MEASURING TRAVEL TIME RELIABILITY VARIABLES IN A NON-SIGNAL HIGHWAY TRAFFIC ROUTE

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Abstract

Traffic congestion has become a severe scourge in highly densely populated towns in both developed and developing countries. Longer travel times, as well as a higher incidence of crushed vehicles, environmental issues, and deterioration in the quality of life, have been caused by increased demand for urban mobility and transit. Highway traffic congestion is often considered a routine occurrence; plan period accordingly. The study looks into the measure variables that influence travel time reliability (TTR). However, severe and unanticipated delays disrupted deliveries, program, and activity schedules, operations, and other logistics. In other words, the study looks into the potential factors that influence travel time reliability (TTR). This study used the Highway Capacity Manual (HCM) as a basis to assess the travel time reliability index. The study employed Log odd ratio to identify the relationship between the Buffer Time Index (BTI) and the planning time index (PTI) and determine the travel time-reliability threshold ratio, and the Planning Time Index (PTI) and also, determine the ratio of the travel time-reliability threshold. The study revealed the following: the diversion of 15%–20% of the total traffic from the high-level congested roads to the results of the least or lesser congested roads into a higher level of service (lower congestion), an increase in speed by 15km/h to 20km/h from the current speed levels, and increases by 10%–15%, respectively. The study indicates no relationship between traffic flow and travel time. The study also provides a better understanding of the system's capabilities, limitations, and data collection for real-time performance measurement.

Keywords: Travel time, Reliability, Buffer time index, Planning time index, Highway Capacity Manual.

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1.1.Introduction

Building variables for the effective performance of corridor highway travel times is critical for transportation planners and highway engineers who specialise in road design. Travel time variables have become a critical and essential facet of transportation accomplishments. They can be treated as effectual elements of travel time, reliability, and execution.

They correspond to the efficiency of highway travel time, which may have an easily understood meaning when travelling with others. Flow, along with other variables such as speed, volume, flow, time, density, traffic incidence, work zone, and weather, form important attributes of travel time reliability. Travel time depends on these variables for efficient and effective travel from the origin to a destination. The travel time reliability model is dependent on volume and density. Volume and density will be considered the main variables for assessment. The method to quantify travel time reliability metrics can be grouped into variation metrics, probabilistic measures, and percentile indices (Kidando et al., 2019).

Traffic flow and volume are very important components that estimate the rate of traffic passing on a road segment at a particular time interval. The flow rate could be minute, hours, day, week, month, and year. Volume is the sum of vehicles flying road at a time interval less than or within an hour.

Various measures, such as level of service, delay, buffer size, and volume capacity ratio, are used to measure travel time reliability (TTR) as key initiatives for the efficiency of vehicular traffic on the explicit road system (Kidando et al., 2019). Travel time can be viewed in two ways: the running time and the intersection delay. The former defined a function of link length, which is dependent on highway geometry design capacity; the latter provides a reliable forecast of intersection delay time prediction performance (Lu et al., 2021)(Otuoze et al., 2021).

Network reliability is the load quantity of connected travel time reliability (Kathuria et al., 2017)(Kathuria et al., 2020). Travel time variability was defined by (Bimpou & Ferguson, 2020) as the distinction between an upper and lower range expressed in terms of travel time percentiles. (Nicholson, 2003) identifies how the effects of disruption lie on the hierarchy of understanding the transport network acquired by the users. Microsimulation may best fit the modelling strategies for assessing the effects of short-term disruption.

Network reliability is the load quantity of connected travel time reliability (Wang & Guo, 2022). It is the accumulated time for the journey from one location to another(Khoo et al., 2021) encoded by the functional consistency of a particular road segment. Travel time reliability is the temporal variability of travel time that influences many aspects of travel decisions, particularly in roadway transportation (Afandizadeh Zargari et al., 2021). The discrepancy in travel time that is not anticipated by motorists is referred to as "travel time reliability"(Texas Transportation Institute & Cambridge Systems, 2006). Travel time can be defined as the amount of time it takes a vehicle to complete a specified trip over a segment of road between two points**.**

Travel Time Reliability describes the consistency of travel times from day to day or across distinct intervals of the day (FHWA, 2019)(Transportation Research Board, 2010)(Zheng et al., 2018)(Kong et al., 2018)(Olszewski et al., 2018)(H. Li et al., 2019)(E. O. A. Tufuor & Rilett, 2019)(E. O. A. Tufuor & Rilett, 2020)(E. Tufuor et al., 2021)(E. O. A. Tufuor & Rilett, 2021)(Bimpou & Ferguson, 2020)(Siddiqui & Ko, 2020)(Wu et al., 2022)(Steinmaßl et al., 2021)(Rivera-Royero et al., 2022)(No & For, 2022)(Chung et al., 2020). The Travel Time Index (TTI) is the ratio of average travel time and free-flow or speed-limit (Chung et al., 2020). Travel Time Index is defined as the ratio of mean travel time to free-flow travel time (Federal Highway Administration, 1991)(Roess et al., 2010)(Transportation Research Board, 2010)(FHWA, 2019)(E. O. A. Tufuor & Rilett, 2020)(Wu et al., 2022).

