>267</td>
<td>250</td>
<td>0.94</td>
</tr>
<tr>
<td>2</td>
<td>27</td>
<td>292</td>
<td>310</td>
<td>1.06</td>
</tr>
<tr>
<td>3</td>
<td>37</td>
<td>229</td>
<td>200</td>
<td>0.87</td>
</tr>
<tr>
<td>4</td>
<td>44</td>
<td>347</td>
<td>375</td>
<td>1.08</td>
</tr>
<tr>
<td>( T_i )</td>
<td>232</td>
<td>1135</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( V_i )</td>
<td>210</td>
<td></td>
<td></td>
<td>1135</td>
</tr>
<tr>
<td>( F_i )</td>
<td>0.90</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) Initial Expansion of O-D Matrix (Iteration 0)
## O-D Counts Example (5)

<table>
<thead>
<tr>
<th>Destination Station</th>
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<th>V_j</th>
<th>F_j</th>
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(c) First Iteration of O-D Matrix

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### O-D Counts Example (6)

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</tr>
</tbody>
</table>

(d) Second Iteration of O-D Matrix

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Cordon Counts

Vehicles entering and leaving cordon area between 6:00 a.m. – 8:00 p.m. (14 hrs.)
- Total vehicles entering – 86,170
- Total vehicles leaving – 86,098
Screen-Line Counts
For more information...