Impacts of Snow on Traffic Congestion

DRCOG Congestion Mitigation Program White Paper 07-2
(Feb. 7, 2007)

Introduction

The ability of roadways in the Denver region to handle traffic smoothly is impacted by many factors. Some factors are static (number of lanes, hills), some can be adjusted day-to-day (traffic signal green-light time), and some are a function of the travel demand (number of vehicles on the road). Other factors that influence congestion occur more randomly, such as break-downs, crashes (or accidents), special events, and of course snowfall!

Driving to work, home, school, or ski areas on snow covered roads is slower, more difficult, and likely more stressful. Drivers must be as alert as possible to react quickly and properly to slippery conditions or stopped vehicles in front of them. Travelers and residents experience a wide array of impacts from snow-related traffic congestion:

- injuries and fatalities from crashes or break-downs;
- costs due to travel time delays;
- car repair costs;
- late or missed deliveries (e.g., Meals-on-Wheels, home-visit nurses, plumbers, etc.);
- delays with school buses or cancellation of school (of course, children love snow-days!); and
- some businesses have increased revenues (e.g., snow shovel stores), some have less (e.g., restaurants), and some can have fickle “Catch-22” results (e.g., ski resorts that receive so much snow that very few people can get there).

State and local agencies have a huge logistical task in responding to snowstorms. Snowplow drivers, vehicles, and road treatment materials (sand and deicers) must be mobilized and organized like a military operation. Specialists must monitor real-time road and weather conditions via cameras and roadside weather stations to issue specific warnings, regulations, and messages to display on overhead signs. This information is also provided to maintenance crews to plan their response to snow or ice.
Even with all of these responses, why does it still take so long to drive home? The remainder of this paper discusses the reasons for traffic congestion and delays on snow covered roads. While this paper focuses on traffic congestion, it is also important to note that pedestrian sidewalks along streets also face great impacts from snowfall and the storage of plowed snow. Sidewalks and bus stop areas should be kept as free of snow as possible to decrease the need for people to walk or stand in streets.

**Overall Impacts**

Even if you are driving the only car on the road at 3 a.m., snowfall may entice you to drive 40 mph instead of 60 mph – thus causing “delay” even though there is no congestion. So at 7:30 a.m. with 10 times as many vehicles, shouldn’t traffic just move along at the same 40 mph? This is where roadway capacity comes into play. The following examples illustrate the relationship between capacity and roadway conditions:

Example 1 – Good Weather Day: Traffic flows at 60 mph at 3 a.m. and at 40 mph from 7:30 a.m. to 8:30 a.m. Why? The carrying capacity of the highway (e.g. number of lanes) cannot handle the high traffic volumes, so traffic slows down (even if there are no crashes or lane closures).

Example 2 – Snowy Day: Traffic flows at 40 mph at 3 a.m. and only 15 mph from 7 a.m. to 9 a.m. Why so much slower and for a longer period of time? The normal capacity is decreased even further because of the following example situations:

- vehicles are spaced further apart to allow for greater stopping distance;
- vehicles start-up from a stop more slowly – especially on steep grades;
- vehicles maneuver more cautiously because of missing lanes and/or markings;
- turning vehicles nearly come to a complete stop to make a turn; and
- stuck vehicles and crashes.

Put simply, fewer vehicles can pass by per hour. And all of the factors contribute to a (pardon the pun) snowball effect of increasing congestion.
Freeway and Arterial Characteristics

Freeways and arterials each have unique factors that affect their carrying capacity for vehicles during a snowstorm.

Arterials:

Arterial street operations are very similar to a water pipe system. The diameter of the pipe could represent the number of lanes. Faucets and valves represent traffic signals that control specific flows. A scoured or rough inner pipe is like a street that has a lot of driveways inducing turning vehicles and turbulence.

How does snow make things worse?

1. The number of vehicles that can pass through an intersection on a green light is greatly reduced. For example, normally, 20 vehicles per lane would pass through an intersection with 40-second green-light time (two-second gap between vehicles). During a snowstorm, however, because of slower start-up times, stuck vehicles, and wider gaps between cars, maybe only 10 vehicles make it through 40 seconds of green time. Thus the capacity of the arterial intersection is cut in half.
2. The number of vehicles traveling along an arterial between signalized intersections is also reduced further because of turning vehicles slowing down or slipping on the road, busses stopping longer to permit passengers to board, and “missing lane” situations when vehicles may use two lanes instead of three, for example.