Travel time estimation and forecasting assist transportation operators in initiating better monitoring and coordination of an efficient signal control system, as well as allowing travellers to plan informed journeys based on road selection and take-off time (Lu et al., 2021). Travel time reliability can be estimated endogenously, and changes in the values. Forecasting mass transit travel times is an effective measure for improving service reliability, optimising travel orders, and mitigating traffic challenges (Zhang et al., 2022).

1.2. Background of the Study

Travel time variables are an important aspect of transportation planning, and highway engineers evaluate unchangeable factors that influence a specific trip. These variables are so significant in this research because they are the ingredients that attach a high value to reliability assessment. These variables serve as a major attribute that defines the changeability of route dependency, without understanding these variables, trip makers may not adequately understand the success and failure of a particular journey. Traffic volume may tend to maintain or reach an equilibrium position when speed increases, and travellers may face delays when the speed reduces. As a result, peak-period trips increase until a certain time of day and limit further flow.

Density affects vehicular movement when the flow and traffic volume exceed the road capacity; which may result in high-density traffic. It may reduce the traveller's benefit from road capacity to accommodate the number of vehicles moving in a particular lane. The variables may influence trip planners because most travellers are willing to forego time wasted on a particular journey. This study aimed to identify the variable used in measuring corridor highway travel time reliability in Nigeria. The following objectives are focused on: First, identify the variables used in measuring corridor highway travel time. Secondly, assess the effectiveness of travel time variables. Thirdly, the relationship between each variable and expected values.

2.0. Literature Review

2.1. Literature Review

Traffic congestion prediction is crucial for strengthening the energy success and reliability of the transportation system (Shelke et al., 2022). Travellers make decisions about which roads to take and when to leave based on the anticipated travel time and their reliability (Zheng et al., 2018); (Khoo et al., 2021). Determining the performance of management measures related to highway system reliability, freight, and traffic composition can be assessed in accordance with FHA standards (Siddiqui & Ko, 2020) Unreliability could be caused by endogenous and exogenous factors such as demand variation, incidents, weather, special events, system malfunctions, and the performance of supplementary and competing transportation modes (Z. Chen et al., 2019). The investigations into travel time reliability include the potential transit satisfaction of smart mobility technology in a mixed highway traffic construction zone (Abdulsattar et al., 2020). Car ownership has generated an enormous concentration of automobiles on the road network in modern cities (Hameed et al., 2019; Tsuboi, 2021).

The presence of heavy and sluggish vehicles in the traffic stream reduces traffic capacity significantly for the flow of moving passenger automobiles (Macioszek, 2019). Road infrastructure, unregulated road conditions, informal activities, off-street parking, and insufficient public transportation were the significant reasons for traffic congestion on the Abuja-Kugbo-Nyaya axis (Chidera, 2020). To establish a congestion travel time reliability threshold, the study will evaluate measures of corridor highway traffic with travel time reliability to disaggregate traffic flow and travel time index using buffer time index (BTI) and planning time index (PTI). In the event of congestion, reliability is measured by the buffer time index and standard deviations from the foreseeable traffic flow connected with a given traffic situation. The study anticipates travel time reliability as a dependent variable for calculating the Highway Capacity Manual's Buffer Time Index (BTI) and Planning Time Index (PTI).

2.2. Traffic Flow Theories, and Travel Time Models

Travel time reliability measures have gained widespread attention in transportation planning and engineering for a couple of years. (Becker, 1965) believes that the budgeting and effectiveness of the no-working period are more important to economic welfare than other working times. According to (Becker, 1965) consumer goods are those that openly promote satisfaction. Gaver proposed a travel time model and predict variability in travel time (Gaver, 1968). Comparing alternative models, it is variations in system reliability tendencies that are more of a concern (Aven, 1988).

