A Literature Review on Travel Time Reliability as a Key Performance Measure

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Abstract : As the traffic density is increasing day by day, the urban road networks are also being developed vastly. The demand has always to be on time to the destination. Travel Time Reliability gives an idea about the performance of a particular route. This article tries to observe the Travel Time Reliability of different types of transportation networks through various studies that have been done. Any network system has a performance criterion through which its reliability is decided and Travel Time Reliability is one of them. This paper gives an idea about various models that have been developed for the reliability measure of travel time. Reliability indices have an important role in measuring the Travel Time Reliability. Measuring the reliability indices and comparing them gives an overall idea of the Travel Time Reliability aspect.

***Index Terms* - Travel Time Reliability, Performance Evaluation, Reliability Models, Reliability Indices.**

I. Introduction

Travel Time Reliability (TTR) as the name suggests is the dependability of the transportation system to move passengers or goods from one place to another on the time in every trip from day-to-day and across different time of the day. The reliability is depended on the travel time taken for each trip. As the travel time varies, the reliability also varies. More the variability in the travel time less will be the reliability and vice-versa. Reliability has a major influence on decisions regarding trip to be made, like how and when it is to be made, which route is to be followed, etc. If Reliability of a route could be predicted, then the travellers can predict their trip travel time in advance. Travel time is a key aspect in defining the effectiveness of the transportation system. Several studies have been made with regard to the Travel Time Reliability. Different aspects of TTR have been observed and tested. Many methods have been developed to estimate Travel Time Reliability which has been used in several studies. Analysis of reliability can be done by developing models and validating them. The methods used to estimate the travel time reliability depend on the accuracy of the travel time.

II. Literature Review

Y. Huo et al. (2014) have analyzed the service reliability of a BRT in China including value ranges of measures, temporal and spatial distributions, and comparisons. The study found that the transit users budget extra time for waiting and journey for on time arrival at the destination. More than 80 percent of that budgeted extra time is spent on waiting only. Potential waiting time can be reduced by enhancing stop accessibility and educating passengers to board in an orderly manner. Variations were found in the service reliability from morning to evening periods. The authors analyzed the spatial distribution of service reliability by direction and section. For the direction dimension, service reliability is better to Downtown than it is from Downtown from both the operator and passenger perspectives. For the section dimensions, service reliability from the operator and passenger perspectives is the same and is the best near the route's origin terminal, gradually deteriorating along the route, then improving when approaching the route's end.

A. Chepuri et al. (2018) used GPS data to evaluate travel time variability as well as reliability indexes. They highlighted the methodology for the identification of effective reliability measures from scattering technique. The Authors focuses on the variation of a few selected reliability measures with respect to parameters of the best-fitted statistical distribution for travel time. Valuable insights were provided for the bus travel time modelling using statistical distributions under heterogeneous traffic conditions. The case study presented in this work is expected to be useful for transit operators and planners so as to evaluate the performance of different links or segments along a given bus route in terms of reliability.

X. J. Li et al. (2015) proposed dynamic travel time reliability from the view of road users. They used Reliability Theory to analyze performance random function of Dynamic Reliability through reasonable hypothesis. TTR index is proposed to compute link and route TTR. Daily characteristic analysis of dynamic TTR is introduced in this study. Authors mentioned that the travel time is not only different in time distribution but also in spatial distribution. The changing phenomenon of TTR with time and space is called temporal-spatial characteristics. When travellers start their trip when traffic volume is low, the travel time will be shorter and the given threshold will be less based on their experience and vice-versa. The given threshold is an increasing function of traffic volume and travel time. Authors compared the reliability index method with the Monte Carlo Method with the help of a numerical example. The dynamic research on reliability is not real time and dynamic reliabilities at various moments on the same route from the view of road users. As per their model the real time dynamic TTR of urban road networks can be estimated if the real time link travel time can be collected.

H. Rakha et al. (2010) attempt to develop a model that estimate travel-time reliability measures for given path from segment travel-time measurements along the path. Path travel-time reliability is estimated as the probability that the travel time between an origin–destination pair is within a specified range. Key parameters in estimating path travel-time reliability include estimating not only the path mean travel time but also the travel-time variance. They conduct a simulation study to characterize travel-time reliability measures under different traffic conditions. This study proposed five methods for estimating path travel time reliability. The simulation analysis demonstrated that the trip travel-time CV prediction error increases as the level of congestion on the freeway increases. The study demonstrated through goodness-of-fit tests that the assumption of normality is, from a theoretical standpoint, inconsistent with field and simulated travel-time observations and that a log-normal distribution is more representative of roadway travel times under steady state conditions. The study also demonstrated that under non–steady-state conditions when localized bottlenecks exist along a corridor, the log-normal distribution fails to characterize travel time variability and that a mixture distribution might be more appropriate to model travel times.

