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CALIBRATION OF PLATOON DISPERSION MODEL FOR URBAN INTERSECTION OF AHMEDABAD

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ABSTRACT - ***The research in this paper calibrated the platoon dispersion model on the basis of field data collected from a signalized intersection Kargil petrol pump, Ahmedabad. In the present study we have also discussed about platoon dispersion. Modelling of dispersion of vehicle platoon is an important consideration for coordinated operation of closely spaced traffic signals. This analysis is based on video photographic data collected at signalized intersection. The study of platoon dispersion is to a certain extent associated to driver manners and car following is one key component of driver behaviour. In this study, field investigation is made by means of videotapes which record traffic flows at several locations. After collection of video data extraction by any platoon dispersion software. This is used to accurate data collection from any intersections. To evaluate the effectiveness of the calibration method for the platoon dispersion model, the downstream flow profiles derived from the calibrated model were compared to the field observed downstream flow profiles within the platoon dispersion process at the intersection studied. Finally, the influence of the time step on the calibrated platoon dispersion model was also analyzed. The study results are of great importance for arterial progression because Robertson's model can depict platoon movements more accurately using the calibrated values of α.***

Keywords: *Platoon, Platoon dispersion, Platoon ratio, Passenger car unit, Congestion*

I. INTRODUCTION

Traffic congestion is a condition on transport networks that occurs as use increases, and is characterized by slower speeds, longer trip times, and increases vehicular queuing. Traffic congestion wastes time, energy and causes pollution. There are broadly two factors, which effect the congestion; micro-level factors and macro-level factors that relate to overall demand for road use. Congestion is 'triggered' at the 'micro' level (e.g. on the road), and 'driven' at the 'macro' level. The micro level factors are, for example, many people want to move at the same time, too many vehicles for limited road space. On the other side, macro level factors are e.g. land-use patterns, car ownership trends, regional economic dynamics, etc.

The traffic movement in India and in other developing countries is more complex due to heterogeneous characteristics of the traffic stream. Traffic consists of both motorized and non-motorized vehicles with lack of lane discipline. "Platoon of road traffic can be defined as a set of vehicles or pedestrians travelling together as a group, either freely or compulsorily, because of signal control, road geometry or other factors". In the Highway Capacity Manual (HCM), a vehicle platoon is defined as a group of vehicles travelling together.

Platoon dispersions the occurrence in which vehicular traffic free from, for example, an upstream signal, will get segregated, as they move over the distance towards the downstream signal. It is common, on urban roads, that the timing of successive traffic signals (when these are closely located) are planned in such a way that the main traffic stream gets the green when arriving at the downstream signal, thus, avoiding stopped delay for the stream of traffic. The study of platoon dispersion is to a certain extent associated to driver manners and car following is one key component of driver behaviour. In this study, field investigation is made by means of videotapes which record traffic flows at several locations.

The aim of this study is to investigate the nature of queue discharge headways, which may provide better information, and, reduce vehicle congestion at selected location of Ahmedabad.

The specific objectives of this research were to,

[1] To study the traffic flow characteristics at selected signalized intersections.

[2] To Approximation the passenger car equivalent unit values of different categories of vehicles at signalized intersections.

[3] To study the influence of platoon dispersion at signalized intersections and to compare with any platoon dispersion model.
[4] To find progression quality of platoon with help of platoon ratio.

II. LITERATURE REVIEW

This chapter assessments the literature concerning the work, which has been carried-out on the Platoon dispersion behaviour of vehicular traffic. Estimation of correct saturation flow rate for specific condition is very important for the calculation of capacity, delays and LOS at signalized intersections. Platoon dispersion models simulate the dispersion of traffic as they move from upstream to downstream. They estimate the downstream flow on the basis of the upstream vehicle departure profile and the average travel time in the link. Devangi hattimare used videographic method for data collection. They were selected pallav cross road, in shastry nagar Ahmedabad as study area. The passenger car units (PCUs) values was derived for different types of vehicles in the traffic stream by different approaches. They find the actual dispersion on that site, compare it with the dispersion given by Robertson's model and thus evaluate model for heterogeneous traffic condition.