Knight developed commuter response data to estimate a "safety margin" (Knight, 1974) Small conducted an experimental and verifiable study on this topic and discovered that the timing of travellers' departures is greatly influenced by plan costs (Arnott & Small, 1994) (D'Este et al., 1999) proposed a game theory to measure the performance of reliability in transport networks to predict the trade-off between users exploring a route to reduce the foreseeable journey cost and selecting a link performance situation to optimise the foreseeable journey cost. Noland and Small used this theory to explain how travel time and departure time relate to different congestion rates. Travel time can be categorised into performance-driven and reliability measures and traveller's response to reliability. Lomax et al. were among the old scholars who studied travel time reliability measures that demonstrate a practical performance (Lomax et al., 2003). The Burr distribution is elastic and easy to apply as a failure-time model.

The Burr has a good estimation of the Weibull, which is a restricted distribution of the Burr (Zimmer et al., 1998). The authors established an alternative statistical distribution for TT variability, with the Burr Type XII distribution scoring the highest value and being more applicable for both links and roads (Susilawati et al., 2010)(Taylor & Susilawati, 2012). (Nicholson, 2003) suggested that unreliability be accepted as a step up from two. The Burr has a good estimation of the Weibull, which has a restricted distribution (Zimmer et al., 1998). The effectiveness of travel time reliability variables is a matter of deciding on departure time, and this research is associated with the relevant theory of variability developed in the context of the transportation field. Studying the current state of reliability data requires a rigorous understanding of the variable measures and the means by which appropriate findings can be made that will contribute to highway travel time reliability.

Reliability demonstrates the concept of recurrence, though it is open to interpretation. A person making a single trip may want to know that the trip time is uncertain, and this must be considered even if the journey is never to be repeated. There is an implicit assumption that if it was recurring. The results and, in some cases, the designated travel time may differ. As a result, reliability is closely related to the statistical concept of variability. Kathuria et al., (2017) demonstrated that speed, density, and volume can be used to estimate travel time reliability (TTR) as well as be viewed as a performance of travel time variability (TTV). (Kathuria et al., 2020) further presented another measure of planning time as the 95th percentile of travel time, meaning how bad a vehicle travel time delay can be. (Samal et al., 2020) used a video graphic mobile camera to estimate traffic volume.

Nnamani et al., (2020) video graphics survey method using a probe vehicle approach. The authors provide the following traffic congestion measures, which include speed, travel time, delay, and level of service (Afrin & Yodo, 2020). Different metrics, probability measures, and percentile ratios can be used to quantify TTR (Kidando et al., 2019). The variable that contributes to the traffic congestion unit of measure can be considered reliable if the volume of traffic remains constant throughout the evaluation (Siddiqui & Ko, 2020). The BTI, according to Hongtai Yang et al. (2020) can be calculated using a regression model to estimate percentile rank and standard error.

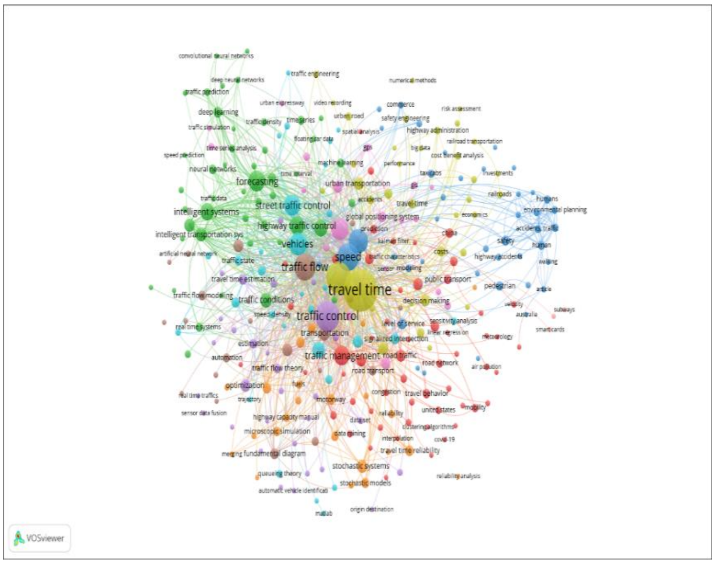

Figure 1. Authors Bibliometric Analysis on traffic flow and travel time

<u>Analysis</u>

-Total number of clustered = 8
-Total number of co-occurrence

<u>Layout Parameters</u>

-Random = 1
-Max, Iteration = 1000
-Initial Stepsize = 1.000
-Stepsize Reduction = 0.75
-Stepsize Convergence = 0.001
Random Seed = 0

2.3. Metric Analysis

Analysis

- Total number of clustered = 8

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- Total number of co-occurrence

Layout Parameters

- Random = 1
- Max, Iteration = 1000
- Initial Stepsize = 1.000
- Stepsize Reduction = 0.75
- Stepsize Convergence = 0.001
- Random Seed = 0

2.4. Method of Estimating Travel Time Index.

The researchers adopt two critical measures which include the ratio of congestion level to traffic congestion and the ratio of travel time reliability (Kong et al., 2018). Travel Time Index – TTIR (travel time index ratio). TTI will be used to measure congestion intensity. The common TTI defines the average TT divided by the free-flow TT.

