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Impact of a Non-Dedicated U-Turn on Traffic

Muhammad Zeeshan Khan* and Zawar H. Khan

National Institute of Urban Infrastructure Planning, University of Engineering & Technology, Peshawar
*Corresponding author: Muhammad Zeeshan (Email:zeeshan1738islamian@gmail.com).

Abstract- **Non-dedicated U turn has a direct effect on road safety, capacity and congestion during the traffic flow. U turn can have significant supremacy on traffic flow and headway. Therefore to study the impact of non-dedicated u turns on traffic is the ultimate requirement of the current time. This is a microscopic traffic study in which the data from a U turn (33°59'48.2"N 71°27'30.2"E) on road leading to Hayatabad and Karkhano in Peshawar is evaluated in terms of headway, speed and flow rate of traffic. Factual data is presented which shows that the average time headway surges when the traffic is interfered by the U turning vehicles. The probability density functions and cumulative density functions fit to the datasets of headway are then evaluated by the techniques of anova analysis to determine which distribution is the most suitable one for the data. Distribution data specific with the interfering U turn was taken in a separate set and evaluated. The result obtained show that the Burr Distribution and Generalized Extreme Value Distribution are the optimum to illustrate the headway data of traffic being interfered by U turning vehicles. The utilization of various time headway distributions of vehicles being interfered by U turning for traffic modeling is legitimized.**

Index Terms-- **Non- Dedicated U turn, Time Headway, Headway Distributions, Probability Density Functions, Cumulative Density Functions.**

I. INTRODUCTION

On the road while driving the driver not only acts as a controller, but also the vital umpire of the quality of the path that is being followed. The chain followed by researchers in driving behavior is known as driver-vehicle-road system. Driver is the weakest part of the driver-vehicle-road system because of the variation of driving experiences, emotions, driving predilection and so on between drivers. And different scenarios shows distinguishable behaviors also called driving style. Drivers' characteristics are identified based on the operation behavior of the vehicle. While driving a vehicle, the driver has his/her own intention and selects a pattern of driving behavior that are most suitable for the current driving conditions U turns are used as open areas for two ways traffic flow on the road mostly set at the middle of the road section.

U turn behaviors of vehicles have monumental impact on the traffic performance. Normally straight vehicle should have priority over U turning vehicles because straight moving vehicles suffers more during the congestion caused by the queues of the U turning vehicle which in turn affect the smooth flow of traffic The absence of U turns or medians at the required points on road sections does not allow the drivers to turn and move along in the opposite direction. Thus the drivers generally find other ways to turn or make a u turn in the road section where it is normally not allowed. Such factors considerably elevate the risk of accidents with other vehicles (while making a U turn) forcing the rear vehicle to decelerate or change their direction. But the composition of a dedicated U turns is complicated as it compromises the width of the road as well as tendencies of the vehicle to move to the first lane which generally acts as a fast speed lane. The fast speed lane has the opportunity to take a U turn. This causes congestion of vehicles [7]. Peshawar is progressively transforming into a city of congested traffic and ill traffic management issues due to existence of high demand of traffic while the road infrastructure remains the same without necessary improvements. It was noted that in the period 1998-2000, the proportion increase in the number of vehicles was 124.6%, while the expansion and developments in the road network was 0.85 percent. in that 124.6 percent, majority belong to a group of private car holders, which constitute 75.35 percent of the total vehicles [1].

The factors that influence the road traffic are driver's behavior, size and shape of the road and the land use in case the bordering properties are occupied. When the bordering properties along the roads are occupied, then the infrastructure administrators have to face difficulties acquiring that land for necessary improvements in the road infrastructure. The characterization of driver's behavior, road geometry and land use into numerical verbalization or mathematical models is difficult because of their dependence on each other and their abnormality because the conditions are not ordinary every time [2]. Zhang et al. [13] presented a comprehensive study on performance of distribution models for headways. Precise data regarding headway was gathered on a highway in Seattle (USA). That data was used to examine the performance of different headway models. Vehicle headway distribution is fundamental for several significant traffic research and simulation issues. Numerous headway models are characterized over the previous decades. Every one of them has its own quality and shortcoming under certain conditions. In some cases, the observations fits well in distribution while in other cases the fitness value of observation crosses the range and does not fit well to the same distribution. Determination of the most reasonable model for a specific traffic condition stays an open issue. Vehicle headway is a measure of space between two vehicles, and is characterized as: the elapsed time between the appearance of the main vehicle and the accompanying vehicle at an assigned test point. It is normally estimated in seconds. Since the headway is the reciprocal of flow rate, vehicle headways represent microscopic measures of flows passing a point. In other words, headway characterizes the roadway capacity. Accurate and adequate characterization of vehicle headway distribution is required to amplify roadway capacity and reduces the travelling time.

Liu et al. [8] studied U turns showing that distance between two vehicles significantly impacts safety on street segments between driveways and downstream U-turn locations; a 10 percent increase in separation distance will result in a 3.3 percent decrease in total crashes and a 4.5 percent decrease in crashes which are related with right-turns followed by U-turns. Zhou et al.[14] examined vehicle operations for right turns followed by U-turn movements on urban and suburban multi-lane roadways. A model was developed that could serve as guide for U-turn median location by minimizing the mean delay for U-turn movements. This case study demonstrates operations and safety improvements of ideal U-turn median design. During traffic alignment at u turns, congestion occurs, which affects headway. Best fit distribution is required to assess the variation in headway in different lanes of a road when a u turning vehicle is noticed. Best fit distributions development is significant for predicting heterogeneous traffic.

This research is an attempt to explore driver behavior specifically moving straight and is not intending to take the u turn. More it can help in the amelioration of current systems for the U turn systems as it will provide an idea about working of the existing U turns and its impact on the straight moving vehicles. It is therefore, the main objectives for this study includes the impact of straight moving vehicles when interfered by a u turning vehicles and secondly, the interpretation of a driver when he/she notices a u turning vehicles in front of him/her.

II. MATERIAL AND METHODS

The study area selected was the U turn near Bab e Peshawar (phase 3 flyover of Hayatabad), Peshawar, (33°59’48.2”N, 71°27’30.2”E) Pakistan shown in figure 1. It is a three-lane road with the one lane that is mostly used as overtaking lane and in most cases considered by the vehicles taking the U turn. The speed limit on this highway is 40 kilometers per hour (km/h). The location of the data collection point on Google maps is shown in Fig. 1. This section of highway is free of emergency refuge areas, ramps, and bus stops as well as traffic lights, so there is no obstruction for U turning vehicles.

A. Data Collection

Video recording was used to collect the headway data. Cameras were installed on the top of the Bab-e-Peshawar Bridge. The two reference lines for vehicles ingress and egress were marked for the detection of vehicles. The two lines are 40 meters apart which can be easily distinguished in the video. These reference lines are indicated in Fig. 2.

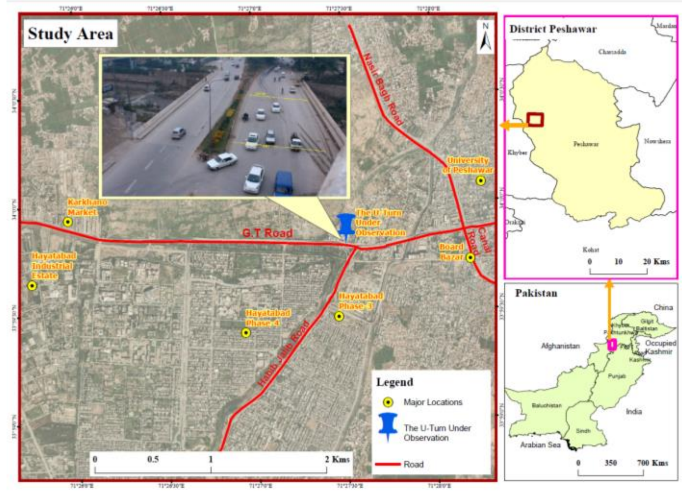

FIGURE 1: Location of the study area

FIGURE 2: Satellite Image of the U turn[11].

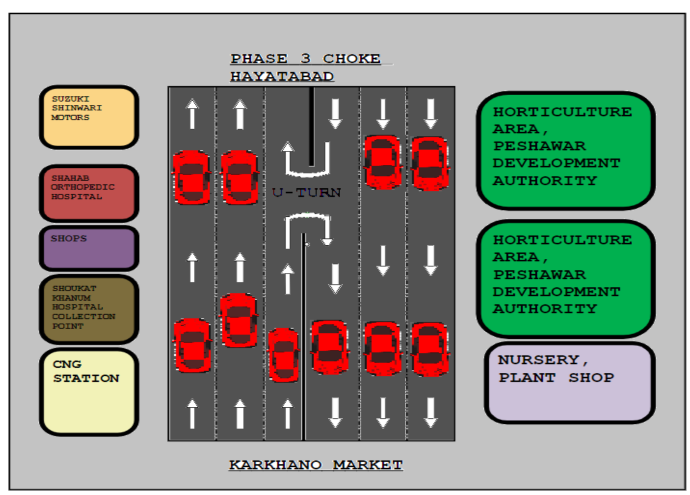

FIGURE 3: Schematic Diagram of the U turn

B. Data Analysis and Presentation

The video was recorded at a rate of 25 frames per second which is the required frame rate for a video that is to be processed by the software. Traffic data such as speed of vehicles and time headway was extracted with software (CAMLYTICS). Information such as the vehicle headway, and vehicle speed was obtained. The time headway was determined as the difference between the time when the first car passes the enter mark and then the second, third and so on. As vehicle speed is defined as the time taken by a vehicle to cover a known distance. In this case the 40 meters is the distance and the duration of time is the times travelled by a vehicle from enter mark to exit, so the distance 40 meters is divided by that elapse time which gives speed. v=s/t v is the speeds is the distance between the two marks which 40 meters and t is the time taken for car to travel between to marks. The headway data sets were than process through easy-fit software to find the best-fit distribution for the data and then the most probable and realistic outcome was determined in the basis of the suitable distribution. The straight moving vehicles reduce their speed when congestion becomes active

III. ANALYSIS, RESULTS AND DISCUSSION

A. Speed Analysis

Table I (a & b) shows different statistical parameters of speed for a week starting from Monday. The statistical parameters are Flowrate, Mean, Mode, Median, and Standard Deviation, variance, Minimum and Maximum values for the speed data.

