ITS HEARTLAND CHAPTER

2013 STUDENT COMPETITION

The Capital Beltway (I-495): Traffic Analysis and ITS Solutions

Congestion is a troublesome issue at I-495 considering the magnitude of demand present. ITS provides the technology and practices that contribute to the improvement of management for the transportation facilities. The traffic analysis involves incidents, travel times, and bottlenecks. From the incident analysis, the types of incidents that predominantly occur at the corridor are disabled vehicles and collisions. There is a significant concentration of these incidents in the section of I-66 to the American Legion Memorial Bridge. Regarding reliability measures, the planning travel time is higher than 95 minutes during peak hours in both directions. Finally, the locations that show the most congestion problem are the American Legion Bridge, MD-650 (Exit 28), VA-7 (Exit 10), and intersection I-270. The suggested ITS solutions to the congestion problems at the corridor are: closer video camera coverage to contribute to the verification step in the process of traffic incident management (TIM) on the Virginia segment, active dynamic message signs (DMS) prior and after the bridge crossing, I-270, and exits 10 and 28, ramp metering and VSL for the American Legion Bridge and I-270 intersection.

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1. Introduction

The Capital Beltway provides an essential east coast highway link serving local, regional, and interstate trips. It is the only circumferential route in the Washington, D.C. area, connecting many radial routes. Because of the extensive linkage to other transportation facilities in the region, severe traffic congestion on the Capital Beltway has cumulative effects on regional mobility. Current traffic exceeds 200,000 vehicles per day in some sections and is projected to increase to about 250,000 vehicles per day by 2030 *(1)*. In 2004, in a nationwide study regarding the 24 most congested transportation facilities, I-495 at I-270 interchange (ranked #7) and I-495 at I-95 interchange (ranked #15) segments have been identified *(2)*.

Congestion is a troublesome issue in this region considering the magnitude of demand present. ITS provides the technology and practices that contribute to the improvement of management for the transportation facilities. It can provide immediate response to incidents on the highway by delivering basic traffic information and assistance to its customers.

The corridor from I-95 to I-66 along I-495 experiences levels of service from E to F *(1)*. The American Legion Memorial Bridge is the main crossing point for commuter routes to and from major employment areas across state lines of Maryland and Virginia. Both VDOT and MDOT have implemented some major projects to accommodate the increasing demand over the years. These projects include major roadway expansions, interchange improvements, optimization of traffic management programs, and express lanes.

The resources used for the analysis are incident data from 2012, travel times, and impact factor from the second quarter of 2012. The project focuses on an ITS modest capital investment that could provide the maximum benefit to the corridor under study.

2. Incident data analysis

The incident data covers the counties of Fairfax, Montgomery, and Prince Georges. The incident analysis concentrates on incident classification, spatial location distribution, duration, and seasonal patterns to identify particular trends that allow the overview of the data.

2.1. Classification of incidents

The incidents with higher occurrence in the corridor are disabled vehicles (56.87 %) and collisions (23.40 %), in table 1. The difference from the rest of the incidents is important. The effect of this two types of incidents on safety and traffic congestion can jeopardize the system by reducing the roadway capacity and contribute to further collisions. In order to understand more about these incidents, a spatial distribution is used to observe any patterns on the corridor. Also, the duration of the incidents are further studied to determine the magnitude of operations to clear events.

Table 1. Classification of accidents by type

Type of incident	Total	%
Alert	30	0.35
Animal Struck	15	0.17
Collision	2013	23.40
Congestion	550	6.39
Disabled Vehicle	4893	56.87
Disturbances	2	0.02
Emergency Roadwork	32	0.37
Fatalities Involved	2	0.02
Flood	5	0.06
Incident	298	3.46
Injuries Involved	201	2.34
Obstructions	227	2.64
Road Maintenance Operations	288	3.35
Special Event	2	0.02
Vehicle On Fire	45	0.52
Weather Condition	1	0.01
Total	**8604**	**100.0**