Jijo Mathew was take a 1.3 km section of an urban arterial in Chennai for his study area. Digital video cameras were placed at three control points along the study section. The observations were carried out for five days in May 2013. The video data were collected for a period of two hours during the morning peak. The data collected was processed in order to extract the required data on the vehicle passing time at each control point. The vehicles were classified into four classes Two-wheelers (2W), Three-wheelers (3W), LMV and HMV. The extraction was carried out manually by recording a macro in Excel which gave the vehicle class along with the timestamp, as the vehicle passed the point. The timestamp had a least count of millisecond, thus giving more precision. The process was carried out for the 2 hour data from all the three control points. The main aim of that study was to find the actual dispersion in that site, compare it with the dispersion given by Robertson model and evaluate for heterogeneous condition.

Priya rai was worked on Saturation Flow Modelling and Level of Service Analysis of Signalized Intersections at Kolkata. That study proposes a new PCU values for different classes of vehicles for the heterogeneous traffic condition of Kolkata. The analysis is based on video photographic data collected at three selected intersections of the city. Firstly dynamic PCU values for each vehicle at the study approaches are obtained and then saturation flow for each survey approach is calculated using the average PCU values.

FENG WAN Analysis of platoon impacts on left-turn delay at signalized intersections. That research aims to develop a methodology for analyzing the platoon impacts on major-street left-turn (MSLT) delay at two-way stop-controlled (TWSC) intersections. The effects of platoons generated from the upstream signal intersection on MSLT delay are investigated in that research. VISSIM simulation was selected as the platform for research and field data was used to calibrate VISSIM simulation.

III. STUDY AREA

The study area identified was a 2.2 km section of a Sarkhej – Gandhinagar highway in Ahmedabad, from kargil petrol pump intersection to cambay circle intersection. The Sarkhej–Gandhinagar Highway colloquially the S.G. Road or S.G. Highway, connects the city of Ahmedabad with Gandhinagar, the capital of the state of Gujarat, India. It forms the major part of NH8C that connects Sarkhej with Chiloda near Gandhinagar. The length of Sarkhej–Gandhinagar Highway is 44.5 km (27.7 mi). It is a major artery road for commercial and public transport and is witnessing a major construction boom along its route towards Gandhinagar.

In this study area two intersection consider i.e. kargil petrol pump intersection and cambay intersection. The intersections are attractive to many traffic users and very high motorcycle volume. Both intersection traffic movement is more complex and heterogeneous. Traffic consists of both motorized and non motorized vehicles with lack of discipline. Both intersection having huge traffic on peak hour and it is one of the busy route of the Ahmedabad because that route also link the Ahmedabad and Gandhinagar. In study area, there are many approach ways are there which provides huge number of traffic and the public transportation and high number of traffic of two-wheeler. When the traffic is low, signalized control system is operated as pre-time control, otherwise police are controlled the traffic by themselves. Due to the great fluctuation in traffic flow, the signalized intersections based on the scope of work are selected in which,

I) Advantage location for conducting survey,
ii) Large motorcycle volume and
iii) Little interference from other factors such as pedestrians, left and right turning and bus stops, etc.