TABLE I (a): Statistical Parameters of Speed

Days	Mon	Tue	Wed	Thu
Flowrate (vph)	1320	1050	1794	1608
Mean Speed (km/hr)	29.3	34.2	28.6	28.7
Mean Headway (s)	2.7	6.4	2	2.2
Median	2	4.4	1.5	1.7
Std Dev	2.2	6.7	1.9	2.1
Variance	5	44.9	3.6	4.3
Min	0	0.1	0	0
Max	11.6	46.5	12	15.1

B. Headway Analysis

Percentage of vehicles having headways less than 4 seconds is showed in Fig. 4. It is evident from the figure that the headway is less than 4 seconds is more that 75 percent on majority of the days (Monday, Wednesday, Thursday, Friday, Saturday, Sunday). The previous studies show that for better visibility and to avoid accidents and congestions it is considered that 4 seconds should be the safest headway magnitude in terms of mix traffic [10].

TABLE I (b): Statistical Parameters of Speed

Days	Fri	Sat	Sun
Flowrate (vph)	1836	1578	1266
Mean Speed (km/hr)	30	29.3	29.7
Mean Headway (s)	1.9	2.3	2.7
Median	1.5	1.7	1.9
Std Dev	2	2	2.6
Variance	3.9	4	6.8
Min	0	0	0
Max	15.2	11.7	12.8

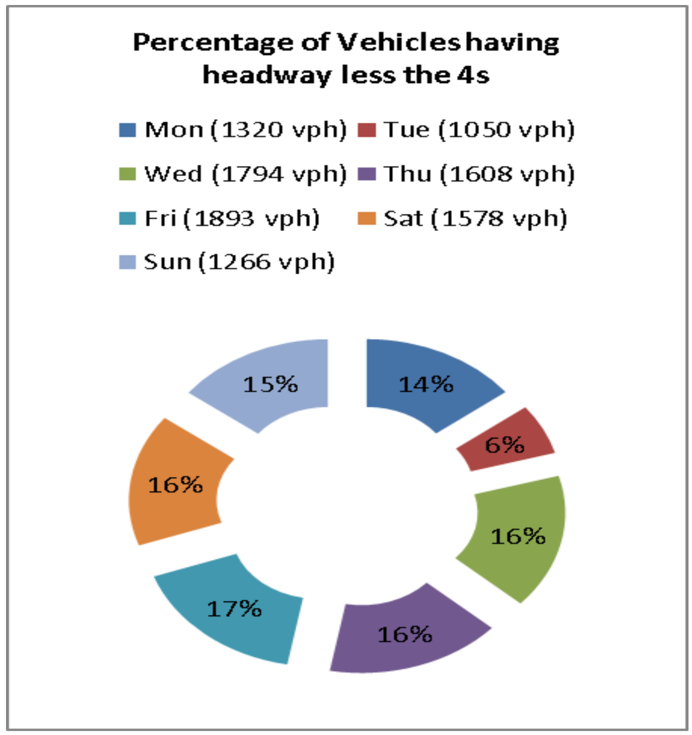

FIGURE 4: Percentage of vehicles having headways less than 4 seconds

C. Best Fit Distribution

Distribution fitting is the process of selecting a statistical distribution that best fits to a data set generated by some random process. In other words, if some random data available and the researcher would want to know the type of distribution that could be best in describing the data. Best fit distribution process is used in actuarial science, risk analysis and reliability engineering etc" [12-17]. To find the best headway distribution, the nine function described previously were used to model each headway dataset. The best fit distribution was done on easyfit software.

The CDF of Figure 5 shows 85 to 90 percent probability for vehicles having headway less than 4 s and 10 to 15 percent probability for headway greater than 4 s. the PDF and CDF indicates that Burr and Generalized Extreme Value Distribution fit the data.

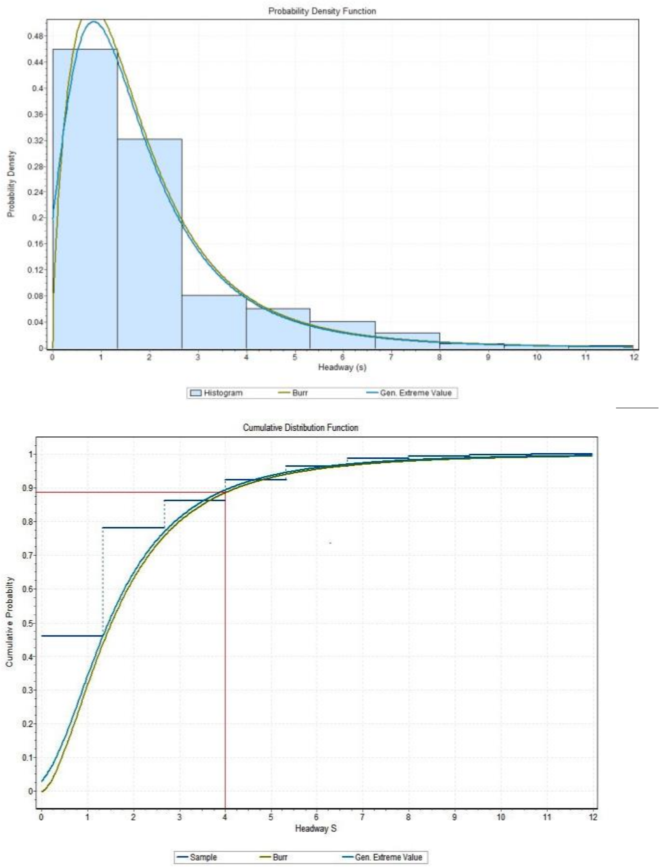

FIGURE 5: PDF and CDF of Monday (1794 vph)

The CDF of Fig. 6 shows 85 to 90 percent probability for vehicles having headway less than 4 s and 10 to 15 percent probability for headway greater than 4 s. The PDF and CDF indicate that Gamma, Weibull and Generalized Extreme Value Distribution fit the data.

The CDF of Fig. 7 shows 90 percent probability for vehicles of headway less than 4 s and 10 percent probability for vehicles having headways greater than 4 s. It is also observed that Generalized Extreme Value Distribution fits the data.

The CDF of Fig. 8 shows 80 to 90 percent probability for vehicles having headway less than 4 s and 10 to 20 percent probability for headways greater than 4 s. the PDF and CDF depicts that Burr and Generalized Extreme Value Distribution fit the data.

The CDF of Fig. 9 shows 80 percent probability for vehicles having headway less than 4 s and 20 percent probability for headways greater than 4 s. It is also observed from the PDF and CDF that Burr and Generalized Extreme Value Distribution fit the data. The CDF of Fig. 10 shows 30 percent probability for vehicles having headway less than 4 s and 70 percent probability for headways greater than 4 s. It is also observed that Burr and Generalized Extreme Value Distribution fit the data.

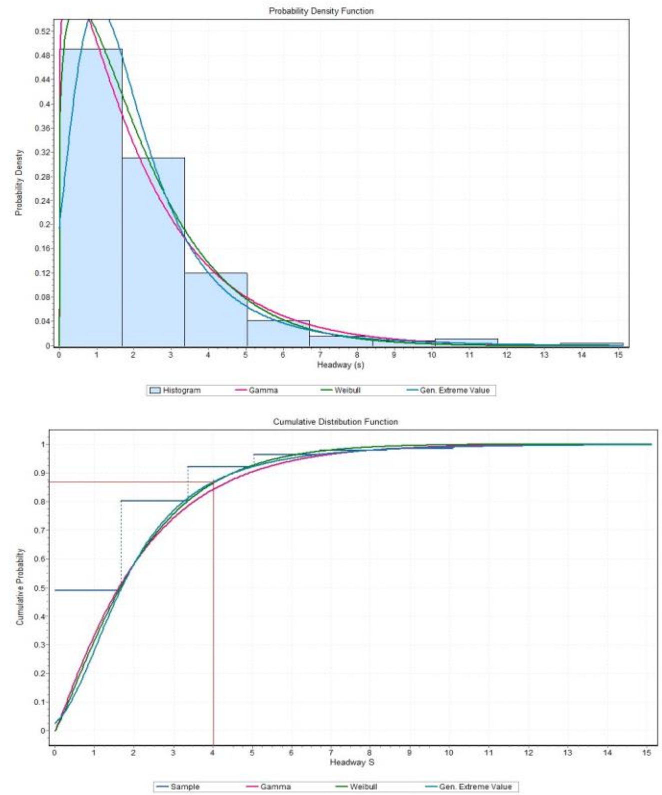

FIGURE 6: PDF of Tuesday (1608 vph)

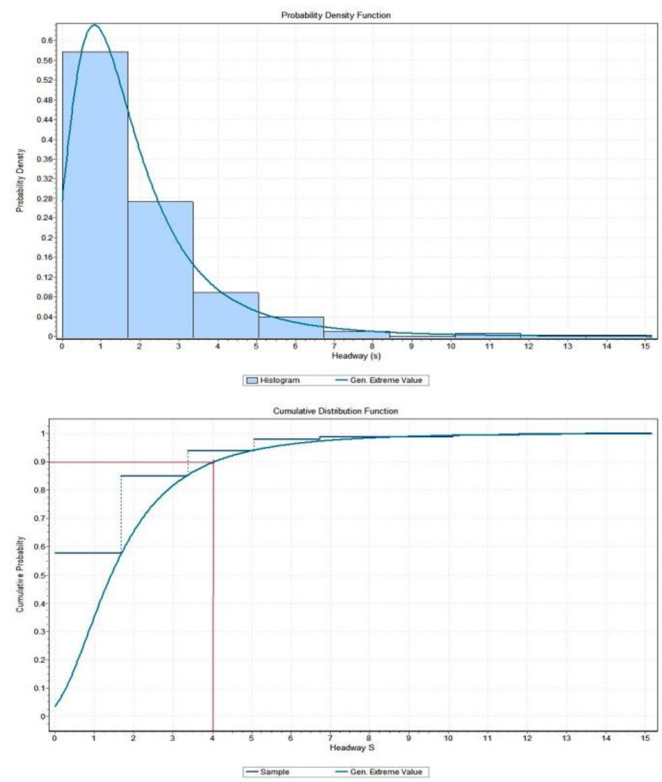

FIGURE 7: PDF and CDF of Wednesday (1836 vph)