2.2. Incident spatial distribution

The locations of disable vehicles and collisions mapped have very similar distributions. Therefore, because of larger number of records, the incidents of disabled vehicles are displayed on Figure 1. The mapped locations have a dense cluster on the segment from the intersection

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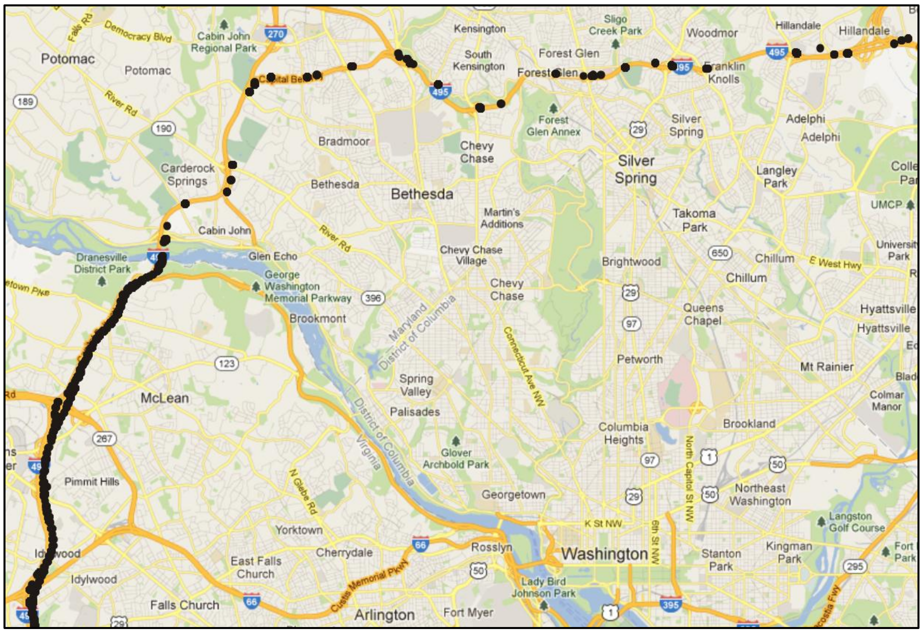

Figure 1. Disable vehicle incident map locations

I-66 to the American Legion Memorial Bridge. Continuing clockwise on the corridor, incidents follow a more widespread distribution with few clusters on the major intersections with arterials until I-95 intersection. The occurrence of disabled vehicle incidents, especially in the segment prior the bridge, are considered to be related to the amount of traffic allocated in such corridor. Also, the on-going construction projects along the region during 2012 have contributed to more complex and changing route characteristics that have consequently influenced the occurrence of the mentioned incidents.

2.3. Incident duration

The relevant duration for each type of incident is analyzed. Using central tendency and variability measures, the incident data distribution does not follow a normal distribution form. Therefore, the median time duration is used as a parameter to quantify their importance. The results are listed in Figure 2. The incidents with the longest time periods are road maintenance and fatalities. In the case of road maintenance, they are mostly planned circumstances where traffic and safety measures are taken into account to prevent the impact on the system. On the other hand, fatalities are unexpected and uncontrolled circumstances that occur very rarely and anytime. The rest of the incident types are distributed in the range of 0 to 150 minutes. In this section, more attention is concentrated on disable vehicles and collisions because of their frequency of occurrence. Disabled vehicle incidents (4893) occurred twice as often than collision incidents (2013) in 2012; however, with the duration of the incidents, the opposite occurs. Collisions have a median duration of 40 minutes whereas disabled vehicles 13 minutes. Even though a collision incident occurs with less frequency, more time is necessary to clear the incident while dealing with all the different circumstances, procedures, and regulations. In contrast, a more frequent type of incident, disabled vehicles can be cleared more efficiently with fewer people and resources involved. ITS incident management programs can greatly affect the duration and frequency of incidents by implementing optimal ITS procedures that allow controllers to activate resources according to the specific needs of the incident.

