Assessment of Transportation System Reliability at Link-, Corridor- and Area-level

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ABSTRACT

There has been a paradigm shift in focus from intersection-level to corridor- and area-level analysis and performance measures in recent years. The possibility of capturing dynamic and continuous travel time and/or speed data from private sources such as INRIX opens many pragmatic avenues to predict reliability of transportation systems. Travel time reliability (or index or variability) is considered the most viable performance measure for corridor-level analysis though it is not being widely used for transportation planning, project prioritization, and allocation of resources. The definition of reliability as a performance measure and associated thresholds to understand or assess transportation system performance could vary for a link, corridor or an area. These definitions and thresholds to assess reliability need to be clearly established prior to its large scale application. This research aims to fill this gap by computing, comparing, and assessing link-, corridor- and area-level reliability measures. Data for the city of Charlotte, North Carolina was used to compute reliability measures, examine temporal and spatial variations, and illustrate how reliability can be used for transportation planning, prioritization and allocation of resources.

KEYWORDS: Reliability, Link, Corridor, Travel Time, Variation

INTRODUCTION

Reliability is defined as the probability that a component or system will perform a required function (without failure) for a given period of time when used under stated operating conditions (Ebeling, 1997). The reliability of a link, corridor or the transportation road network, therefore, could be defined as the ability to provide an acceptable level of service (LOS) to the traveler under stated environmental and traffic operational conditions during a given period.

Literature documents the use of several terms such as connectivity reliability, network reliability, capacity reliability, system reliability, and travel time reliability (Wakabayashi, 2010). The definition of network reliability has its roots in providing good network connectivity. The probabilities of link existence between an origin and a destination are used to define connectivity reliability (Asakura, 1999; Iida, 1999).

Travel time reliability is the level of variability between the expected travel time (scheduled, average or median travel time) and the actual travel time (Elefteriadou and Cui, 2005). Travelers prefer routes with higher mean travel times and smaller travel time variation to routes with a lower mean travel time and larger variability (Lyman and Bertini, 2008; van Lint et al., 2004). Studies also show that travelers remember not only the average travel time, but also the worst few days they have experienced. According to the Federal Highway Administration (FHWA) of the United States Department of Transportation, "the concept of reliability could provide a different perspective to help agencies measure and improve the travel time on those worst days, by decreasing average travel time and increasing travel time reliability".

The possibility of capturing dynamic and continuous travel time and/or speed data from private sources such as INRIX opens many pragmatic avenues to understand and/or predict reliability of transportation systems. The definition of reliability as a performance measure and associated thresholds to understand or assess the actual performance could vary for a link, corridor or an area. These definitions and thresholds to assess reliability need to be clearly established prior to its large scale application. This research aims to fill this gap by computing, comparing, and assessing link-, corridor- and area-level reliability measures.

BACKGROUND ON RELIABILITY

The probability of reaching a destination within an acceptable range of time that takes no longer than the expected travel time plus an acceptable additional time is vital in defining reliability (Elefteriadou and Cui, 2005). Therefore, the three major components to define reliability are expected travel time, acceptable additional time, and the actual travel time. The acceptable additional time is the additional time that a traveler would find acceptable during an on-time performance (Elefteriadou and Cui, 2005). Buffer time is the amount of extra time that must be allowed for the traveler to reach their destination in a high percentage of the trips (Elefteriadou and Cui, 2005).

The expected travel time would be high for some links that are generally congested most of the time. Consequently, the variability between the expected and actual travel time may be marginal. In such a situation, the facility is considered as reliable, though the links are congested (Elefteriadou and Cui, 2005). However, for a regular facility without continuous congestion, the variability for non-congested travel times is smaller than when compared to congested travel times (Elefteriadou and Cui, 2005).

Transportation system operators are interested in the LOS and delay associated with the congestion. Therefore, they would like to study the travel time reliability measures reflecting such delays. Indeed, the travel time within which a majority of travelers complete their trips (i.e., 95 or 90 percentile) is important in the eyes of operators (Wakabayashi and Matsumoto, 2012). However, users are interested in estimated travel time and probability of arriving at their destination in a timely manner (Wakabayashi and Matsumoto, 2012).

Among all the measures of travel time reliability, Buffer Time Index (BTI) and Planning Time Index (PTI) are standardized and used to compare two different roadway systems. On the other hand, measures such as buffer time and planning time are incomparable between different systems. These indices are used to compare the before-after condition of a same roadway system (National Center for Transit Research - NCTR, 2010).