K. Lyman et al. (2008) explore ways in which travel time reliability is measured using archived data over a segment, a corridor and an entire urban area. They described how measures of congestion are used in that evaluation and will suggest that adding travel time reliability measures to the ones currently in use can result in a better understanding of the transportation system. This study explores ways in which travel time reliability is measured using archived data over a segment, a corridor and an entire urban area. It defines the six standard measures of Travel Time Reliability used by Federal Highway Administration (FHWA) which include 90^{th} or 95^{th} percentile travel time, travel time index, buffer index, planning time index and frequency that congestion exceeds some expected threshold. The Authors analyzed twenty Regional Transportation Plans (RTPs) and found that none of them used reliability in a comprehensive way within the document, though a few set overarching goals of improving regional travel time reliability. The Authors conducted a segment level and corridor level analysis to draw the travel time reliability measures. The three reliability indices (planning time index, buffer index and travel time index) were compared and it was found that the planning time index in particular seems to exaggerate the trends more than the buffer index or the travel time index. The buffer index due to it tendency to dilute the trends along the roadway was found to be probably the most conservative measure to use. This study recommends the use of reliability measures in addition to the traditional congestion measures for more informed planning.

X. Tang et al. (2009) presented a general model for traffic assignment with travel time uncertainty. The expected travel time reflects the time need for finishing a trip under typical traffic situation. The variability of travel time usually results in travelers' extra time budget. Traveler's risk aversion not only depends on his or her character but also the request of punctual arrival which differs in the aims of trips. A conservative traveler tends to start early to avoid being late and thereby needs more time budget. They proposed a utility function in which each parameter reflects a factor indecision making of route choice. They suppose traveler's aversion as a random variable which follows a certain distribution among population to consider travelers' different risk aversion. By doing it, they classify travellers more deliberately according to the distribution of risk aversion. Deliberate classification can satisfy the constraint of computer resource and improve the accuracy of model as far as possible. The model that Authors suggested contained integration for the solution of which they were first converted to a discrete format. This process can be realized by dividing all travelers into multiclass according to their heterogeneous risk aversion. A novel algorithm has been present for the multi class model to avoid the exhausting calculation. Authors performed a numerical experiment on a test network of Chen et al. (2002) consisting of two OD pairs. The link travel time is computed using the standard BPR (Bureau of Public Road) function. Different scenarios were tested by equally dividing all travellers into three classes. They found that the risk aversion has obvious effect on link flows when the risk mean is not equal to zero, especially the high value risk aversion. The traffic flow on Links with more time variation significantly decreased with the increase of risk aversion. These results can be explained by noting that travellers with high risk aversion tend to seek path with low travel time variability, regardless of certain amount of travel time increase. This model found out to be more suitable for dealing with heterogeneous risk aversion.

C. Chen et al. (2011) attempts to reflect the traveler's satisfaction degree on bus operating service and route travel time, this paper redefined the bus route perceived travel time and travel time reliability according to traveler's psychological characteristics. They defined a perceived travel time equation by considering average travel time, standard deviation of the bus route travel time and coefficient of risk. They also considered the travel time buffer into account in that equation. The authors defined the TTR as the probability that the absolute travel time delay between actual travel time and perceived travel time can be accepted by travelers under general traffic conditions and bus services. A model for travel time reliability is established and solved with the help of Monte Carlo method. For analysis, a bus route was selected and travel time survey had been carried out for seven working days on morning peak hours. The Authors found that the Travel Time Reliability for Adventurist and Rationalist is more or less the same. As the traffic flow along the route increases, the Travel Time Reliability ascends and vice-versa. The analysis reflect the level of bus route operation service for transportation managers and also suggests travellers to take which bus route and when to start off at the bus stop to satisfy their travel requirement.

D. S. Mcleod et al. (2012) attempt to give an overview of the model developed by Florida Department of Transportation (FDOT) and suggests its application, presents results, and provides insights into how FDOT might use the model for its planning and programming processes in the future. The methodology developed to by FDOT considered a series of different scenarios that may occur over a year. Expected travel times are calculated for those scenarios as well as the probability of occurrence of each scenario. In order to analyze and report travel time reliability, the Freeway System is segmented into facility lengths based on the criteria like Strategic Intermodal System (SIS) freeway to freeway interchanges, Non-adjacent urbanized area boundaries, SIS intersecting routes, Length, etc. The developed model considers four major causes of congestion; recurring congestion, incidents, weather and work zones. This study used the input data from the FDOT roadway and level of service databases and typical hourly volume distributions. Demand to capacity ratios was determined for each hour. Preferable travel time reliability statistics from FDOT are the percentage of trips arriving on-time and the planning time index. The model may also make use of the combination of the planning time index and an on-time arrival threshold into one overall travel time reliability index. The model can be used to analyze and track travel time reliability for an entire freeway system.

III. CONCLUSIONS

By reviewing various literatures, we can say that the travel time reliability is now been seen as a major aspect in performance evaluation of the transportation system. The estimates of the travel time reliability can vary depending on the model that being used for the analysis. The reliability indices should have been considered for the analysis as they can be used for time comparisons among different periods of the day and they can be used for better understanding of time planning from users perspective. For overall success of a transportation network system, the travel time reliability is of the utmost importance for both the network operators as well as for travellers. The functioning of a route should be reliable and for that the travel time should also have least possible variations.

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