Table 1. Travel Time Reliability Measures

S/NO.	*TT Measures*	*Definition*	*Relevance*
1	*PTI*	$\frac{90^{th}/95^{th}\ Percentile}{FFT}$	*Personal trip & urban trip*
2	*BTI*	$\frac{95^{th}\ Percentile - T_{avg}.}{FFT}$	*Commercial trip, logistic service, carriers*
3	*TTI*	$\frac{T_{avg}}{FFT}$	*Used as a congestion measure*
4	*Misery Index*	$\frac{5\%\ worst\ Tavg}{FFT}$	*Used as an instrument to estimate bad trips*
5	*λ Skew*	$\frac{5\%\ worst\ Tavg.}{FFT}$	*Operator Side Index*
6	*λ variance*	$\frac{TT90 - TT\ 10}{TT50}$	*Operator Side Index*
7	*P (T_{ave} + ATTV)*	*Percentile when TT is ATT above T_{ave}*	*User Side Index*
8	*P (T_{ave} - DTTR)*	*Percentile when TT is ATT above T_{ave}*	*User Side Index*
9	*TT80 – TT20*	-	*Range of average TT*
10	*TT70 – TT30*	-	*Range of average TT*

Source: Adapted from Jose and Ram., 2019

2.4.1. Planning Time Index (PTI)

The planning time index measures the dependability of travel time. It is calculated by dividing the 95th percentile by the smooth flow journey time.

$$PTI = \frac{95th\ percentile\ of\ travel\ time\ of\ all\ observations\ during\ one\ hour\ of\ the\ selected\ route}{free\ flow\ travel\ time\ of\ route}$$

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$$TTI = \frac{95th\ percentile\ travel\ time\ of\ point\ A / free\ flow\ travel\ time\ of\ route\ A}{95th\ percentile\ travel\ time\ of\ route \frac{B}{free} flow\ travel\ time\ of\ route\ B}$$

$$TTI = \frac{95th\ percentile\ speed\ of\ point\ A * free\ flow\ travel\ time\ of\ route\ B}{95th\ percentile\ of\ travel\ time\ of\ route\ B * free\ flow\ travel\ time\ of\ route\ A}$$

2.4.2. Buffer Time Index (BTI)

Travel Time Index (Chung et al., 2020)

$$TT_{mean} = \frac{TT_{95th-Average\ Travel\ Timme}}{Average\ Travel\ Time} \times 100\ (\%)$$

$$BI_{median} = \frac{TT_{95th-Median\ Travel\ Timme}}{Average\ Travel\ Time} \times 100\ (\%)$$

$$PI = \frac{TT_{95th}}{TT_{free\ flow\ or\ pasted\ speed\ limit}}$$

$$\text{BTI} = \frac{T_{95-}T_{50}}{T_{50}} = \frac{T_{95}}{T_{50}} - 1$$

Table 2. Reliability Performance Measures

Reliability Performance metrics	Definition	Unit
Planning Time Index	90^{th} percentile travel time index (90^{th} percentile travel time divided by the free flow travel time)	None
Buffer Index	Is the 95^{th} travel time minus the average normal travel time	Percentile
Failure/On-Time Measures	Percentile travel times multiply by median travel time. Measures, 45 mph; and 30 mph	Percentile
8^{th} Percentile Travel Time Index	80^{th} percentile travel time divided by the free flow travel time	None
Skew Statistic	(90^{th} percentile minus the median) travel time)	None
Misery Index	The average travel time divide Skew Statistics by the free flow travel time	None

Source: Adapted from ("Inc. Reliab. Perform. Meas. into Transp. Plan. Program. Process.," 2013).