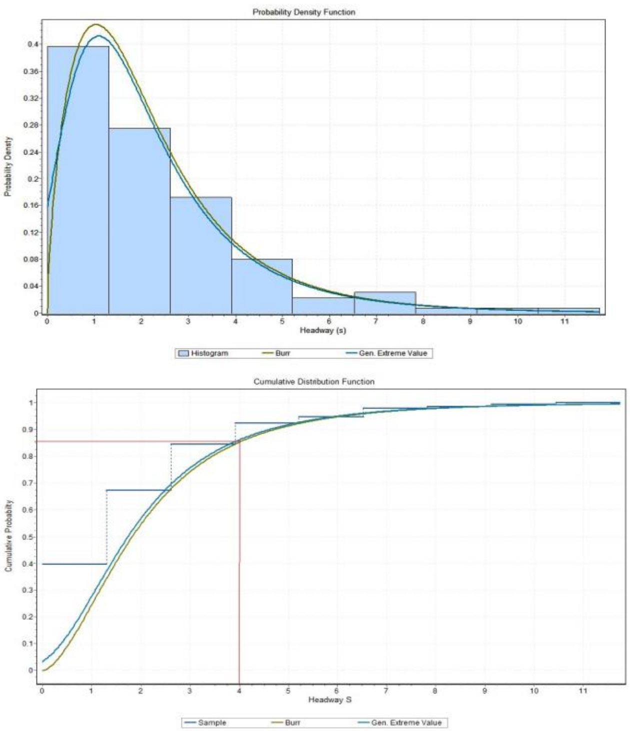

FIGURE 8: PDF and CDF of Thursday (1578 vph)

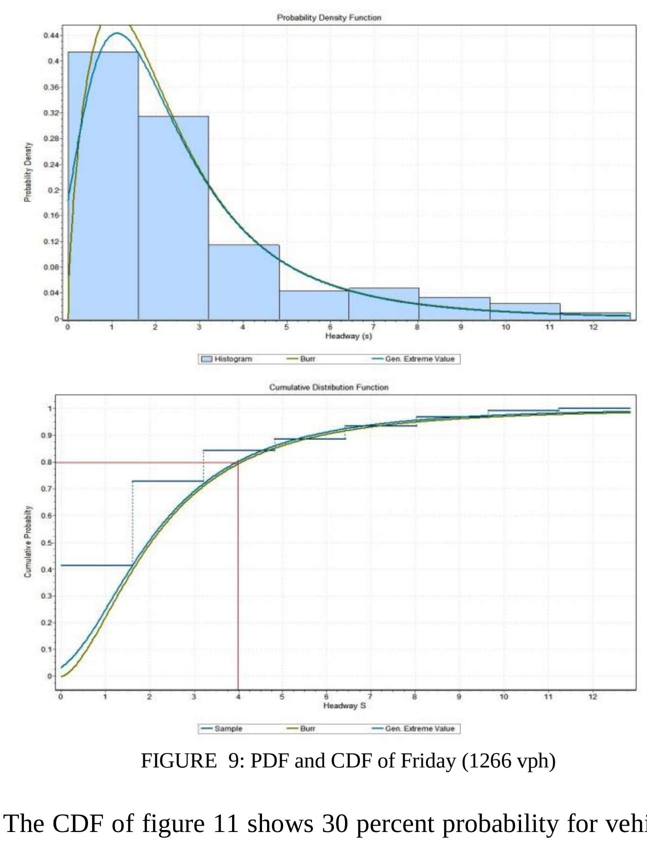

FIGURE 9: PDF and CDF of Friday (1266 vph)

The CDF of figure 11 shows 30 percent probability for vehicles having headway less than 4 s and 70 percent probability headways greater than 4 s. It is also observed that Burr and Generalized Extreme Value Distribution fit the data.

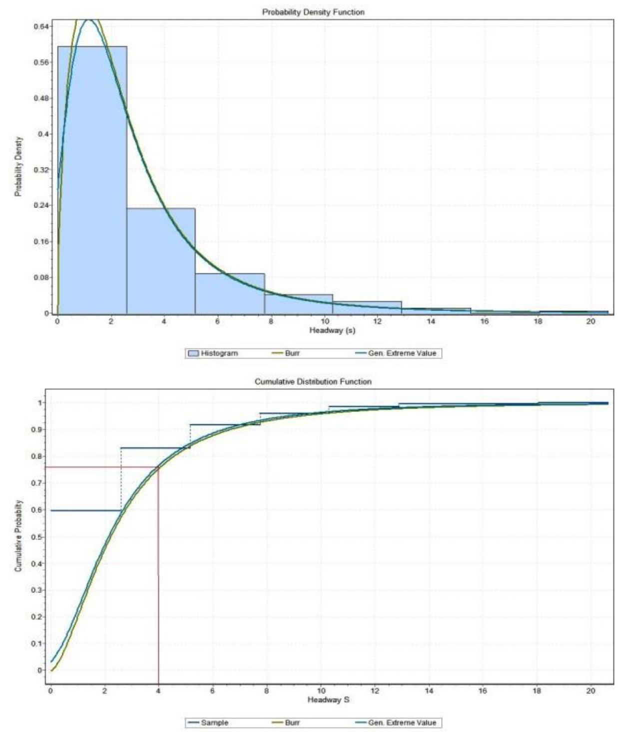

FIGURE 10: PDF and CDF of Saturday (1165 vph)

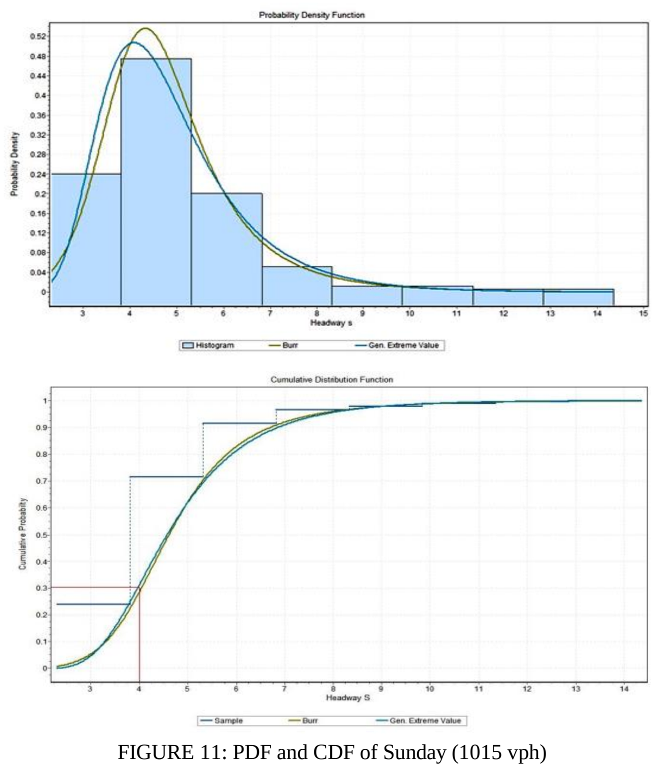

FIGURE 11: PDF and CDF of Sunday (1015 vph)

D. Goodness of Fit

To determine well a distribution fits to datasets of observations, the goodness of fit test is used. To evaluate how well the distributions fit the headway datasets, three goodness of fit tests are used [3]. Quantile-quantile (Q-Q) plot is determined that indicated the graphical closeness of the data to the specific distribution. At first the dataset is arranged in ascending order [9]. Then the data is plotted against $F^{-1}([i-0.5]/n)$, where F is the Cumulative Density Function. If the points of Q-Q plots are align with a 45 degree line, then it is confirmed that the data sets are taken from the distribution for which it is tested. Figures (12-25) show that Q-Q plots of the analyzed nine distributions for data sets. If in the Q-Q plot the data is aligned to the 45 degree line, so distribution is considered the best fit. Figure 12 and 13 shows Q-Q plots for distributions for the headway data of Monday. The data is aligned with the 45 degree line for Burr Distribution and Generalized Extreme Value Distributions are the best fit for the headway data sets of Monday.

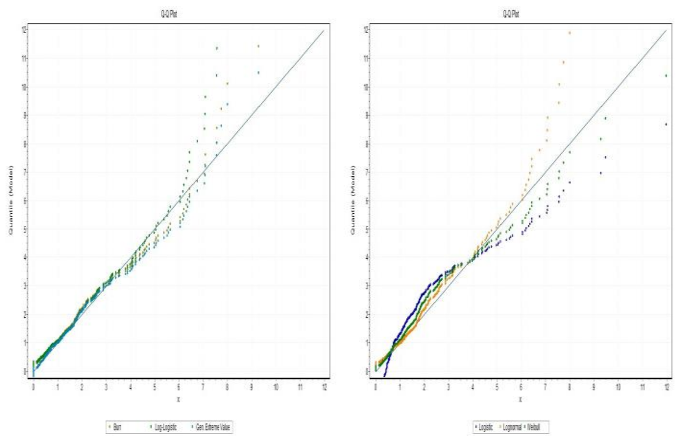

FIGURE 12: QQ plots for Monday (1794 vph) of Burr, Loglogistic, Generalized Extreme Value, Logistic, Lognormal And Weibull Distribution

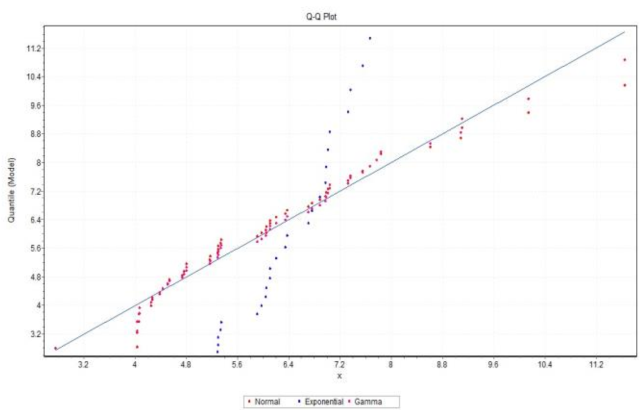

FIGURE 13: QQ plots for Monday (1794 vph) of Normal, Exponantial and Gamma Distribution

Figure 14 and 15 shows Q-Q plots for distributions for the headway data of Tuesday. The data is approximately aligned with the 45 degree line for Burr Distribution and Generalized Extreme Value Distributions are the best fit for the headway data sets of Tuesday. Figure 16 and 17 shows Q-Q plots for distributions for the headway data of Wednesday. The data is aligned with the 45 degree line for Burr Distribution and Generalized Extreme Value Distributions are the best fit for the headway data sets of Wednesday.