The travel time reliability relates to properties of the day-to-day travel time distribution as a function of time-of-the-day, day-of-the-week, month-of-the-year, and external factors such as weather, incidents and road works (van Lint and van Zuylen, 2005).

Table 1 summarizes selected reliability measures defined by practitioners and researchers in the past.

Table 1. Summary of Reliability Measures.

Index / Reference	Measure / Equation	Index / Reference	Measure / Equation
NCHRP (1998) Definition	Std. Dev. of travel time	λ_{Skew} (van Lint et al., 2004)	$(TT_{90} - TT_{50})/(TT_{50} - TT_{10})$
AASHTO (2008) Definition	On-time performance	λ_{Var} (Bogers and van Lint, 2007)	$(TT_{90} - TT_{10})/TT_{50}$
TranSystems Definition (2005)	Probability of on-time performance	Variability (Wakabayashi, 2010)	TT_{85}-TT_{15}
Buffer time (Lomax et al., 2004)	$TT_{95} - TT_{Ave}$	Variability (Wakabayashi, 2010)	TT_{80}-TT_{20}
Buffer Time Index (BTI) (Lomax et al., 2004)	$\frac{TT_{95} - TT_{Avg}}{TT_{Avg}} \times 100$	Variability (Wakabayashi, 2010)	TT_{70}-TT_{30}
First worst travel time over a month (Wakabayashi and Matsumoto, 2012)	TT_{95}	Acceptable Travel Time Variation (ATTV) index (Wakabayashi, 2010)	$P(TTavg + ATTV)$
Second worst travel time over a month (Wakabayashi and Matsumoto, 2012)	TT_{90}	Desired Travel Time Reduction (DTTR) index (Wakabayashi, 2010)	$P(TTavg - DTTR)$
Planning time (Wakabayashi and Matsumoto, 2012)	TT_{95}	Travel Time Index (TTI) (Lyman and Bertini, 2008)	$\frac{TT_{Ave}}{TT_{free\ flow}}$
Planning Time Index (PTI) (Sisiopiku and Islam, 2012)	$\frac{TT_{95}}{TT_{free\ flow}}$	Frequency of congestion (Lyman and Bertini, 2008)	Percent of days/periods that are congested
Travel time variability (Tu et al., 2007)	$TT_{90} - TT_{10}$		

Note: TT indicates travel time; ATTV is acceptable travel time variation and DTTR is desired travel time reduction.

NCHRP (1998), TranSystems (2005), and AASHTO (2008) defined the reliability as standard deviation of travel time, probability of on-time travel, and on-time performance, respectively. In Table 1, TT_{95} and TT_{90} are 95th and 90th percentile travel times, respectively, which are the first and second worst travel times over a month. TT_{95}, which is defined as planning time (Wakabayashi and Matsumoto, 2012), is more general because it shows the delay for one day out of the twenty work days in a month and is two times the standard deviation of a normal distribution (Wakabayashi, 2010). TT_{Avg} is the average of travel time. PTI represents the total required travel time for an on-time performance, while the buffer time represents the required additional time for an on-time performance (Sisiopiku and Islam, 2012).

$TT_{free\ flow}$ is free flow travel time, which is 15th percentile travel time during weekdays off-peak hours (Wakabayashi and Matsumoto, 2012; Tu et al., 2007).

The difference between 90th and 10th percentile travel time is considered as the measure of travel time uncertainty, which is defined by Tu et al. (2007) as travel time variability index. λ_{Skew} and λ_{Var} were defined by van Lint et al. (2004) and Bogers and van Lint (2007) as other measures of reliability.

TT_{85}-TT_{15}, TT_{80}-TT_{20}, and TT_{70}-TT_{30} are other indices to define the travel time reliability. They are useful measures for both transportation system operators and users (Wakabayashi, 2010). Wakabayashi (2010) defined $P(TTavg + ATTV)$ and $P(TTavg - DTTR)$ in which $P(t)$ is the function of computing percentile value of travel with time t, $ATTV$ is acceptable travel time variation and $DTTR$ is desired travel time reduction. Travel Time Index (TTI) and frequency of congestion (number of times congestion exceeds an expected threshold; defined as percent of days or time that mean speed falls below a certain speed) are two other indices defined by FHWA (Lyman and Bertini, 2008).