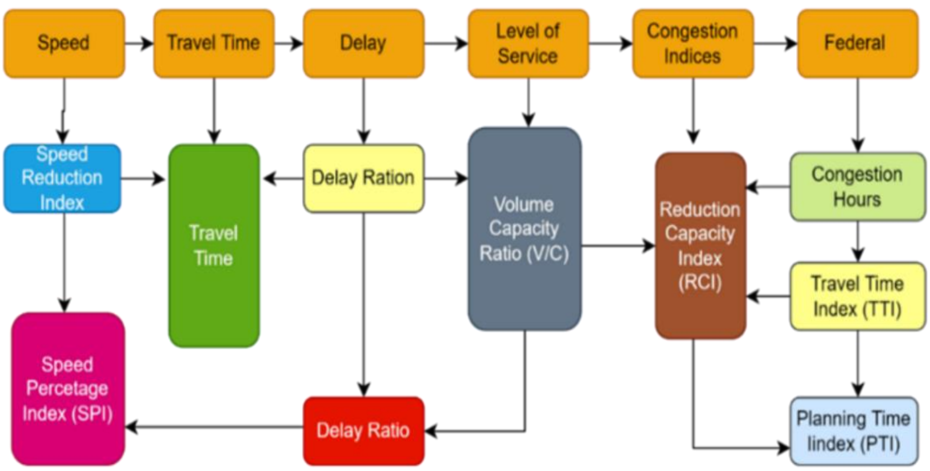

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Figure 2 Reliability Measures: (Afrin & Yodo, 2020).

Table 3. Different Author's Reviewed Variables for measuring Travel Time Reliability

S/No	Author's	Identified variables	Outcome
1	(S. Li et al., 2022)	Volume, density map	Time Spatial Net outperforms the tested representation of variables
2	(Tsuboi, 2021)	Traffic volume, vehicle speed	Traffic flow proved better
3	(E. O. A. Tufuor & Rilett, 2021)	The incident, work zone, and weather	Suitable for assessing TTR for a large corridor and network in a single run.
4	(Z. Chen & Fan, 2021)	Time of day, day of week, and weather	Travel time ahead 15 minutes contribute the most forecasted travel time
6	(Romanowska & Jamroz, 2021)	Average speed, flow, and density	The model used does not provide good results for the variables, and suggested for standard deviation
7	(Nnamani et al., 2020)	Traffic volume, speed of a vehicle, density, and traffic flow.	Highly significant
8	(Afrin & Yodo, 2020)	Speed, travel time, delay, and level of service	Applied a non-probabilistic technique. Future studies should employ probabilistic measures in assessing the variables
10	(Jabari et al., 2019)	Volume, density, and speed	Inadequate information about the number of vehicles in the system is expected
11	(Maghrour Zefreh & Török, 2020)	Flow, speed, and density.	Lognormal is mostly fitted with variables.
12	(Ibarra-Espinosa et al., 2019)	Filter (speed), assignment, Fill, traffic flow, & aggregation using mean & STD.	GPS Mean & standard deviation values are mostly fitted
13	(Kidando et al., 2019)	TTR, TV(AADT), truck volume, landuse, speed, road condition, lanes, road function, segment	Bayesian & multi-logistic proved same though, Bayesian performance better.
12	(P. Chen et al., 2018)	Time, and road types	Future studies should adopt larger-scale probe data in the time frame.
14	(Fulari et al., 2019)	Flow, and density	The method was highly fitted in evaluating error and can be used in computing density

Source: Author Review 2022.

2.4.3. Variable Use in Assessing Travel Time

a. **Speed:** Is the distance covered (traveled) per unit of time that is how fast a vehicle is moving. It is also the time rate at which a vehicle is moving along the road.
b. **Volume:** Is the comprises all modes of vehicles fly at a segment or lane during a specific time interval.
c. **Density:** Is the total number of vehicles count per lane per freeway (highway) length in miles or kilometres.
d. **Flow**: Is the movement of individual vehicle between two location and interchange with each other. That is the total number of vehicles passing a road at both entry and exit

e. Time: Is the measure of sequence of events. It is the dimension on event that take place

3.1. Methodology and Data Description

The traffic survey was conducted at Masaka, and Ado along Abuja road, which is a four-lane road. The traffic volume was daily traffic based on hourly traffic count data. The survey data was used to determine the percentage change traffic flow for the morning hours and that of the evening period. The percentage change was applied to the travel for a complete day to obtained an estimated flow and travel time or delay time at the traffic spots. The study recorded both entry and exit traffic. The study employed a smartphone to record traffic data every minute. The techniques are easy to transfer to an external storage device.

The video camera was used to collect traffic data at an interval of one hour. The recorded data was compared with manual counting for accuracy. The study employed passenger car unit (PCU) values to determine the various modes of transport, and the average traffic density for the time period (6:00 a.m. to 6:00 p.m.).