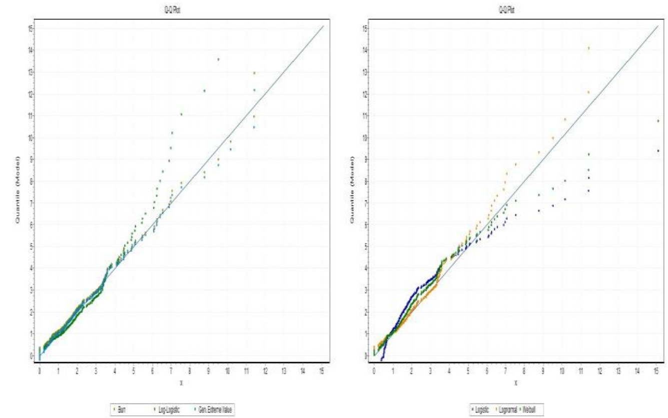

FIGURE 14: QQ plots for Tuesday (1608 vph) of Burr, Loglogistic, Generalized Extreme Value, Logistic, Lognormal And Weibull Distribution

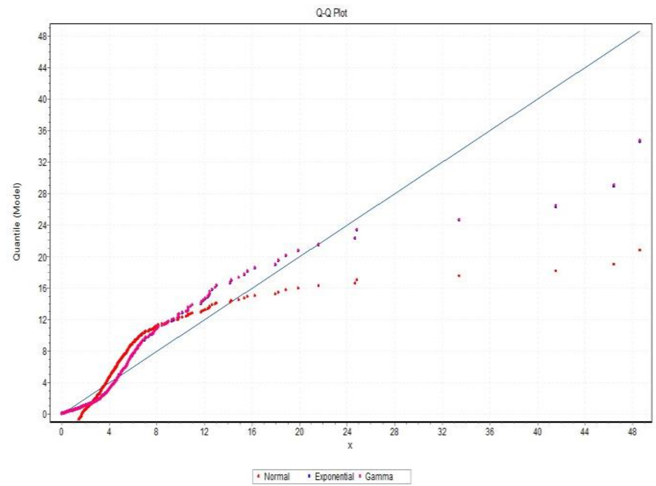

FIGURE 15: QQ plots for Tuesday (1608 vph) of Normal, Exponantial and Gamma Distribution

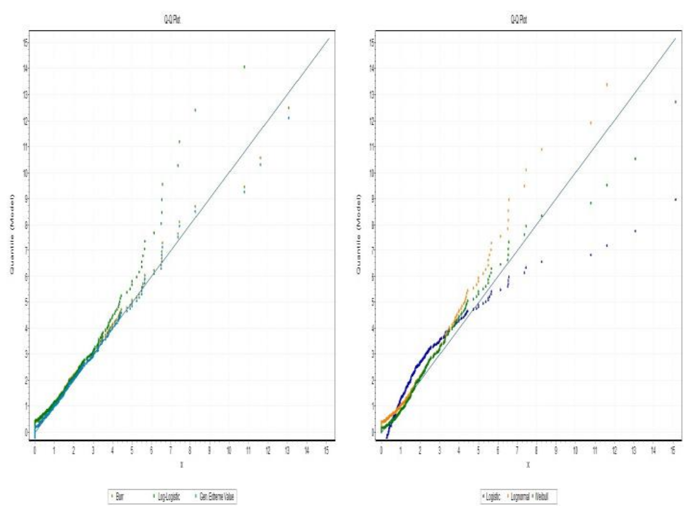

FIGURE 16: QQ plots for Wednesday (1836 vph) of Burr, Loglogistic, Generalized Extreme Value, Logistic, Lognormal And Weibull Distribution

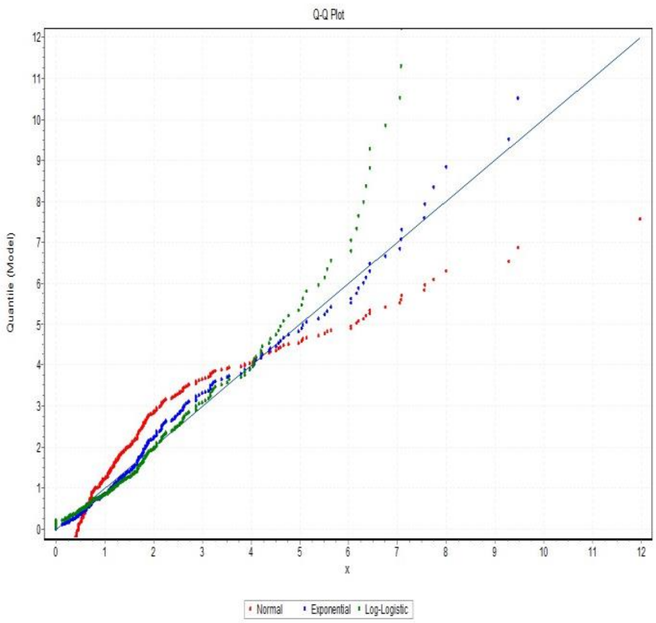

FIGURE 17: QQ plots for Wednesday (1836 vph) of Normal, Exponantial and Gamma Distribution

Figure 18 and 19 shows Q-Q plots for distributions for the headway data of Thursday. The data is aligned with the 45 degree line for Burr Distribution and Generalized Extreme Value Distributions are the best fit for the headway data sets of Thursday.

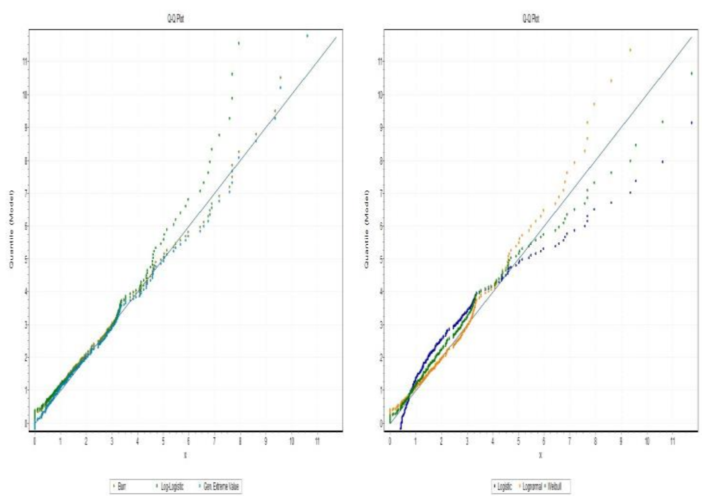

FIGURE 18: QQ plots for Thursday (1578 vph) of Burr, Loglogistic, Generalized Extreme Value, Logistic, Lognormal And Weibull Distribution

Figure 20 and 21 shows Q-Q plots for distributions for the headway data of Friday. The data is aligned with the 45 degree line for Burr Distribution and Generalized Extreme Value Distributions are the best fit for the headway data sets of Friday. Figure 22 and 23 shows Q-Q plots for distributions for the headway data of Saturday. The data is aligned with the 45 degree line for Burr Distribution, so Burr Distribution the best fit for the headway data sets of Saturday.

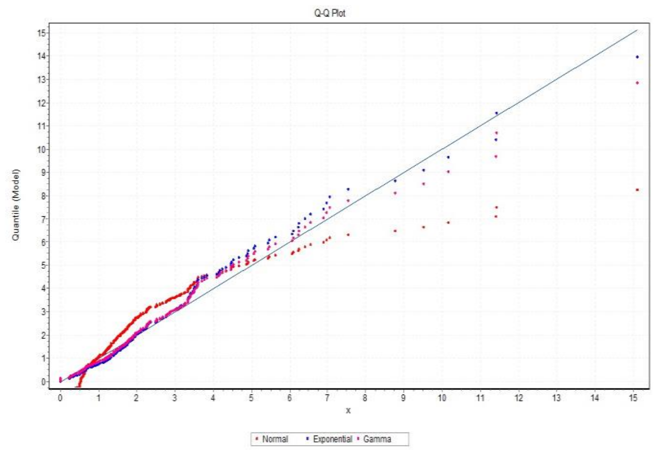

Figure 19: QQ plots for Thursday (1578 vph) of Normal, Exponantial and Gamma Distribution

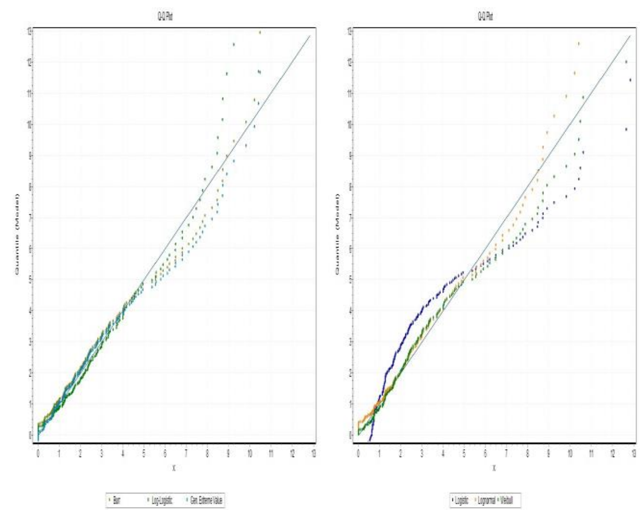

Figure 20: QQ plots for Friday (1266 vph) of Burr, Loglogistic, Generalized Extreme Value, Logistic, Lognormal And Weibull Distribution

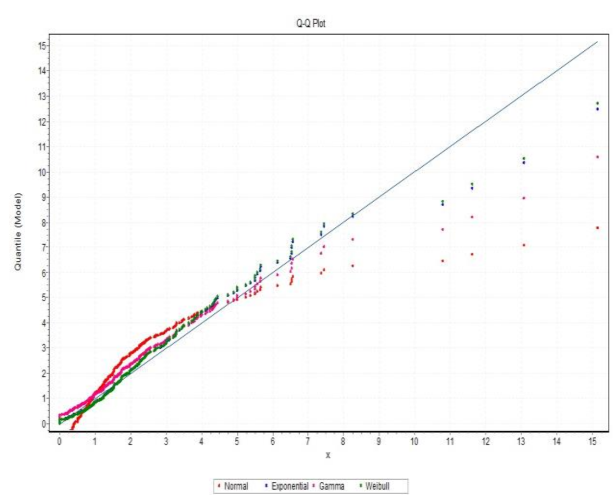

Figure 21: QQ plots for Friday (1266 vph) of Normal, Exponantial and Gamma Distribution