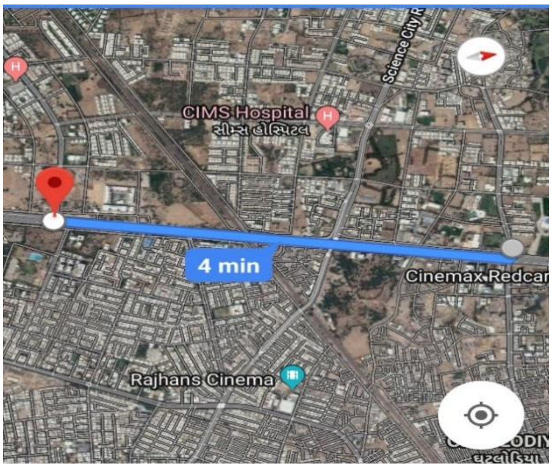

Fig: 2 Kargil petrol pump intersection to cambay intersection

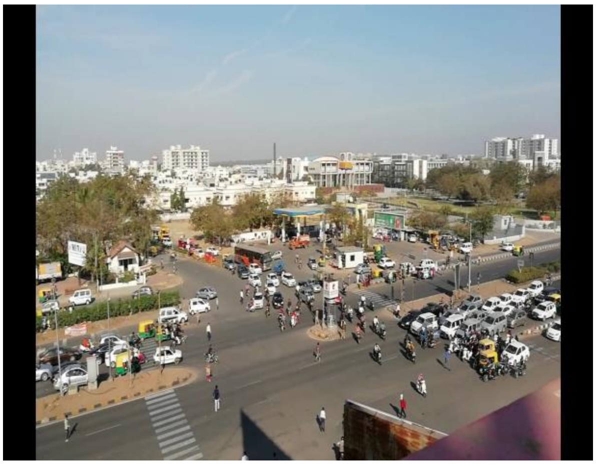

Fig: 3 Kargil petrol pump intersection

IV. METHODOLOGY FLOW CHART

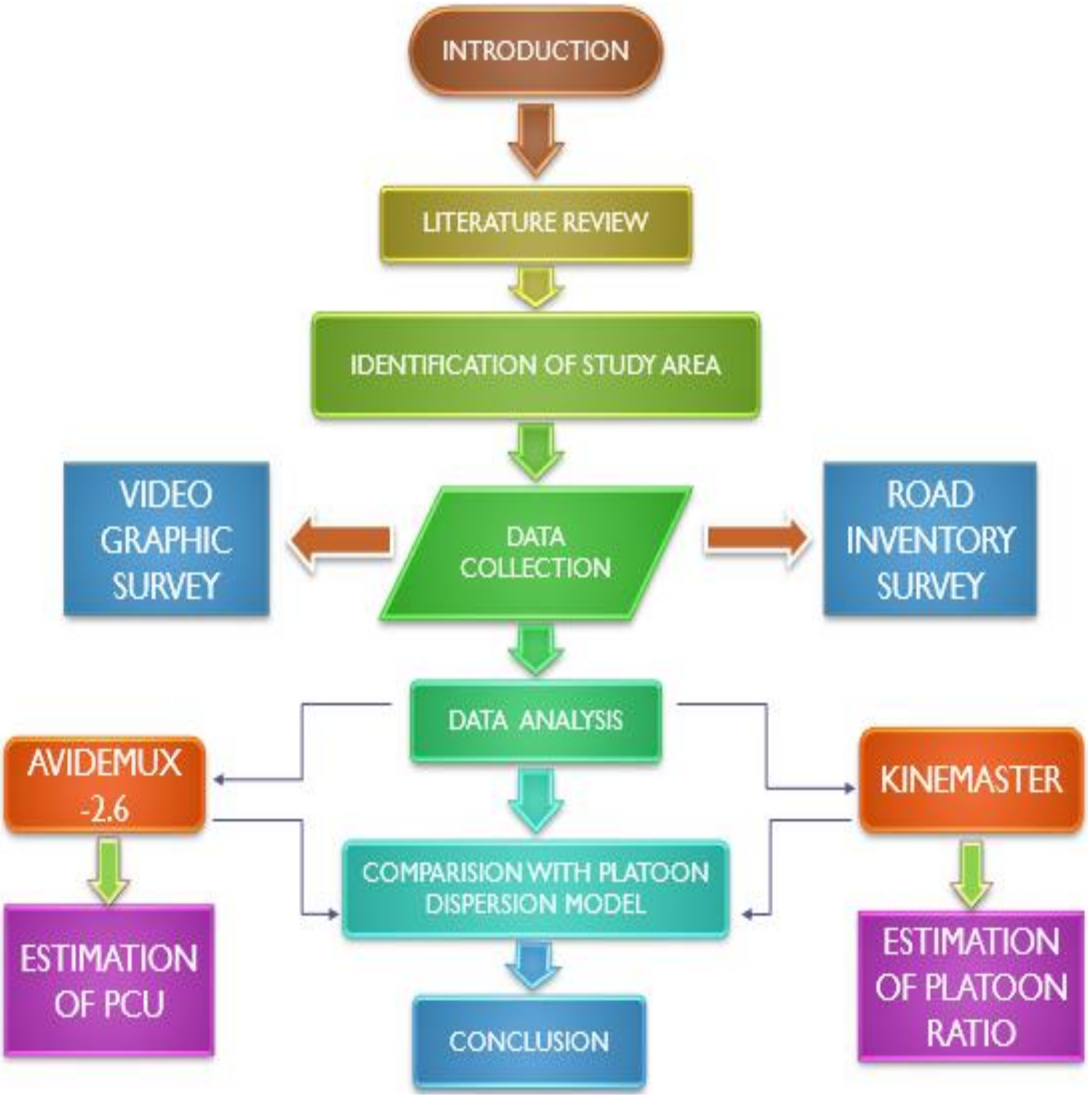

Fig: 4 Methodology flow chart

V. DATA COLLECTION

Data was collected on a typical weekday covering peak hours. During morning peak hours, substantial queue formation was observed due to which there was a considerable delay to traffic streams. This aspect was focused to get data on traffic operation at intersection over varying traffic conditions. Kargil petrol pump intersection to cambay intersection having huge traffic on peak hour and it is one of the busy route of the Ahmedabad because that route also link Ahmedabad and Gandhinagar. In study area, there are many approach ways are there which provides huge number of traffic and the public transportation and high number of traffic of two-wheeler. Data collection was carried out during peak periods from 9:30 am to 10:30 am on 15th February 2018 at satyamev - 2 complex opposite kargil petrol pump. The traffic flow at inner and middle lanes, which is mixed traffic of passenger car, bus, and motorcycle, is taken into consideration.

TABLE: 1 IDENTIFICATION OF SIGNALIZED INTERSECTION