Freeways:

Freeway capacity is actually more comparable to a river. On-ramps are like merging streams, rush-hour traffic is like spring run-off, and lane-weaving vehicles are like large boulders that create river turbulence. A severe crash can act like a dam, completely stopping the river, other than allowing a relatively small trickle to pass through. Each of these factors is amplified during a snowstorm.
Technical Analysis of Regional Impacts

To analyze the snowstorm phenomenon further, the DRCOG Congestion Mitigation Program database was used to conduct a test of the impacts of reducing the typical capacity on every main arterial and freeway in the region by 45 percent.

No specific assumptions were made of how many inches of snow fell, temperature, time of snowfall, amount of snow plowing, or any other factors that, in real life, impact the operation of roadways. This was a simplified method to come up with general values to depict the scale of impact of snow-covered roads. Some snow days will be worse and some not as bad.

Crashes and breakdowns were not fully accounted for in the analysis because of the difficulty in trying to estimate their impacts. Partial and non-specific impacts were accounted for in the capacity reduction. Obviously, a freeway segment that has several crashes will encounter much more delay that what is depicted in the results below.

In the end, the results verify what any commuter, truck driver, bus driver, or traffic reporter could tell you. However, the immensity of the impact can now be presented to understand the total delay-related economic costs of snowstorms. What are the results and impacts during a representative snowstorm?

- Peak period travel times will more than double;
- The average resident faces 29 minutes of delay time compared to seven for a typical day;
- The average vehicle driven encounters 38 minutes of delay time (compared to nine for a typical day);
- Drivers and passengers face an additional 980,000 delay hours compared to a typical day; and
- The cost of the extra delay is nearly $26 million (980,000 x $26.5).

<table>
<thead>
<tr>
<th>Sample Roadway Segments</th>
<th>Typical Off-Peak</th>
<th>Typical Peak-Hour</th>
<th>Snowstorm Peak Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>US-36/I-25: Boulder to Denver (25 miles)</td>
<td>25</td>
<td>44</td>
<td>135</td>
</tr>
<tr>
<td>I-25/I-70: Denver to DIA (28 miles)</td>
<td>22</td>
<td>33</td>
<td>77</td>
</tr>
<tr>
<td>I-25: Denver to DTC (13 miles)</td>
<td>14</td>
<td>33</td>
<td>108</td>
</tr>
<tr>
<td>Colorado Blvd.: I-25 to Alameda (2 miles)</td>
<td>4</td>
<td>9</td>
<td>23</td>
</tr>
<tr>
<td>Wadsworth Blvd.: US-285 to I-70 (9 miles)</td>
<td>14</td>
<td>30</td>
<td>65</td>
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Conclusion

Snowstorms clearly have a large economic impact on the Denver region. This report looked solely at the direct costs due to travel delays ($15,000,000). Further costs related to snow plowing equipment and personnel, personal health and injuries, storm damage, emergency services, lost productivity, and decreased economic activity likely far exceed the costs of delay. The “perfect storm” related to snowfalls, traffic jams, and snow removal has developed over the past few months, amplifying the need for public agencies, homebound residents and drivers to be prepared and be patient.

What can you do to be better prepared?

- Carry emergency equipment in your car – shovel, food, first-aid kit, blanket, traction material, etc.;
- Stay home if possible – keep adequate provisions at home;
- Work at home – contact the DRCOG RideArrangers Telework program for assistance in offering and encouraging teleworking to employees (http://www.drcog.org/index.cfm?page=RideArrangers)
- Ensure that homebound friends or relatives have adequate supplies (e.g. Meals-on-Wheels’ “blizzard boxes”);
- Carpool to work or school. Why? 1) So you have a passenger with you, and 2) to eliminate a car from the road. Contact the DRCOG RideArrangers program (above) for assistance;
- Check out road conditions in the Denver region and throughout the state via the www.CoTRIP.org web site. This web site displays real-time roadside camera views, freeway travel speeds, message sign displays, alerts, and weather conditions.

2. Regionwide Person Travel Time Delay on Freeways and Major Streets
(Hours of Delay Time per Day)

<table>
<thead>
<tr>
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<th>Typical Day</th>
<th>Snowstorm Day</th>
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<tbody>
<tr>
<td>On Freeways</td>
<td>125,550</td>
<td>724,950</td>
</tr>
<tr>
<td>On Arterials (Streets)</td>
<td>167,805</td>
<td>550,800</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>293,355</strong></td>
<td><strong>1,275,750</strong></td>
</tr>
<tr>
<td><strong>Average Travel Delay per Capita</strong> (2,650,000)</td>
<td>7 minutes</td>
<td>29 minutes</td>
</tr>
<tr>
<td><strong>Average Delay per “Vehicle that Traveled”</strong> (1,500,000 &amp; divide by 1.35 vehicle occupancy)</td>
<td>9 minutes</td>
<td>38 minutes</td>
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</tbody>
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