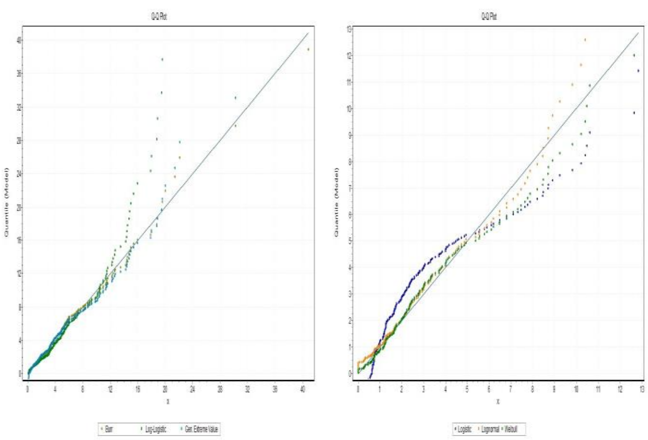

Figure 22: QQ plots for Saturday (1165 vph) of Burr, Loglogistic, Generalized Extreme Value, Logistic, Lognormal And Weibull Distribution

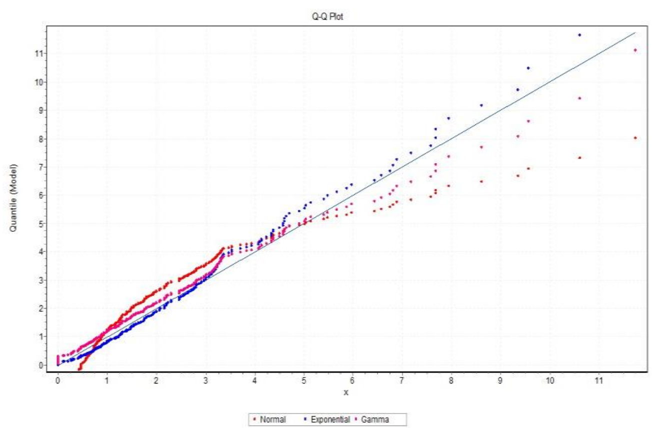

Figure 23: QQ plots for Saturday (1165 vph) of Normal, Exponantial and Gamma Distribution

Figure 24 and 25 shows Q-Q plots for distributions for the headway data of Sunday. The data is aligned with the 45 degree line for Burr Distribution and Generalized Extreme Value Distributions are the best fit for the headway data sets of Sunday.

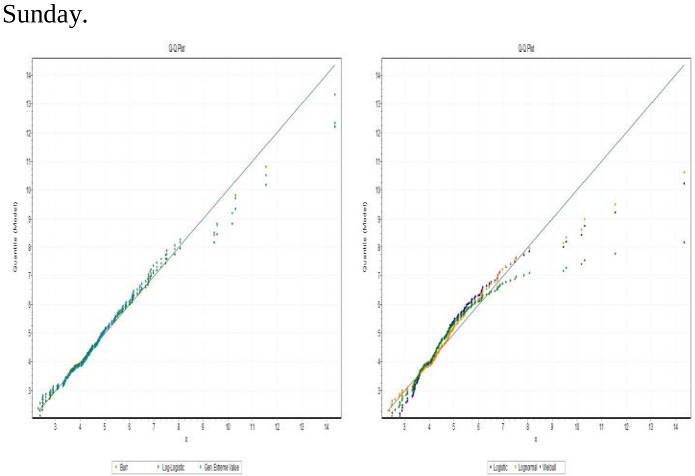

Figure 24: QQ plots for Sunday (1015 vph) of Burr, Loglogistic, Generalized Extreme Value, Logistic, Lognormal And Weibull Distribution

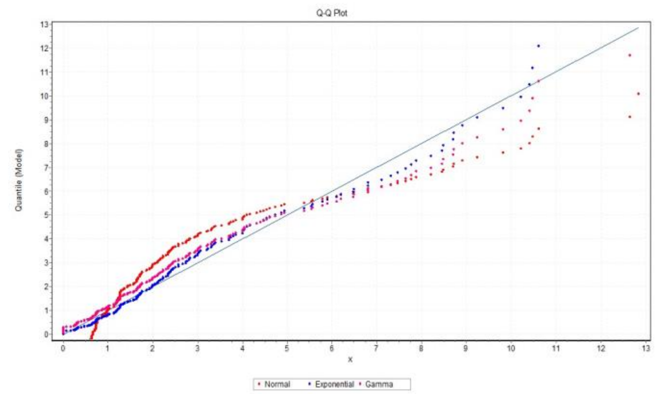

Figure 25: QQ plots for Sunday (1015 vph) of Normal, Exponantial and Gamma Distribution

Comparison of Q-Q plots for the data set shows that Burr Distribution and Generalized Extreme Value Distribution better fit the data set compared to other data sets. The non-linear shape of the Q-Q plots of all datasets for Log-logistic Distribution, Lognormal Distribution, Logistic Distribution, Weibull Distribution, Exponential Distribution, Gamma Distribution and Normal Distribution suggests that are not suitable for modeling the headway data. For numerical results to be supported by the visual evaluation, two statistical goodness of fit test are used. The Chi-Squared (C-S) (see Tab. II) and Kolmogorov-Smirnov (K-S) (see Tab. III) tests are used to examine the goodness fit of a distribution [4].

E. The Kolmogorov-Smirnov (K-S) Test

The K-S test compares the empirical cumulative density function with the cumulative density function. For a data suppose x1,x2,x3,…….xn, the empirical cumulative density function is

$$S_n(x) = k/n \quad (1)$$

Where k is the number of observation less than or equal to x. The K-S formula is [9]:

$$d = \max_x |F(x) - S_n(x)| \quad (2)$$

where d is the absolute difference between cumulative density function and empirical cumulative density function for the entire data set. A significance level of 5 percent is set to test the hypothesis below H0: the data is from the distribution, H1: the data is not from the distribution For testing of the hypothesis, the p value of the K-S statistic is compared with significance level. The expression for the p value is .

$$p = d\sum_{j=1}^{|n(1-d|} \binom{n}{j}(1 - d - \tfrac{j}{n})^{n-j}(d + \tfrac{j}{n})^{j-1} \quad (3)$$

If the value of p is greater than 5 percent, than the distribution is considered to be accepted by the goodness of test, and if the p value is less than 5 percent than the distribution is rejected [6].

F. The Chi-Squared (C-S) Test

The Chi-Squared (C-S) test is also a statistical test that checks that goodness fit for distributions and is given in Tab. II. The C-S test determines that whether or not the dataset comes from a probability distribution. The data is preprocessed to reduce the effects of minor observations error the original data is replaced by it representative in interval (bin), therefore the data is divided in to N bins. The results from the goodness of fit tests are dependent on the bin size. The value from the data that falls into each bin is compared to the values that are expected for that bin. Any distribution that has a cumulative density function can be checked with the C-S test. The Chi-Squared (C-S) test determines whether there is significance difference between the expected values and observed values. The expression for the Chi-Squared (C-S) test is [6]:

$$X^2 = \sum_{i=1}^{N} \frac{(O_i - E_i)^2}{E_i} \quad (4)$$

Where N is the number of bins Oi is the frequency observed for the ith bin and Ei is the expected frequency. A statistical software called easyfit recommends $N = \sqrt[5]{2n}$ to be optimum [5, 18]. The Expression for Ei is

$$E_i = n \times P_i \quad (5)$$

With $P_i = P[x_i < x < x_{i+1}] = F(x_{i+1}) - F(x_i)$, where Pi is the value for probability that falls in the ith bin, F is the cumulative density function of the distribution, and the boundaries of ith bin are $x_{i+1}$and x_i. The hypotheses for the test are H0: There is no difference accountable between expected and observed data, H1: There is difference between the expected and observed data 5 percent significance level was set for the hypothesis testing of a distribution by the comparison of the test statistic to a critical value with N-k-1 degrees of freedom where k is the number of parameters the P value for the C-S statistic (X^2) is [6]:

$$p = 1 - F_{X^2}(X_0^2; N - k - 1) \quad (6)$$

where $F_{X^2}(.N - k - 1)$ is the cumulative density function of X^2 distribution with $N - k - 1$ degrees of freedom and X_0^2 is the C-S statistics. Greater p value represents high compatible distribution for a dataset.

TABLE II: Goodness Fit Test Results: Headway Data (Chi-Squared (C-S) Test

Probability Distribution	Data Set	Chi-Squared Test	P
Burr	Mon (45 v/km)	Accepted	0.06773
	Tue (31 v/km)	Accepted	0.54435
	Wed (63 v/km)	Rejected	0.00675
	Thu (56 v/km)	Accepted	0.05505
	Fri (61 v/km)	Accepted	0.05611
	Sat (54 v/km)	Accepted	0.38877
	Sun (43 v/km)	Accepted	0.82647
Generalized Extreme Value	Mon (45 v/km)	Accepted	0.58663
	Tue (31 v/km)	Accepted	0.98185
	Wed (63 v/km)	Rejected	0.03808
	Thu (56 v/km)	Accepted	0.55238
	Fri (61 v/km)	Accepted	0.87556
	Sat (54 v/km)	Accepted	0.82193
	Sun (43 v/km)	Accepted	0.89582
Log-Logistic	Mon (45 v/km)	Accepted	0.11654
	Tue (31 v/km)	Accepted	0.41606
	Wed (63 v/km)	Rejected	0.02898
	Thu (56 v/km)	Rejected	0.00812
	Fri (61 v/km)	Rejected	1.21E-04
	Sat (54 v/km)	Accepted	0.34111
	Sun (43 v/km)	Accepted	0.46548
	Tue0 (40 v/km)	Accepted	0.67652
Lognormal	Mon (45 v/km)	Rejected	0.03081
	Tue (31 v/km)	Accepted	0.49344
	Wed (63 v/km)	Accepted	0.1169
	Thu (56 v/km)	Rejected	0.00537
	Fri (61 v/km)	Rejected	0.01096
	Sat (54 v/km)	Accepted	0.16619
	Sun (43 v/km)	Accepted	0.84843
Logistic	Mon (45 v/km)	Rejected	2.41E-04
	Tue (31 v/km)	Rejected	3.73E-09
	Wed (63 v/km)	Rejected	1.07E-08
	Thu (56 v/km)	Rejected	3.04E-06
	Fri (61 v/km)	Rejected	1.04E-08
	Sat (54 v/km)	Rejected	3.97E-04
	Sun (43 v/km)	Rejected	5.18E-09
Weibull	Mon (45 v/km)	Accepted	0.22284
	Tue (31 v/km)	Accepted	0.05805
	Wed (63 v/km)	Rejected	0.00683
	Thu (56 v/km)	Accepted	0.45111
	Fri (61 v/km)	Accepted	0.08764
	Sat (54 v/km)	Accepted	0.5027
	Sun (43 v/km)	Accepted	0.16021
Exponential	Mon (45 v/km)	Accepted	0.06943
	Tue (31 v/km)	Rejected	2.48E-06
	Wed (63 v/km)	Rejected	5.96E-04