SR NO	LOCATION	GPS COORDINATE	TIME OF VIDEOGRAPHIC SURVEY	DURATION
1	Kargil petrol pump intersection(satyamev-2 complex)	23.0769’ N 72.5248’ E	9:30 am to 10:30 am	1 hour (morning) 15th Feb 2018

Fig: 5 camera set up at satyamev – 2 complex

Fig: 6 footpath width measuring at study area

VI. DATA ANALYSIS

After collection of video graphic data extraction by Kinemaster and Avidemux – 2.6 software. For the present study, straight movement count was carried out manually by observing the recorded video and playing it repeatedly for various times. When vehicles move from upstream to downstream, disperse to some extent mostly due to the difference in the desired speed of different drivers in the platoon. This dispersion was captured by analysing the same platoons at

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upstream and downstream points. After extraction of video graphic data around 48 platoons in morning are analyzed. From the video films, vehicle types and passing time are captured later by interpreting in the traffic.

For the traffic survey, the different types of vehicles in the traffic stream are classified into different groups as follows:

1. Motorcycles, scooters
2. Passenger cars, vans, Auto rickshaw
3. Buses (AMTS, BRTS, GSRTC)
4. LCV (Tempo, Tractor, Chota-hathi)
5. HCV (Truck, Water tanker)