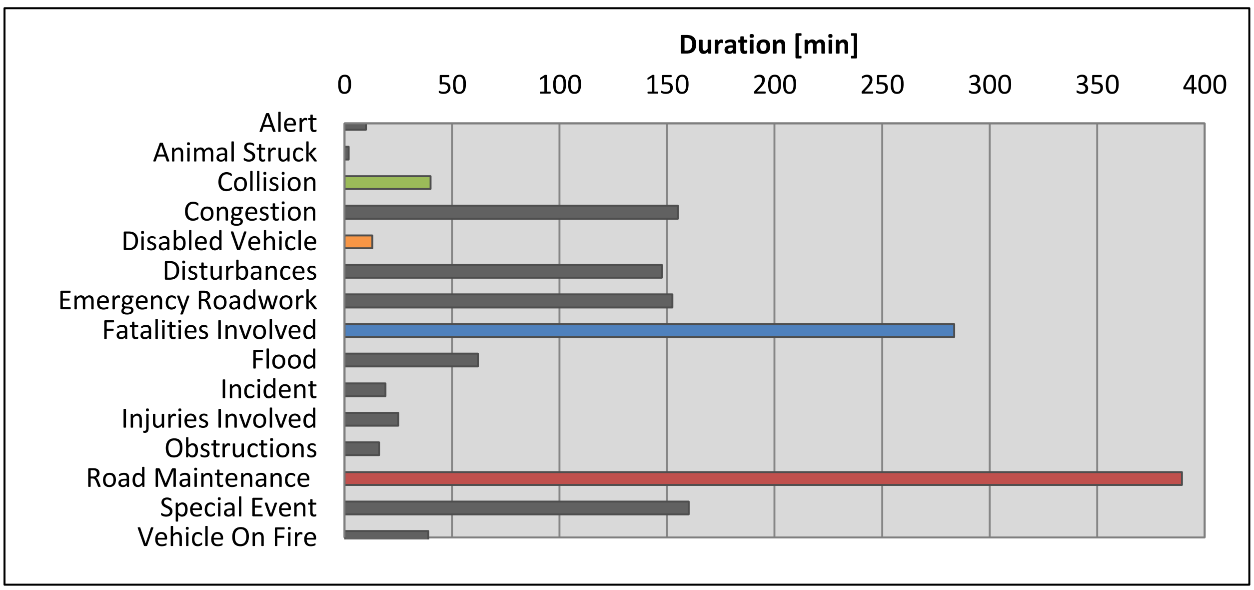

Figure 2. Median time duration of incidents

2.4. Seasonal incident patterns

The seasonal analysis focuses on daily and hourly patterns. It provides a clear insight into understanding the frequency distribution of incidents in time, contributing to the management systems on planning, organization, and decision-making.

The daily incident frequency distribution begins with few records on Sunday, and increases constantly towards its peak on Thursday. It remains similar for Friday, but it drops dramatically on Saturday. The critical days of incidents are Thursdays and Fridays. During the weekend the incidents drop to the lowest levels.