	Thu (56 v/km)	Rejected	0.01107
	Fri (61 v/km)	Accepted	0.05907
	Sat (54 v/km)	Rejected	0.00133
	Sun (43 v/km)	Accepted	0.23119
Gamma	Mon (45 v/km)	Accepted	0.28677
	Tue (31 v/km)	Rejected	6.11E-04
	Wed (63 v/km)	Rejected	0.02095
	Thu (56 v/km)	Accepted	0.10934
	Fri (61 v/km)	Rejected	0.01467
	Sat (54 v/km)	Accepted	0.29473
	Sun (43 v/km)	Accepted	0.24364
Normal	Mon (45 v/km)	Rejected	1.11E-05
	Tue (31 v/km)	Accepted	0.49344
	Wed (63 v/km)	Rejected	4.36E-11
	Thu (56 v/km)	Rejected	1.10E-06
	Fri (61 v/km)	Rejected	1.24E-10
	Sat (54 v/km)	Rejected	3.06E-07
	Sun (43 v/km)	Rejected	2.53E-09

TABLE III: Goodness of Fit Test Results For Headway Data (The Kolmogorov-Smirnov (K-S) Test

Probability Distribution	Data Set	Kolmogorov-Smirnov Test	P
Burr	Mon (45 v/km)	Accepted	0.10176
	Tue (31 v/km)	Accepted	0.72907
	Wed (63 v/km)	Accepted	0.12832
	Thu (56 v/km)	Rejected	0.0471
	Fri (61 v/km)	Rejected	0.03505
	Sat (54 v/km)	Accepted	0.20305
	Sun (43 v/km)	Accepted	0.44223
Generalized Extreme Value	Mon (45 v/km)	Accepted	0.79181
	Tue (31 v/km)	Accepted	0.91071
	Wed (63 v/km)	Accepted	0.81808
	Thu (56 v/km)	Accepted	0.69126
	Fri (61 v/km)	Accepted	0.77533
	Sat (54 v/km)	Accepted	0.89393
	Sun (43 v/km)	Accepted	0.89498
Log-Logistic	Mon (45 v/km)	Rejected	0.02658
	Tue (31 v/km)	Accepted	0.41435
	Wed (63 v/km)	Rejected	0.02393
	Thu (56 v/km)	Rejected	0.01512
	Fri (61 v/km)	Rejected	0.00289
	Sat (54 v/km)	Accepted	0.0927
	Sun (43 v/km)	Accepted	0.15505
	Tue0 (40 v/km)	Accepted	0.27383
Lognormal	Mon (45 v/km)	Rejected	0.03309
	Tue (31 v/km)	Accepted	0.34134
	Wed (63 v/km)	Accepted	0.28077
	Thu (56 v/km)	Accepted	0.06098
	Fri (61 v/km)	Rejected	0.01809
	Sat (54 v/km)	Accepted	0.17747
	Sun (43 v/km)	Accepted	0.29789
Logistic	Mon (45 v/km)	Rejected	2.78E-04
	Tue (31 v/km)	Rejected	1.85E-04
	Wed (63 v/km)	Rejected	6.61E-09
	Thu (56 v/km)	Rejected	5.17E-06
	Fri (61 v/km)	Rejected	2.27E-07
	Sat (54 v/km)	Rejected	1.98E-04
	Sun (43 v/km)	Rejected	1.07E-06
Weibull	Mon (45 v/km)	Accepted	0.10268
	Tue (31 v/km)	Accepted	0.2974
	Wed (63 v/km)	Accepted	0.25343
	Thu (56 v/km)	Accepted	0.37816
	Fri (61 v/km)	Rejected	0.00881
	Sat (54 v/km)	Accepted	0.19445
	Sun (43 v/km)	Rejected	0.03574
Exponential	Mon (45 v/km)	Rejected	0.0168
	Tue (31 v/km)	Rejected	3.69E-05
	Wed (63 v/km)	Accepted	0.08789
	Thu (56 v/km)	Rejected	0.01144
	Fri (61 v/km)	Accepted	0.05777
	Sat (54 v/km)	Rejected	0.04769
	Sun (43 v/km)	Accepted	0.13761
Gamma	Mon (45 v/km)	Accepted	0.24434
	Tue (31 v/km)	Rejected	0.00418
	Wed (63 v/km)	Accepted	0.26901
	Thu (56 v/km)	Accepted	0.11887

	Fri (61 v/km)	Rejected	0.01076
	Sat (54 v/km)	Accepted	0.18075
	Sun (43 v/km)	Accepted	0.42357
Normal	Mon (45 v/km)	Rejected	8.13E-04
	Tue (31 v/km)	Accepted	0.34134
	Wed (63 v/km)	Rejected	7.03E-09
	Thu (56 v/km)	Rejected	3.65E-06
	Fri (61 v/km)	Rejected	1.55E-07
	Sat (54 v/km)	Rejected	2.64E-04
	Sun (43 v/km)	Rejected	1.77E-06

If the p value (probability) is less than 0.05, that means that the distribution is rejected by the goodness of fit test, and if the p value is greater than 0.05 means that the goodness of fit test has accepted that distribution. From the results of Chi-Squared (C-S) and Kolmogorov-Smirnov (K-S) test, it was evident that the Burr Distribution and Generalized Extreme Value Distribution were accepted for all the datasets. Thus, it provides best fit for headway of vehicles having some impact or interference by U turning vehicles. Thus Burr Distribution and Generalized Extreme Value Distribution passed both goodness of fit tests at 5% significance level for the five datasets Further, Kolmogorov-Smirnov (K-S) and Chi-Squared (C-S) tests results reinforce the Q-Q plot results which indicated that Burr and Generalized Extreme Value distributions are best for headway data.

G. Best Fit Distribution of straight vehicles interfered by U turning vehicles

Datasets of headway of straight moving vehicles being interfered by U turning vehicles were examined. Test was done lane wise for best fit distributions. The distribution curves and histogram of the headway of each dataset are presented in figures. Figure shows that the all headway dataset has the percentage of very small headway values (less than 0.5s) and this is because of congestion. The headway percentages of lane reduce with the passage of time as the congestion increases. The headway values of lane 2 are comparatively less than that of lane 1. The headway values in lane 3 is lesser than both lane 1 and 2 and there is considerable up and down in the histograms, which means that there is congestion and the up and downs are due to interference of other vehicles as the vehicles from lane 1 and lane 2 tries to move to lane 3. Figure (38 to 42) shows PDFs and CDFs of Lane 1, Lane 2 and Lane 3 respectively.

H. Goodness of Fit

Figures 29 to 43 shows that Q-Q plots of the analyzed nine distributions for lane wise headway data sets. On comparison of the plots it was concluded that headway data set for Burr Distribution, Lognormal Distribution and Generalized Extreme Value Distribution of all the nine distributions for exact u turning phenomenon are approximately closest to the 45 degree line, so it was decided that burr distribution, log normal distribution, Generalized Extreme Value distribution to be considered the best fit than the other seven distributions for the datasets.

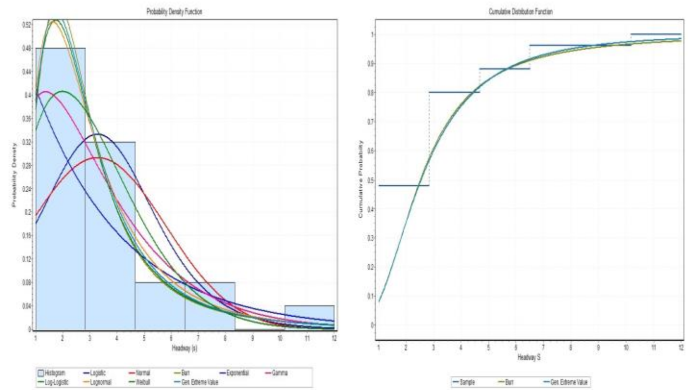

FIGURE 26: PDF and CDF of LANE 1

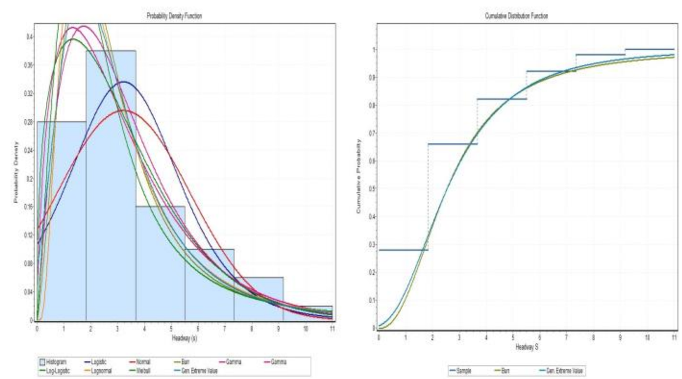

FIGURE 27: PDF and CDF of LANE 2

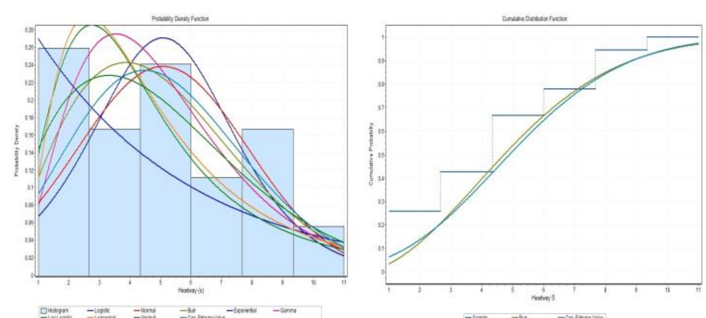

FIGURE 28: PDF and CDF of LANE 3

Comparison of Q-Q plots for the data set shows that most of the distribution better fit the data set compared to other data sets. The non-linear shape of the Q-Q plots of all datasets for log-logistic distribution, Exponential Distribution, Logistic Distribution, Weibull Distribution, Gamma Distribution and Normal Distribution suggests that are not suitable for modeling the headway data (see Tab. IV).