In summary, reliability indices are travel time percentiles (e.g., planning time, acceptable travel time variation index, and desired travel time reduction index), ratios of two travel times or travel time percentiles (e.g. PTI and TTI), differences between two travel times or travel time percentiles (e.g., buffer time, travel time variability, $TT_{85} - TT_{15}$, $TT_{80} - TT_{20}$ and $TT_{70} - TT_{30}$), ratios of difference between two travel times, and a travel time percentile (e.g., BTI and λ_{var}), or ratios of two differences between pairs of travel times (e.g., λ_{skew}).

Travel time reliability could be based on the definition of failure where reliability is defined as the probability of an on-time performance. Using this definition, it is possible to track the reliability over time and evaluate the condition of the facility for agencies (Elefteriadou and Cui, 2005). Alternatively, travel time reliability could be based on the variability of travel time (i.e., unpredictability of travel times from the users' viewpoint), using some measures of central tendency (e.g., mean or median) and a measure of dispersion (e.g., standard deviation or acceptable additional time) which will make a sense for users (Elefteriadou and Cui, 2005).

STUDY CORRIDORS AND METHODOLOGY

Two corridors, 1) a freeway corridor (I-85, ~5.75 miles) and 2) a major thoroughfare (North-Tryon, ~5.75 miles), in Charlotte metropolitan area were considered to assess differences in computed reliability measures by functional class. INRIX data was obtained for these corridors for the year 2011. The data obtained consisted of average travel times on each link along the corridor, for every minute, for the entire year 2011. Each link has a Traffic Message Channel (TMC) code. The selected I-85 and North Tryon corridors comprised 10 and 9 TMC's (say, links), respectively.

The data was categorized based on TMC code, day-of-the-week, and time-of-the-day (each hour in a day) to generate a new database for each link. The average travel times for each link (TMC) along selected corridors as well as the minimum, average, maximum, 15th percentile, 85th percentile, and 95th percentile travel times for each link were computed by time-of-the-day and day-of-the-week.

As the lengths of the links are not the same, travel time reliability measures that are standardized (travel time reliability indices) were only considered for comparison and assessment in this paper.

Buffer time indices (BTI_{85} and BTI_{95}), as defined in equations 1 and 2, were also computed and compared with the aforementioned measures.

$$BTI_{85} = \frac{TT_{85} - TT_{Avg}}{TT_{Avg}} \times 100 \qquad \text{… Equation (1)}$$

$$BTI_{95} = \frac{TT_{95} - TT_{Avg}}{TT_{Avg}} \times 100 \qquad \text{… Equation (2)}$$

As BTI_{95} is computed from the difference between the average travel time and 95th percentile travel time, a high difference between these travel times indicate a huge variation in the expected and actual travel time. So, the links with low BTI_{95} values (≤ 5) are considered to be highly reliable whereas the links with higher BTI_{95} values (> 25) are considered to be highly unreliable. BTI_{95} is also an indicator of the measure of expected travel times when compared to average travel times. For example, a BTI_{95} value of 5 indicates that expected travel times are 5% higher than the average travel times. Similarly, inferences could be made based on BTI_{85}.

The travel time data for each link were aggregated to evaluate travel times on the corridors considered in this study. They were then used to compute corridor-level reliability measures. The percent of links or lane miles that provide reliable service are computed and used as a reliability measure at an area-level.

RESULTS

The minimum, maximum, and average travel times along with 15th, 85th, and 95th percentile travel times by time-of-the-day and BTI values based on 85th and 95th percentile travel times, at link- and corridor-level, are presented and discussed in the next sub-sections. In general, marginal differences were observed in minimum, average, 15th, and 85th percentile travel times.

Reliability at Link-level

Tables 2 and 3 summarize travel time statistics and computed reliability measures for the selected links on North Tryon corridor by day-of-the-week and time-of-the-day. From Tables 2 and 3, during weekdays and weekends, the BTI_{95} values are observed to be high during peak hours and closer to zero during the selected off-peak hour. This indicates that the selected links on North Tryon corridor are reliable during off-peak hours and unreliable during the peak hours. A comparison of results shown in the two tables indicates that more links are reliable during weekend peak hours (compared to weekday peak hours). On the other hand, if congestion is acceptable 15% of times rather than 5%, from BTI_{85} values in Tables 2 and 3, the selected links along North Tryon corridor are observed to be reliable even during weekday peak hours.