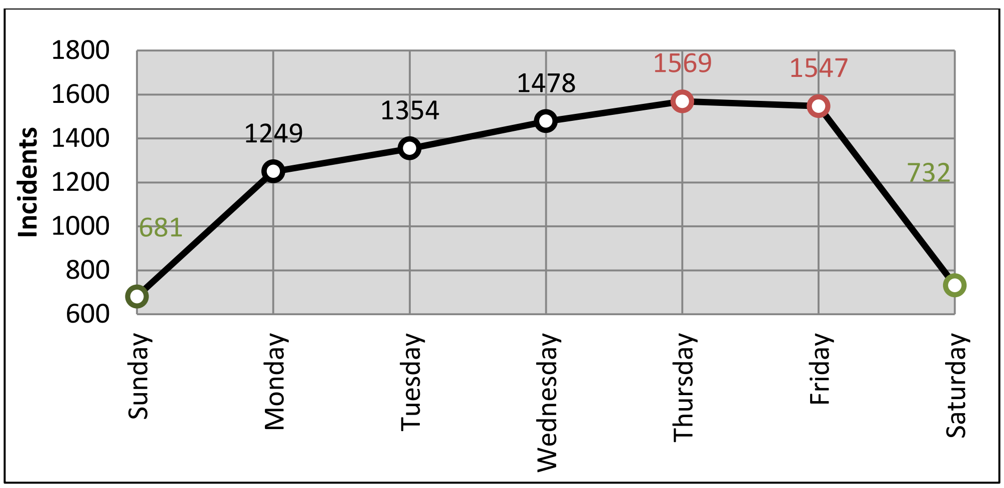

Figure 3. Daily incident distribution

Regarding the hourly incident distribution, the hours when the most incidents are recorded are during the peak hours that range between 7:00-9:00 and 14:00-18:00. For the rest of the hours, the incident records are low, especially during late night or early morning time.

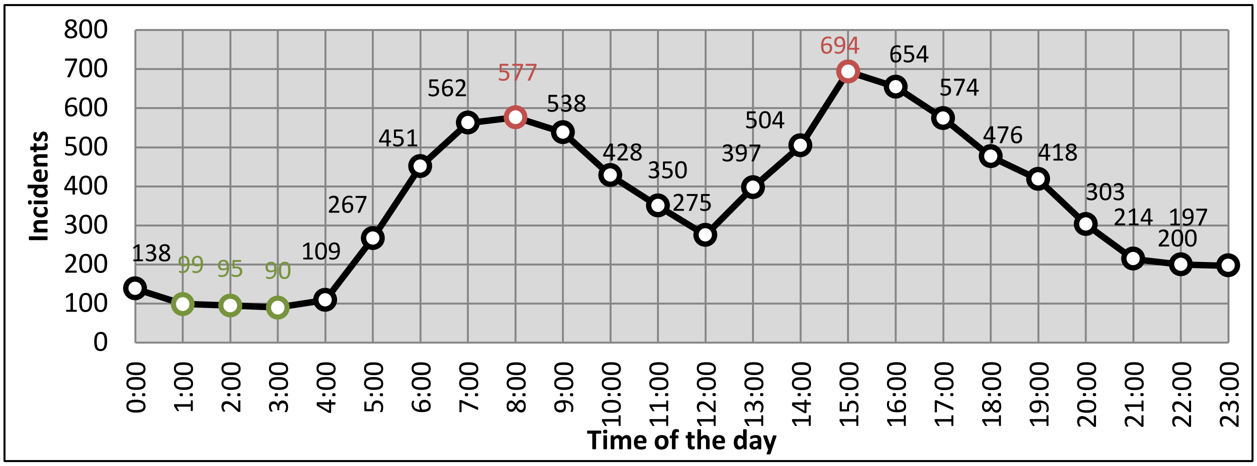

Figure 4. Hourly incident distribution

3. Travel time analysis

Travel time parameters are a measure used to determine the amount of congestion experienced in the system by its travelers. Travelers want travel time reliability, consistency or dependability in travel times, as measured from day to day or across different times of day *(3)*. With the use of the continuously integrated ITS systems, it is possible to collect data and develop different methods to determine reliability measures: 95th or another percentile travel time, buffer time, and planning time.

For this analysis, the second quarter of 2012 is targeted. For the clockwise direction, the month of June displays an average travel time peak of 54 minutes during the 16:00 hour. In the case of the counterclockwise direction, a similar pattern is observed with the month of June having the highest average values. However, there are two travel time peaks, one of 36 minutes at 8:00 and the second of 35 minutes at 17:00.