3.1.2 Research Framework

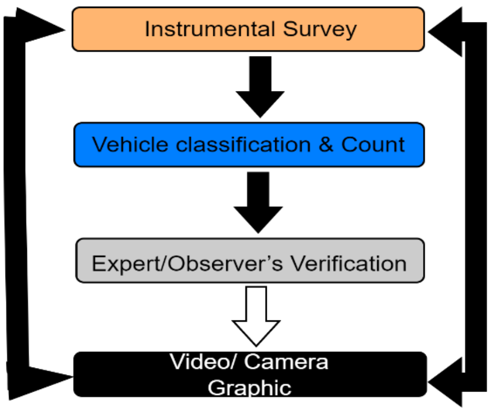

Figure 3. Process of Data Collections

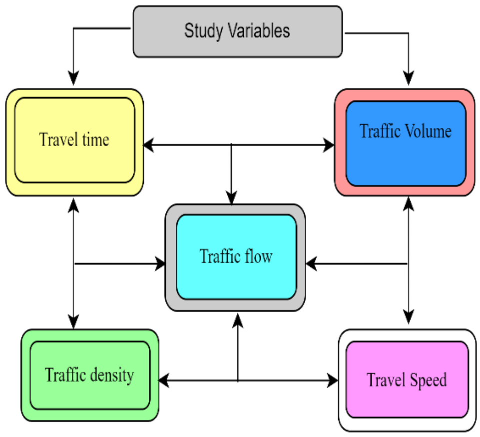

Figure 4. Study Variables

Table 4. Roads Designs and Capacity Volume.

S/No.	Type of carriageway	Design service for different categories of urban road		
		Arterial *	Sub-arterial **	Collector ***
1	2 lanes (1 way)	2400	1900	1400
2	2 lanes (2 way)	1500	1200	900
3	3 lane 91 way0	3600	2900	2200
4	4 lanes undivided (2 way)	3600	2400	1800
5	4 lanes divided (2 way)	3600	2400	-
6	6 lanes undivided 92 (way)	4800	3800	-
7	6 lanes divided (2 way)	5400	4300	-
8	8 lanes divided 2 (way)	7200	-	-

Adapted from (Indian Roads Congress, 1990)

- * Road with no frontage access, no standing vehicle cross traffic
- * ** Roads with frontage access but no standing vehicles and high-capacity intersection
- * *** Road with free frontage access, parked and heavy cross traffic

3.2. The Highway Capacity Manual (HCM6) Travel Time Reliability.

The HCM6 measure developed a strategy to model variables such as work zones, snow-rain weather, special events, incidents, demand differences, and hybrid systems. The target of the HCM6 principle is to provide a quality source of variability when calculating the travel time distribution (probability). The assessment covered a period of one year. This is considered the reliability report based on the HCM analysis of travel time distribution. The study selected a 1-hour interval aggregate for data analysis.

3.2.1. Congestion Index

CI = $\frac{TT}{TTN}$

CI = $f(x1\ x2\ x3\ ) + f\ (HA)$

CI = $\frac{C - C_0}{C_0}$

Where: C = Actual travel time, C_0 = Free flow time

CI near/close to zero meaning very low level of congestion.

CI > 2 meaning severely congested condition.

Travel Time Ratio

TTR = $\frac{CTR}{FFTR}$

Congestion time rate

CTR = $\frac{TT}{D}$

Delay Time rate

DTR = $\frac{DR}{CTR}$

Speed: V = $\frac{d}{t}$

Time: T = $\frac{d}{s}$

Distance: S = s * t

3.2.2. Standard Deviation and Variance

$$SD = \sqrt{\sum \frac{(x-\bar{x})^2}{n-1}}$$

$$SD = \sqrt{\sum \frac{(X_1-\mu)^2}{n-1}}$$

3.2.3. Variance.

$$V = \sum \frac{(X-\mu)^2}{N}$$

Determinant of PCU (Tullu & Quezon, 2021) adopted dynamic method PCU for non-lane-based traffic movement of vehicles and heterogeneity of vehicular movement.

PCU = ((Vc/Vi)/(Ac/Ai))

Where:
Vc = mean speed of a car and *Vi* = mean speed of vehicle type i.
Ac = projected area of a vehicle and *Ai* = projected area of car vehicle i.