Tables 4 and 5 summarize travel time statistics and reliability measures for the selected links on I-85 corridor by day-of-the-week and time-of-the-day. From Tables 4 and 5, during weekdays and weekends, the BTI_{95} values are observed to be low ($\leq$ 10). If the selected links with up to 5% increase in travel times are considered reliable, all the links are observed to have BTI_{95} values greater than 5, indicating the links are relatively unreliable on weekdays and weekends during peak and off-peak hours. However, if the selected links with up to 10% increase in travel times are considered reliable, all the links are observed to have BTI values less than 10, indicating that all the links are reliable. As in the case of North Tryon corridor, all links are reliable during weekdays and weekends if congestion is acceptable 15% of times in a year (from BTI_{85} values in Tables 4 and 5).

Table 2. Link-level Travel Time and Reliability Measures - North Tryon during Weekdays.

Link	Off-peak Hour (10:00 PM - 11:00 PM)								Peak Hour (8:00 AM - 9:00 AM)							
	Travel Time (Minutes)			Travel Time Percentile			BTI (85)	BTI (95)	Travel Time (Minutes)			Travel Time Percentile			BTI (85)	BTI (95)
	Min	Max	Avg	15	85	95			Min	Max	Avg	15	85	95		
1	2.20	2.99	2.58	2.57	2.57	2.70	-0.31	4.66	2.03	11.98	2.95	2.70	3.08	3.48	4.26	17.70
2	0.44	1.40	0.49	0.49	0.49	0.49	-1.03	-1.03	0.43	2.04	0.56	0.49	0.59	0.86	5.21	53.88
3	1.50	2.61	1.56	1.54	1.54	1.63	-1.04	4.28	1.63	4.89	2.53	2.19	2.68	3.62	5.83	42.64
4	1.73	2.52	2.12	2.13	2.13	2.13	0.50	0.50	1.18	5.01	2.10	1.67	2.61	3.17	24.41	50.64
5	1.00	1.27	1.06	1.06	1.06	1.06	-0.13	-0.13	0.34	0.92	0.50	0.44	0.55	0.63	9.89	26.96
6	0.12	0.18	0.13	0.13	0.13	0.13	0.21	0.21	0.04	0.39	0.14	0.09	0.18	0.28	25.96	97.12
7	0.07	0.11	0.07	0.07	0.07	0.07	-0.38	-0.38	0.95	2.17	1.19	1.08	1.21	1.33	1.86	12.30
8	0.01	0.03	0.01	0.01	0.01	0.02	-3.99	10.78	0.12	0.52	0.15	0.13	0.16	0.23	3.72	50.33
9	0.40	0.55	0.41	0.41	0.41	0.41	-0.28	-0.28	0.01	0.11	0.03	0.02	0.02	0.04	-5.32	73.57

Table 3. Link-level Travel Time and Reliability Measures - North Tryon during Weekends.

Link	Off-peak Hour (10:00 PM - 11:00 PM)								Peak Hour (8:00 AM - 9:00 AM)							
	Travel Time (Minutes)			Travel Time Percentile			BTI (85)	BTI (95)	Travel Time (Minutes)			Travel Time Percentile			BTI (85)	BTI (95)
	Min	Max	Avg	15	85	95			Min	Max	Avg	15	85	95		
1	0.47	0.70	0.49	0.49	0.49	0.50	-0.62	1.62	2.07	3.99	2.67	2.63	2.76	2.84	3.60	6.34
2	2.34	2.91	2.57	2.57	2.57	2.57	-0.15	-0.15	1.85	3.33	2.32	2.25	2.45	2.68	5.58	15.76
3	0.96	1.41	1.06	1.06	1.06	1.06	0.10	0.10	0.11	0.28	0.14	0.14	0.14	0.15	-1.68	10.53
4	2.08	2.87	2.14	2.13	2.13	2.13	-0.23	-0.23	0.42	0.90	0.50	0.49	0.51	0.58	1.86	14.84
5	1.54	3.01	1.57	1.54	1.54	1.63	-1.87	3.41	1.40	3.01	1.94	1.82	2.15	2.51	10.56	28.94
6	0.01	0.08	0.01	0.01	0.01	0.01	-2.27	-2.27	0.05	0.32	0.09	0.08	0.10	0.13	6.61	41.78
7	0.38	0.53	0.42	0.41	0.41	0.41	-0.59	-0.59	0.90	1.58	1.11	1.11	1.13	1.18	2.08	6.69
8	0.13	0.21	0.13	0.13	0.13	0.13	-0.35	-0.35	0.34	1.01	0.50	0.47	0.51	0.56	1.11	12.30

Table 4. Link-level Travel Time and Reliability Measures - I-85 during Weekdays.