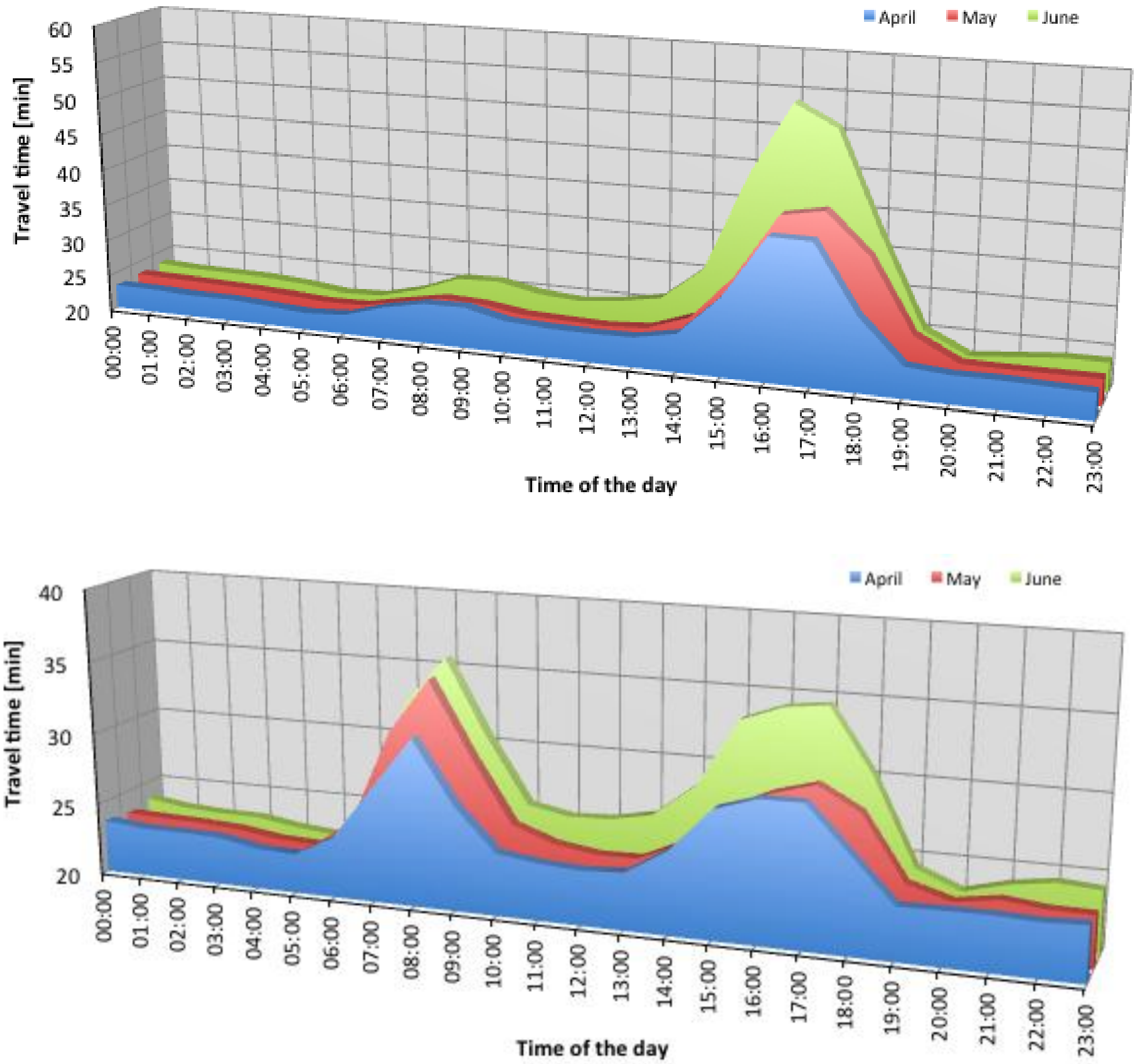

Figure 6. Travel time second quarter 2012 (Counterclockwise)

Consequently, June has the highest travel times, and the buffer time and planning time are incorporated in the analysis to quantify the magnitude of congestion and variation in a day. In both directions the travel planning time exceeds 90 minutes with a buffer time of between 60-80 minutes during the afternoon rush hour. The increase of that much time to the average travel time provides an overview of the severity of congestion in the corridor.