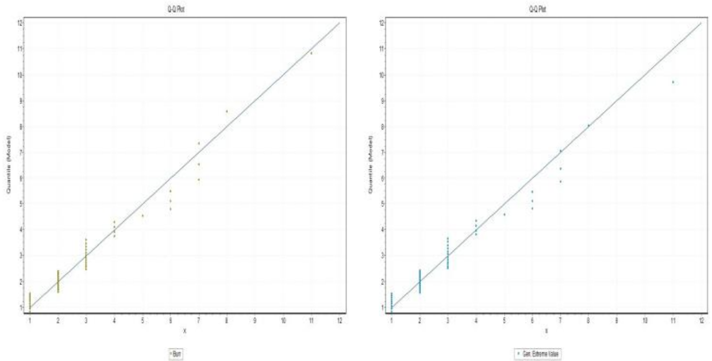

FIGURE 29: QQ plot for Lane 1 of Burr and Generalized Extreme Value Distribution

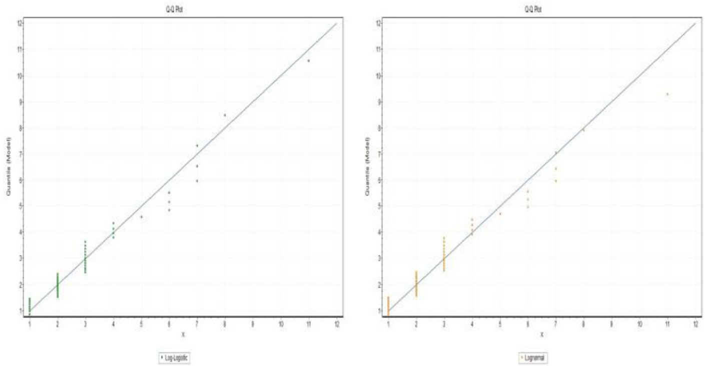

FIGURE 30: QQ plot for Lane 1 of Loglogistic and Lognormal Distribution

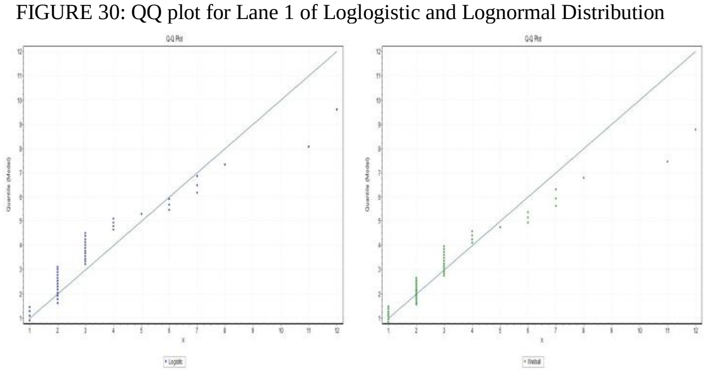

FIGURE 31: QQ plot for Lane 1 of Logistic and Weibull Distribution

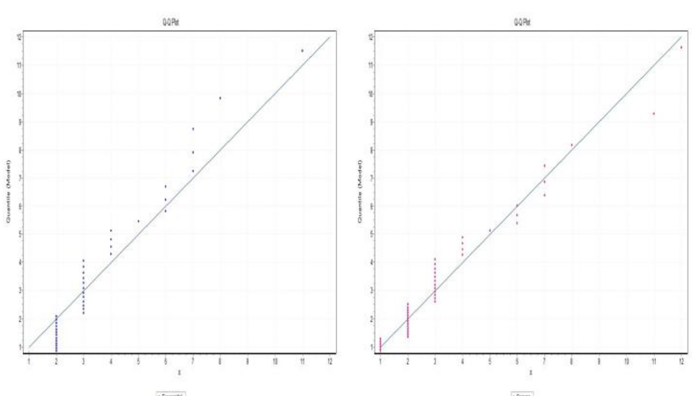

FIGURE 32: QQ plot for Lane 1 of Exponential and Gamma Distribution

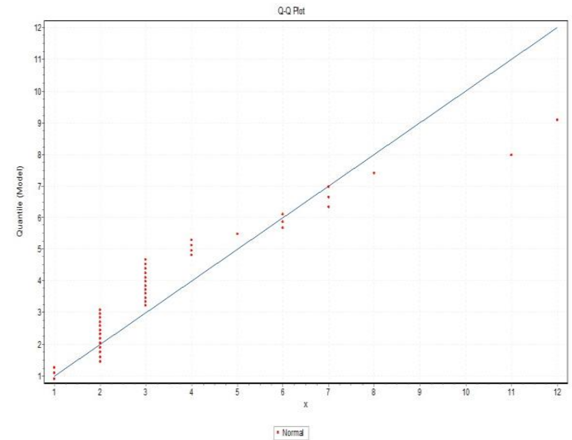

FIGURE 33: QQ plot for Lane 1 of Normal Distribution

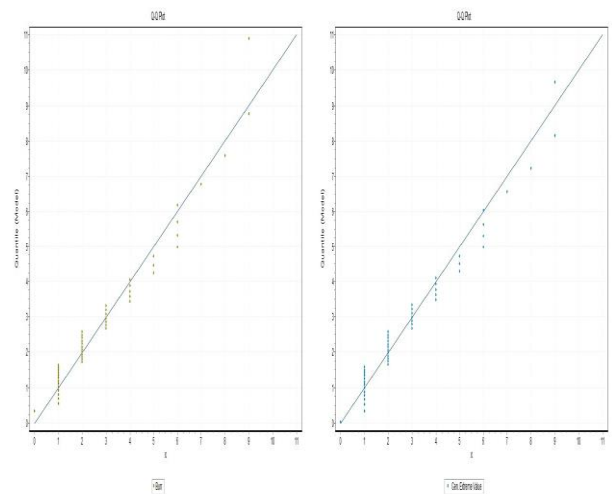

FIGURE 34: QQ plot for Lane 2 of Burr and Generalized Extreme Value Distribution

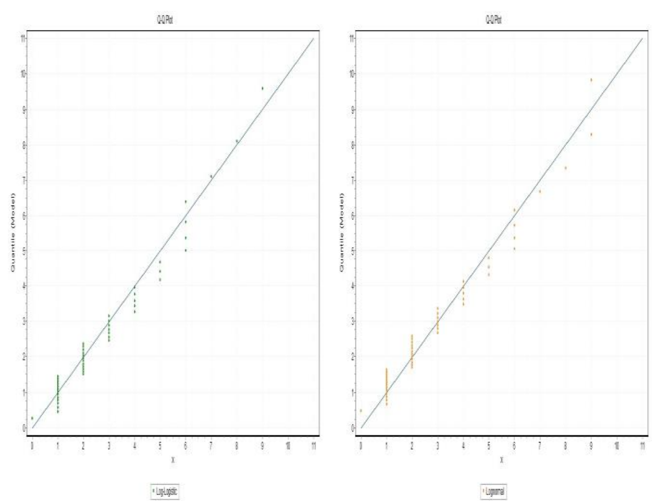

FIGURE 35: QQ plot for Lane 2 of Loglogistic Distribution and Lognormal Distribution