Link	Off-peak Hour (10:00 PM - 11:00 PM)								Peak Hour (8:00 AM - 9:00 AM)							
	Travel Time (Minutes)			Travel Time Percentile			BTI (85)	BTI (95)	Travel Time (Minutes)			Travel Time Percentile			BTI (85)	BTI (95)
	Min	Max	Avg	15	85	95			Min	Max	Avg	15	85	95		
1	0.30	0.41	0.35	0.34	0.36	0.37	3.59	6.73	0.29	4.43	0.42	0.34	0.36	0.36	-15.39	-13.97
2	0.59	0.77	0.68	0.65	0.71	0.72	4.86	6.48	0.58	6.13	0.68	0.64	0.70	0.71	3.67	5.45
3	0.70	1.01	0.80	0.77	0.83	0.84	4.18	5.81	0.70	0.91	0.79	0.75	0.82	0.84	3.83	6.37
4	0.79	1.18	0.91	0.88	0.94	0.96	3.66	5.31	0.78	1.21	0.89	0.85	0.92	0.94	3.02	5.71
5	0.24	0.31	0.27	0.27	0.28	0.29	2.90	6.18	0.24	0.57	0.27	0.26	0.28	0.28	3.20	5.06
6	0.32	0.44	0.38	0.36	0.39	0.40	2.87	6.31	0.31	0.50	0.37	0.35	0.38	0.39	3.61	5.23
7	0.15	0.19	0.17	0.16	0.18	0.18	3.69	6.05	0.15	0.39	0.17	0.16	0.17	0.18	3.31	5.71
8	0.54	0.80	0.63	0.60	0.65	0.66	3.35	5.10	0.54	0.75	0.61	0.59	0.64	0.65	4.53	6.00
9	0.47	0.70	0.54	0.52	0.57	0.58	3.84	5.68	0.47	0.67	0.53	0.51	0.56	0.57	4.64	6.34
10	0.51	0.74	0.58	0.56	0.60	0.61	3.92	5.64	0.51	0.77	0.57	0.54	0.58	0.60	3.16	6.34

Table 5. Link-level Travel Time and Reliability Measures - I-85 during Weekends.

Link	Off-peak Hour (10:00 PM - 11:00 PM)								Peak Hour (8:00 AM - 9:00 AM)							
	Travel Time (Minutes)			Travel Time Percentile			BTI (85)	BTI (95)	Travel Time (Minutes)			Travel Time Percentile			BTI (85)	BTI (95)
	Min	Max	Avg	15	85	95			Min	Max	Avg	15	85	95		
1	0.30	0.41	0.35	0.34	0.36	0.38	3.53	6.95	0.30	0.53	0.34	0.33	0.36	0.36	3.83	5.58
2	0.57	0.80	0.68	0.65	0.71	0.74	4.11	8.20	0.59	0.79	0.67	0.64	0.70	0.72	4.78	7.02
3	0.70	0.93	0.80	0.77	0.83	0.84	3.68	5.30	0.70	0.90	0.79	0.75	0.82	0.83	3.90	5.55
4	0.78	1.02	0.91	0.88	0.94	0.96	3.34	5.64	0.78	1.01	0.89	0.85	0.93	0.94	3.99	5.67
5	0.24	0.34	0.28	0.27	0.29	0.29	3.87	5.69	0.24	0.31	0.27	0.26	0.28	0.29	4.19	6.04
6	0.32	0.44	0.38	0.36	0.40	0.41	4.67	7.85	0.31	0.42	0.37	0.35	0.38	0.40	3.92	7.17
7	0.15	0.19	0.17	0.16	0.18	0.18	3.86	5.62	0.15	0.20	0.17	0.16	0.17	0.18	3.69	6.09
8	0.55	0.71	0.63	0.60	0.66	0.67	4.68	6.27	0.54	0.69	0.62	0.59	0.65	0.66	4.94	6.72
9	0.47	0.62	0.54	0.52	0.57	0.58	4.08	5.92	0.47	0.60	0.53	0.51	0.56	0.57	4.72	6.41
10	0.51	0.70	0.58	0.56	0.60	0.61	3.91	5.63	0.51	0.64	0.57	0.55	0.59	0.60	4.05	5.63