Table 5. Estimated Number of Traffic Flow Per Passenger Car Unit (P.C.U)

Point 'A' Maraba-Abuja Express Road					Point 'B' Ado-Abuja Expressway			
Direction	Total Both Direction		P.C. U	Total	Total Both Direction		P.C. U	Total
Vehicles	NO	%	-	-	NO	%	-	-
Trucks	255	0.60	4.38	384	79	0.24	4.85	306
Cars	5470	12.87	2.80	2747	2408	7.36	3.00	3129
Bus	442	1.04	3.25	332	278	0.85	3.85	542
Tricycle	2116	4.98	0.80	904	141	0.43	0.75	155
Motorcycle	23451	55.18	0.65	5887	24543	75.01	0.95	15940
Bicycle	72	0.17	0.43	11	95	0.29	0.50	37
Handcarts	1288	3.03	0.62	485	376	1.15	0.75	365
Pedestrian	9405	22.13	0.46	472	4800	14.67	0.52	624
Total	42499	100	-	11222	32720	100	-	21098

Source: Author's, 2022

Table 6. Traffic flow along Maraba-Abuja Expressway (point 'A')

Time	6:00-700 am	7:00-8:00 am	8:00-9:00 am	9:00-10:00 am	10:00-11:00 am	11:00-12:00 pm	12:00-1:00 pm	1:00-2:00 pm	2:00-3:00 pm	3:00-4:00 pm	4:00-5:00 pm	5:00-6:00 pm	Total
T/Flow	854	1708	3841	2561	1707	1067	854	854	1494	2134	3201	1067	21338
%	4.0	8.0	18.0	12.0	8.0	5.0	4.0	4.0	7.0	10.0	15.0	5.0	100%

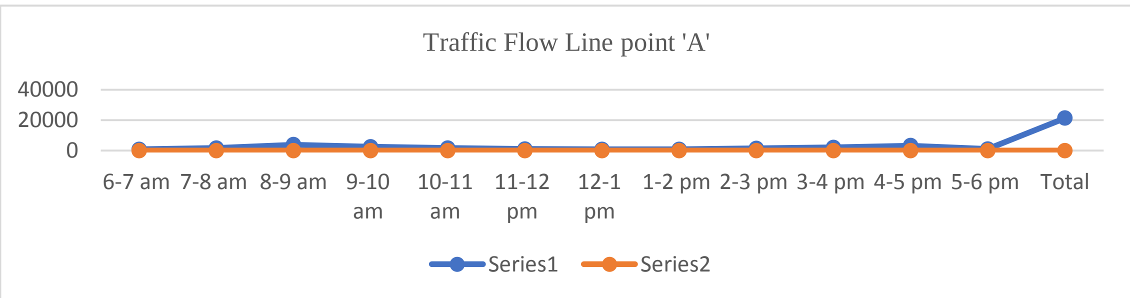

Figure 5. Traffic flow graph at point (A).

Table 7. Traffic flow along Ado-Abuja Expressway (point 'B')

Time	6:00-7:00 am	7:00-8:00 am	8:00-9:00 am	9:00-10:00 am	10:00-11:00 am	11:00-12:00 pm	12:00-1:00 pm	1:00-2:00 pm	2:00-3:00 pm	3:00-4:00 pm	4:00-5:00 pm	5:00-6:00 pm	Total
T/Flow	1402	1997	7777	4420	3442	2295	2507	2762	3570	7140	3655	1350	42499
%	3.3	4.7	18.3	10.4	8.1	5.4	5.9	6.5	8.4	16.8	8.6	3.6	100%

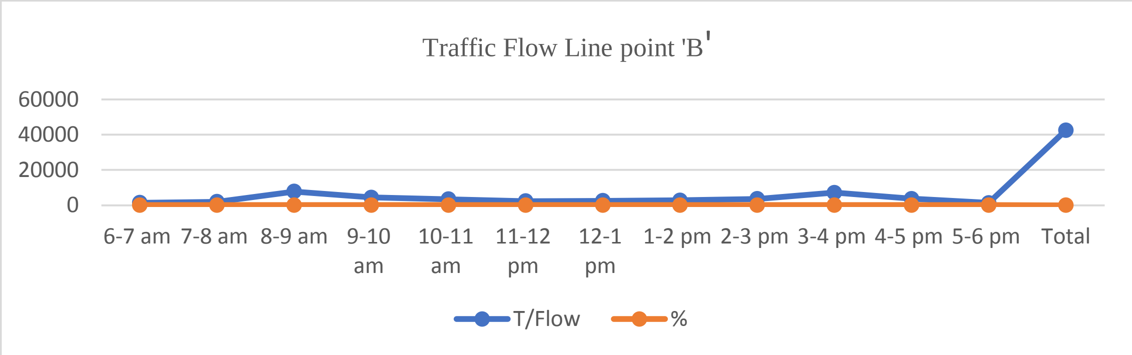

Figure 6.Traffic flow graph at station (B).