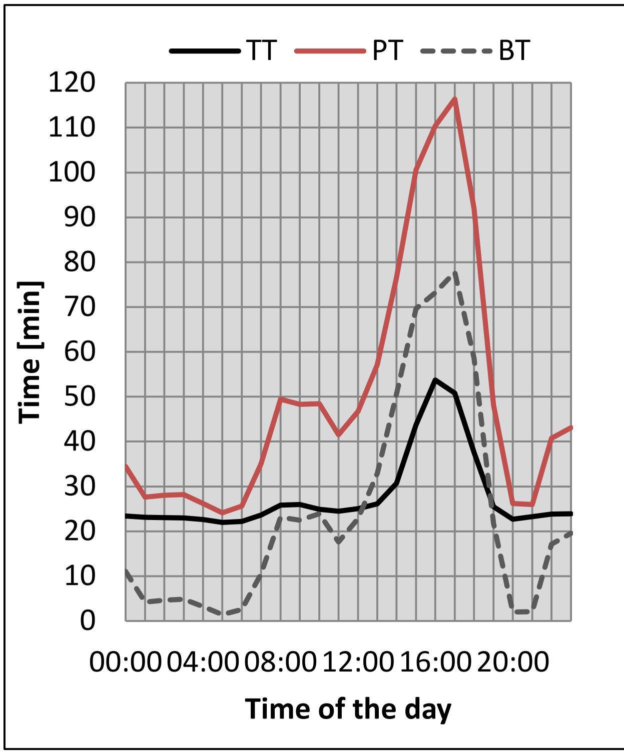

Figure 7. Clockwise travel times

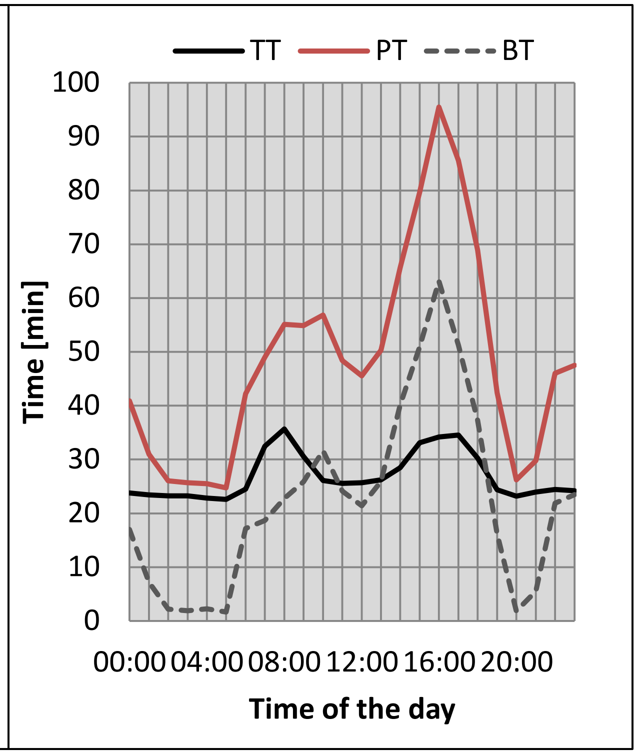

Figure 8. Counterclockwise travel times

4. Bottleneck analysis

In order to quantify the bottleneck ranking, the impact factor, is used as a rating measure. The impact factor is the multiplication of the average duration, average max distance, and number of occurrences. Table 2 lists the bottlenecks for the second quarter of 2012. The locations that show the most congestion problems are the American Legion Bridge (CW), MD-650 (Exit 28 CW), VA-7 (Exit 10 CCW), and I-270 (CW). The magnitudes of these bottlenecks exceed an impact factor of 100,000 while the rest of the locations are below 70,000. Therefore, the congestion at these locations is so severe that the average distance of the some bottlenecks reached 10-12 miles and occurred about 50 times during the three month time period. Alternately, other reached 6-7 miles and occurred around 130 times in the same time period. The congestion problems at these locations are of large magnitude.