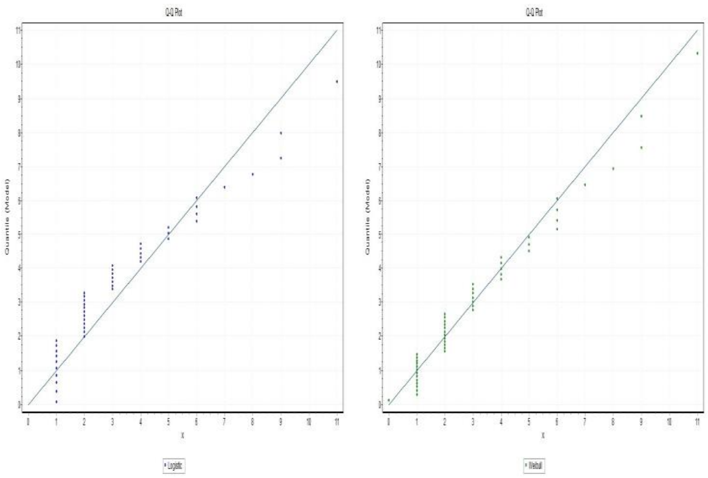

FIGURE 36: QQ plot for Lane 2 of Logistic and Weibull Distribution

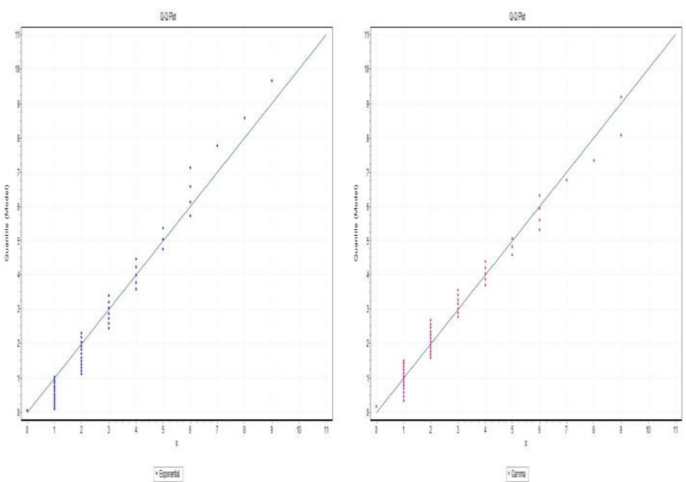

FIGURE 37: QQ plot for Lane 2 of Exponential and Gamma Distribution

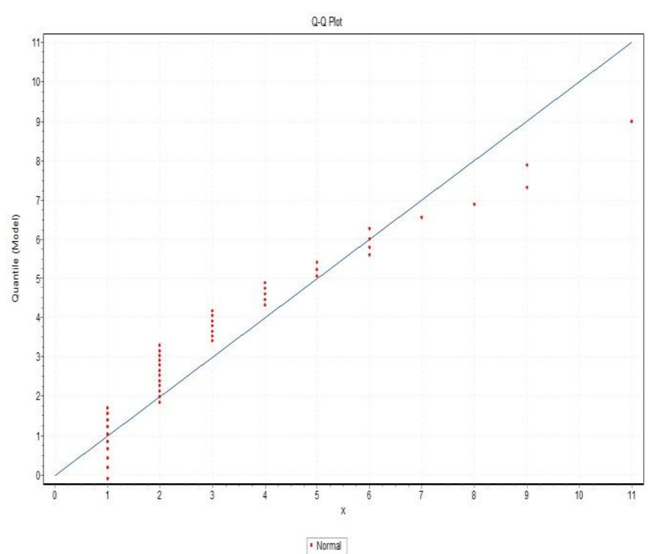

FIGURE 38: QQ plot for Lane 2 of Normal Distribution

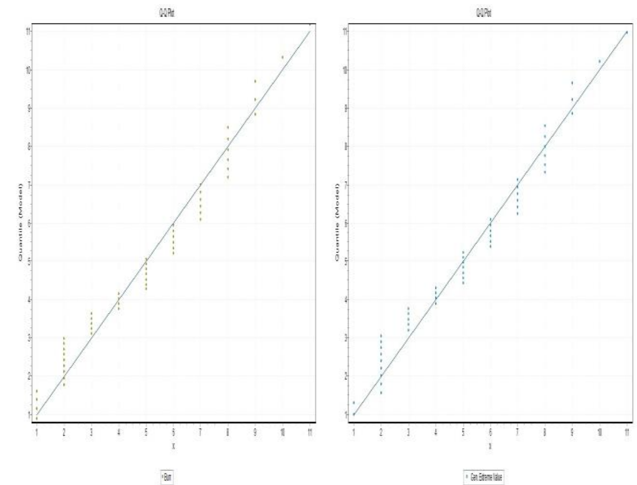

FIGURE 39: QQ plot for Lane 3 of Burr and Generalized Extreme Value Distribution

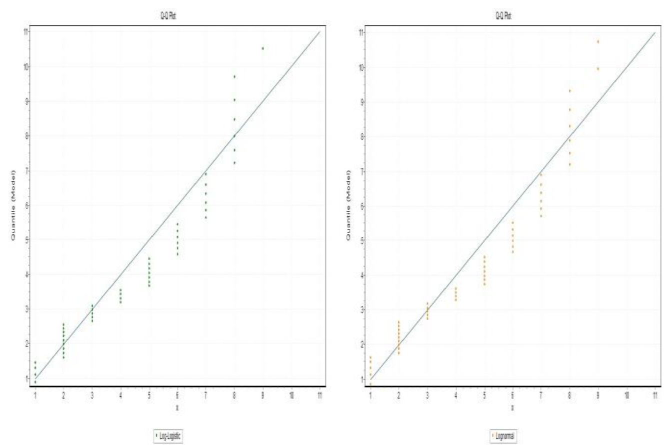

FIGURE 40: QQ plot for Lane 3 of Loglogistic and Lognormal Distribution

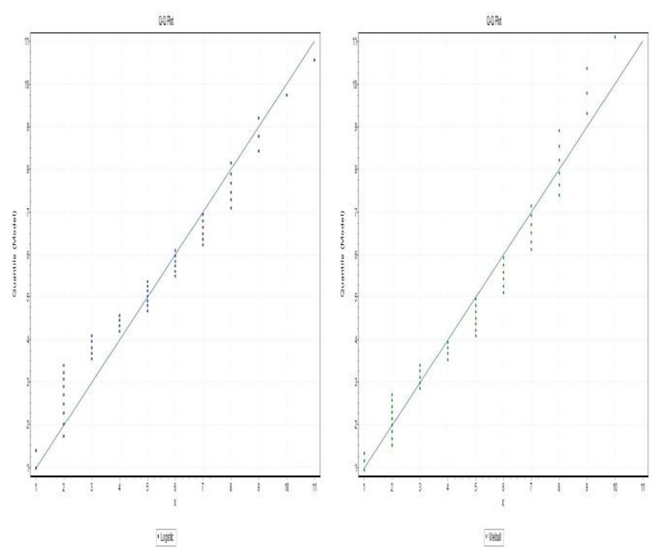

FIGURE 41: QQ plot for Lane 3 of Logistic and Weibull Distribution

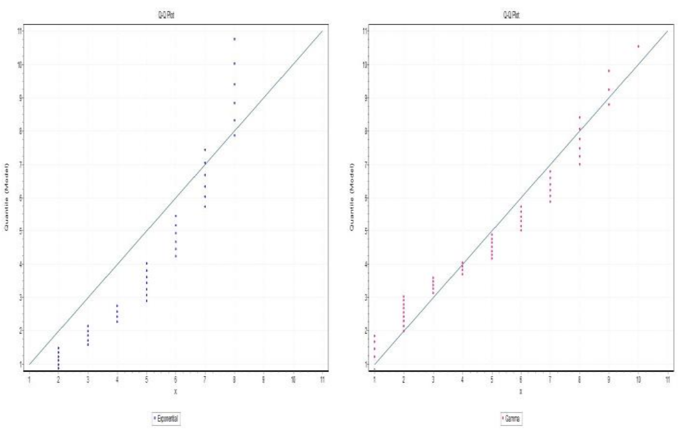

FIGURE 42: QQ plot for Lane 3 of Exponantial and Gamma Distribution

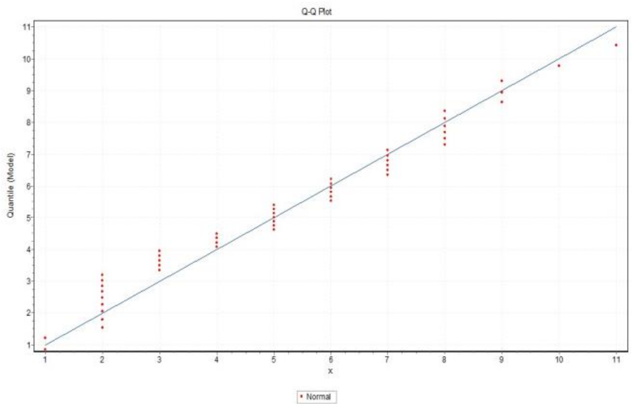

FIGURE 43: QQ plot for Lane 3 of Normal Distribution

TABLE IV: Goodness of Fit test result for the headway data of exact u turning phenomenon

Probability Distribution	Data Set	Chi-Squared Test	P	Kolmogorov-Smirnov Test	P
Burr	Lane 1	Accepted	0.17322	Accepted	0.26062
	Lane 2	Accepted	0.11845	Accepted	0.09006
	Lane 3	Accepted	0.15794	Accepted	0.27042
Generalized Extreme Value	Lane 1	Accepted	0.18252	Accepted	0.26761
	Lane 2	Accepted	0.14652	Accepted	0.21513
	Lane 3	Accepted	0.49344	Accepted	0.37462
Log-Logistic	Lane 1	Accepted	0.1587	Accepted	0.21043
	Lane 2	Accepted	0.12664	Accepted	0.25028
	Lane 3	Rejected	0.0122	Rejected	0.03947
Lognormal	Lane 1	Accepted	0.23589	Accepted	0.26266
	Lane 2	Accepted	0.10874	Accepted	0.06054
	Lane 3	Accepted	0.06975	Accepted	0.55614
Logistic	Lane 1	Rejected	0.00757	Rejected	0.001
	Lane 2	Accepted	0.12077	Rejected	0.00845
	Lane 3	Accepted	0.08641	Accepted	0.18456
Weibull	Lane 1	Rejected	0.00598	Accepted	0.0705
	Lane 2	Accepted	0.68209	Accepted	0.19716
	Lane 3	Accepted	0.12605	Accepted	0.23681
Exponential	Lane 1	Rejected	6.1950E-4	Rejected	0.00155
	Lane 2	Accepted	0.66343	Accepted	0.00359
	Lane 3	Rejected	0.00384	Rejected	0.00459
Gamma	Lane 1	Rejected	0.00342	Accepted	0.1244
	Lane 2	Accepted	0.24547	Accepted	0.05733
	Lane 3	Accepted	0.11399	Accepted	0.12515
Normal	Lane 1	Accepted	0.07819	Rejected	0.0014
	Lane 2	Accepted	0.35492	Rejected	0.02165
	Lane 3	Accepted	0.75493	Accepted	0.35175

IV. CONCLUSION

To understand the behavior of drivers, the impact of non-dedicated u turn on straight moving vehicles were examined. Data obtained from Karkhano road in Peshawar was used to determine the statistical characteristics and several distributions were considered. The headway data, traffic flow rates and average speed during normal traffic and specific phenomenon (only u turn analysis) differ as the traffic flow rate increases then the headway decreases. The non-dedicated U turn was showing evident influence on the straight moving vehicles coming from the opposite direction as they modify their behavior considering the U turning vehicles by either changing the lane or stopping or decreasing the speed.

While determining the speed, it was observed that the speed has inverse relation with the flow rate. With the increase of the flow rate, decrease in the speed and headway was noted and vice versa. Determining the suitable headway distribution is very important for traffic simulation. During the study different statistical distribution were considered and their fit was determined utilizing three goodness of fit tests, Q-Q plot, K-S, C-S, while some distributions were accepted by either of them, some were rejected by all three. Burr distribution and Generalized Extreme value distribution was accepted by all of the three tests.

Comparing the results for headway data it confirms that Burr distribution, Generalized Extreme Value Distribution and Lognormal Distribution are the best for traffic with interfering u turning vehicles. Results show the relation between headway data distribution of straight moving vehicles and interfering u turning vehicles. They will be useful in determining suitable headway distributions for traffic management and control over the use of a non-dedicated u turn.

It was also determined from the statistics that on week days more than 75 percent of the drivers are driving with a headway that is less than the safe headway and on weekends less than 25 percent of the vehicles were observed to have headway less than 4 seconds. The safe headway time in this study was taken as 4 seconds.

It was also concluded from the research that vehicle flow rate range 1100vph to 1800vph Burr Distribution and Generalized Extreme Value Distribution were followed. In lane 1 there was significant reduction observed in the headway of straight moving vehicles when interfered by the U turning vehicles. The probability for headway less than or equal to 4 seconds in lane 1 was found to be in range of 35 percent to 40 percent and from the PDF it was noted that the probability of almost every individual headway was fluctuating indicated recurrent congestion. In lane 2 headways were comparatively less than lane 1. The probability for headway less than or equal to 4 seconds in lane 2 was found to be in range of 70 percent to 75 percent and the probability for headways 1 second to 3 seconds in higher (from the PDF). In lane 3 the headways becomes much lesser than both of the lanes as vehicles disseminate more quickly than Lane 1 and lane 2. The probability for headway less than or equal to 4 seconds in lane 3 was found to be in range of 70 percent to 75 percent and the probability for 2 seconds to 3 seconds is higher degree in lane 3 (from PDF of lane 3).

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