Reliability at Corridor- and Area-Level

The travel time data for each link was aggregated to evaluate travel times at corridor-level. Similar to the link-level statistics, reliability measures at corridor-level were then computed. Table 6 summarizes travel time statistics and reliability measures for the two study corridors (North Tryon and I-85). From Table 6, the BTI_{95} values for North Tryon and I-85 during weekdays and weekends are observed to be low except for North Tryon corridor during morning peak hours, indicating that the corridors are generally reliable. The BTI_{95} value for North Tryon during morning peak is observed to be high indicating that the link is unreliable during morning peak hours. However, the BTI_{95} values at corridor-level are observed to be lower than

BTI_{95} values for the links, indicating that the reliability varies when computed at link- and corridor-level.

If congestion is acceptable 15% of times in a year, from BTI_{85} values in Table 6, all the corridors are observed to be reliable (including North Tryon during morning peak hour).

Table 6. Summary of Corridor-level Travel Time Statistics and Reliability Measures.

DOW	TOD	Travel Time (Minutes)			Travel Time Percentile			BTI (85)	BTI (95)
		Min	Max	Avg	15	85	95		
North Tryon Corridor									
Weekday	8 AM – 9 AM	7.25	28.61	10.20	9.32	11.07	12.10	8.54	18.63
	10 PM -11 PM	8.06	9.73	8.46	8.44	8.46	8.66	0.04	2.42
Weekend	8 AM - 9 AM	8.24	21.95	9.36	8.95	9.71	10.17	3.64	8.54
	10 PM - 11 PM	8.21	9.95	8.48	8.44	8.45	8.72	-0.35	2.83
I-85 Corridor									
Weekday	8 AM – 9 AM	4.97	14.96	5.61	5.35	5.71	5.93	1.79	5.61
	10 PM -11 PM	5.00	6.29	5.61	5.45	5.74	5.89	2.39	5.06
Weekend	8 AM - 9 AM	4.93	5.89	5.51	5.34	5.66	5.75	2.87	4.43
	10 PM - 11 PM	5.02	11.51	5.65	5.46	5.78	5.87	2.30	3.96

At an area-level (say, considering both corridors), 100% and ~42% of the selected links have BTI_{85} and BTI_{95} less than or equal to 5 (highly reliable) during weekday off-peak hours, while only ~26% and ~5% of the selected links have BTI_{85} and BTI_{95} less than or equal to 5 (highly reliable) during weekday peak hours. On the other hand, 100% and ~53% have BTI_{85} and BTI_{95} less than or equal to 5 (highly reliable) during weekend off-peak hours, while ~84% and 0% of the selected links have BTI_{85} and BTI_{95} less than or equal to 5 (highly reliable) during weekend peak hours.

CONCLUSIONS

This paper presents computation, comparison and assessment of travel time reliability measures. The computed measures were observed to vary by functional class, time-of-the-day, and day-of-the-week. Findings from the analysis of data for selected links along the corridors show that only marginal differences exist between minimum, average, 15^{th}, and 85^{th} percentile travel times. In other words, excluding the worst three travel times during a period may not yield statistically different travel times along a link during a time period on a day.

The use of 85^{th} or 95^{th} percentile travel times to compute reliability and assess link-, corridor- or area-level performance should depend on user's acceptance levels in the region. They or buffer time indices based on these travel times would be more suitable to compute and assess reliability. The links could be ranked based on the computed link-level reliability to examine causes of congestion and allocate resources.

The identification of specific locations for improvements will be difficult if corridor-level reliability measures are computed and used instead of link-level reliability measures. Using corridor-level measures for prioritization and ranking may also lead to unnecessary and additional expenditures. On the other hand, the percent of links or lane miles with poor reliability scores by time-of-the-day could be used for assessment of transportation network performance (area-level).

The volume-to-capacity ratio is traditionally used to assess link-level performance and as a measure of LOS. There could be relationship between computed LOS and volume-to-capacity ratio. This needs an investigation. Also, LOS thresholds that correlate to volume-to-capacity ratio need to be identified for easy understanding and applicability of travel time reliability as a measure.

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DISCLAIMER

The views, opinions, findings, and conclusions reflected in this paper are the responsibility of the authors only and do not represent the official policy or position of the USDOT/RITA, or any State, or the University of North Carolina at Charlotte or other entity. The authors are responsible for the facts and the accuracy of the data presented herein. This report does not constitute a standard, specification, or regulation.

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