Hypothesis

H_o: There is statistical difference between traffic flow and travel time variability
H_1: There is no statistical difference between traffic flow and travel time variability

Table 8. Result for the test of sample

S/No	Traffic flow	Travel time (per hour)	Degree (s)	Variations
1	7083	1 hr, 30 minutes	3.15	0.66
2	5453	1hr, 45 minutes	2.82	0.60
5	Speed	12.85	9.57	3.31

Table 9. Travel time, speed, and travel distance Variability

S/No	Time (t)	Speed (v)	Distance (km)	Variations
1	1hr 15 minutes	15 km/hr	54 km	3.60
2	1hr 45 minutes	18 km/hr	54 km	3.00
Total	3:00 hrs	33 km/hr	108 km	6.60

Table 10. Correlation coefficient of traffic flow and travel time

S/No	Variables/	X^2	Degree of freedom	Variations
1	Time	3.83	3.15	0.66
2	Traffic volume	3.42	2.82	0.60
3	Traffic density	2.94	2.23	0.71

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4	Traffic flow	2.65	1.72	0.93
5	Speed	12.85	9.57	3.31

3.2.4. Correlation coefficient.

$$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{[n\sum x2 - (\sum x)2]\ [n\sum y2 - (\sum y)2}}$$

Morning traffic flow point (A): f = $\frac{21338}{12} = 1778$

Morning traffic flow pint (B): f = $\frac{42499}{6}\ 7083$

Evening traffic flow f = $\frac{32720}{6} = 5453$

Total flow = 42499 + 32720 = 75219

Average traffic flow = $\frac{75219}{12} = 6268$

Travel time

Speed: V = $\frac{54}{75}\ 0.75$

Time: T = $\frac{54}{105} = 0.51$

Distance: S = s * t = 12.85 * 8.83 + 49.2 km

Figure 7. Congestion along Abuja-Kubwa

Figure 8 Congestion along Lagos Road

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Figure 9. Congestion along Abuja-Nyanya

Figure 10. Congestion along Lagos Road

4.1. Discussion

Based on the findings of this study, it was discovered that when density was combined with other variables, longer travel times occurred on the Ado Highway between 8:00 a.m. and 9:00 a.m. in the morning and between 4:00 p.m. and 5:00 p.m. in the evening. The point, which is Maraba Highway, has a bite difference. During peak periods for the two locations, morning peaks occurred between 8:00 a.m. and 9:00 a.m., and evening peaks occurred between 3:00 p.m. and 5:00 p.m. These times denoted the point at which trip makers, or travellers who had recently left their origin (home), encountered serious travel time uncertainty.

In addition, apart from pedestrian movements, cars and motorcycles constitute the highest percentage of traffic (68.05%) at point A and 82.37% at point B. During the morning and evening peak periods, it takes between 25 and 40 minutes to get to point "A," while getting to point "B" takes between 15 and 25 minutes. The slow traffic point had an occasional traffic flow because of an oversized number of vehicles present at the time, whereas the fast-moving traffic point had the next highest traffic flow due to a better proportion of moving cars. The study revealed the following: the diversion of 15%–20% of the total traffic from the high-level congested roads to the results of the least or lesser congested roads into a higher level of service (lower congestion), an increase in speed by 15km/h to 20km/h from the current speed levels, and a decrease in travel time by 10%–15%, respectively. This study indicates that at point (A), the peak hourly period recorded between 8:00 – 9:00 am in the morning, and 4:00 pm – 5:00 pm during evening time. The second segment recoded 8:00 am at morning hours, and 3:00 pm – 4:00 pm at evening peak period.

5.0. Conclusions and Recommendations

Travel time variables are deemed to have high levels of consistency in order to assure drivers' smooth travel times; however, traffic flow, volume, speed, and density variation may lead to unanticipated delays. The variables of corridor highway travel time were identified in this study on Abacha Road, Karu, Nigeria, along the Abuja expressway. The study started by defining the problems associated with the variables of highway traffic reliability. The variables of travel time are also examined for different countries and their suitability.

Variables in corridor highway travel time pose global challenges to improving trip-maker reliability. In this proposal, travel time variables adopted in different countries were examined and compared to the study. In this research proposal, the current available corridor highway reliability variables include speed, travel time, traffic flow, traffic volume, traffic density, delay, level of services, weather, and traffic incidence. The study found that travel speed, traffic flow, density, volume, and travel time had a significant impact on corridor highway travel time reliability. The calculated variables were validated and compared to one another. The statistical mean was deemed significant at the 0.05% level (degree of freedom). Travel speed can also be computed using density and flow. The level of service was calculated by the minimum and maximum congestion. The results of all variables measured indicate no statistical relationships between the corresponding values.

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