Table 2. Second quarter 2012 bottlenecks ranking

N	Location	Exit	Dir.	Average duration	Average [mi]	Occur.	Impact factor
1	American Legion Bridge	-	CW	4 h 14 m	12.18	53	163,961
2	MD-650/New Hampshire Ave	Exit 28	CW	2 h 32 m	6.98	133	141,090
3	VA-7/Leesburg Pike	Exit 10	CCW	3 h 39 m	10.13	49	108,679
4	I-270 Spur	-	CW	2 h 17 m	5.55	134	101,910
5	VA-267	Exit 12	CCW	2 h 19 m	7.04	70	68,497
6	MD-97/Georgia Ave	Exit 31	CCW	1 h 46 m	3.59	128	48,758
7	I-66	Exit 9	CCW	4 h 5 m	11.39	15	41,867
8	MD-185/Connecticut Ave	Exit 33	CCW	2 h 3 m	5.57	42	28,768
10	I-270	Exit 35	CCW	1 h 14 m	3.62	58	15,554
11	MD-97/Georgia Ave	Exit 31	CW	1 h 16 m	2.85	66	14,301
12	I-66	Exit 9	CW	55 m	1.57	127	10,942

CW: Clockwise, CCW: Counterclockwise

5. Summary of Current Conditions

The data analysis provides important information to assess congestion. The types of incidents that predominantly occur at the corridor are disabled vehicles and collisions. There is a significant concentration of these incidents in the section of I-66 to the American Legion Memorial Bridge. The median time necessary to clear a collision is two times longer than the time of clearing a disabled vehicle incident. The seasonal incident data follows common roadway traffic patterns. Regarding the travel time reliability measures, the month of June is the most congested of the second quarter of 2012. The planning travel time is higher than 95 minutes during peak hours in both directions. Finally, the locations that show the most congestion problems are the American Legion Bridge (CW), MD-650 (Exit 28 CW), VA-7 (Exit 10 CCW), and I-270 (CW).

6. Recommendations

The corridor has multiple traffic management resources available for its travelers. Both DOTs have regional information centers that provide online interactive maps or traveler information via phone. There are also highway advisory radios. They have developed programs regarding incident and road management to achieve more efficient responses to incidents. There are major construction projects involving the implementation of express lanes. The presence of overhead dynamic message signs (DMS) has only been observed along Maryland with little or no operation. Both agencies have implemented ramp metering and variable speed limit systems (VSL) in their roadway systems. Finally, video cameras are available along the roadway and located at the major intersections.

After the identification of the major problems at the corridor regarding incidents and congestion, the improvements of the operations of some current systems are suggested. First of all, the video camera coverage is limited with only 7 cameras over the 6 miles in Virginia where there is a significant occurrence of incidents. It is suggested to implement a closer coverage in order to contribute to the verification step in the process of traffic incident management (TIM). This coverage would allow a more complete assessment of the resources necessary to be deployed and the influence on traffic according to the severity of the incident.

Overhead dynamic message signs (DMS) are also considered for the segment. More specifically, prior and after the bridge crossing, I-270, and exits 10 and 28. Under such congested conditions, the importance to be able to deploy and organize traffic management measures is important. In order to inform and prepare drivers for high-congested sections, the signs could be used by traffic management centers to provide alerts, alternative routes information, and times of travel in order to give drivers the opportunity to decide their best alternative route regarding their objective of travel *(4)*.

The DOTs could consider implementing variable speed limit (VSL) systems and ramp metering to improve safety and traffic flow. VSLs can be used in congestion reduction by delaying the onset of congestion at bottlenecks. Research conducted by the University of Virginia has found that VSLs are beneficial at eliminating dangerous speed differentials and subsequently smoothing vehicle speeds through bottlenecks from case studies on I-66 and I-95 in Northern Virginia *(5)*. Ramp metering, with a thorough analysis of the arterials connected to I-495, will contribute to optimum travel times with the objective to reduce congestion in the system and contribute to the environment *(6)(7).* The suggested locations for its implementations are on the approaches and arterials to the American Legion Bridge and I-270 intersection.

References

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