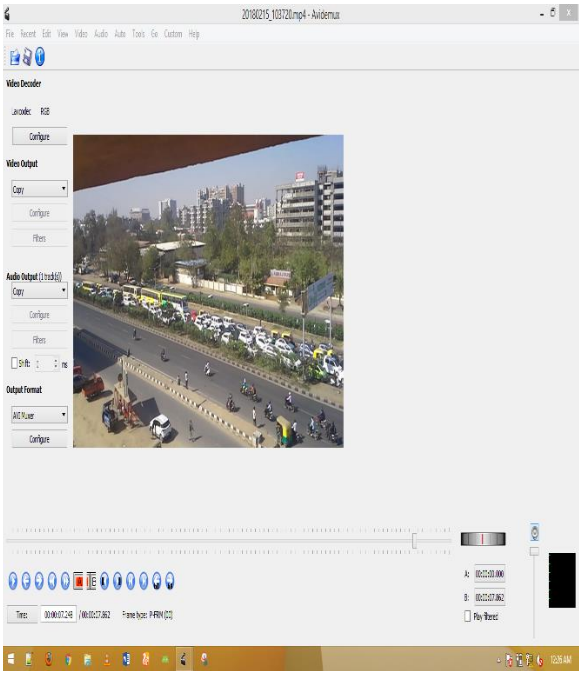

Fig: 7 screenshot of vehicle movement in Avidemux-2.6

Fig: 8 screenshot of vehicle movement in Kinemaster

CHART: 1 COMPOSITION OF VEHICLES

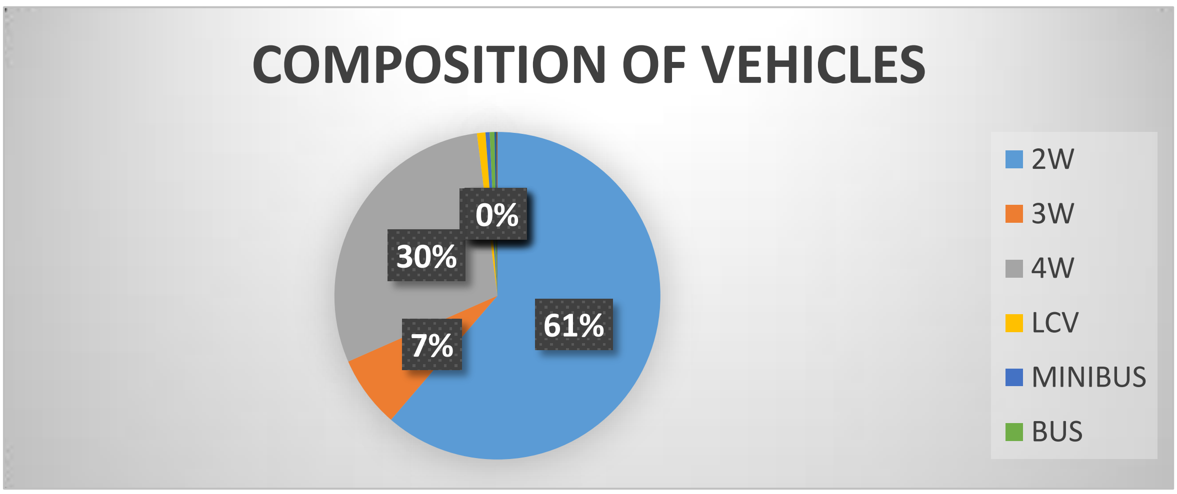

Table: 2 Vehicle compositions each category vice Analysis

PLATOON N0	PLATOON SIZE	2W	3W	4W(CAR)	LCV	MINI BUS	BUS	HCV	CYCLE
1	246	165	18	59	3	1	0	0	0
2	139	82	10	45	0	0	0	2	0
3	213	132	17	63	1	0	0	0	0
4	111	53	13	43	2	0	0	0	0
5	147	112	6	26	0	0	0	0	3
6	132	60	11	57	2	0	1	0	1
7	158	94	15	44	2	1	2	0	0
8	157	87	13	53	1	2	1	0	0
9	158	104	17	32	3	0	1	1	0
10	133	57	10	62	2	1	0	1	0
11	151	98	13	38	0	1	0	1	0
12	133	70	9	53	0	0	1	0	0
13	159	113	7	37	1	1	0	0	0
14	150	76	15	56	0	1	1	0	1
15	192	113	17	58	2	1	0	1	0
16	156	88	13	51	3	0	1	0	0
17	206	151	7	47	1	0	0	0	0
18	140	70	15	53	0	1	1	0	0
19	159	112	9	36	1	1	0	0	0
20	158	97	13	48	0	0	0	0	0
21	166	98	8	56	2	0	1	1	0
22	147	77	7	59	3	1	0	0	0
23	142	87	13	39	2	0	0	1	0
24	173	113	6	51	0	0	2	1	0
25	234	156	13	61	3	0	1	0	0
26	142	73	16	48	3	0	1	0	1
27	228	148	12	64	2	1	1	0	0
28	225	138	12	69	3	0	3	0	0
29	130	78	8	38	2	1	2	0	1
30	189	114	17	54	1	2	1	0	0
31	144	89	12	39	3	0	0	1	0
32	216	137	13	63	1	2	0	0	0
33	194	117	15	58	1	2	1	0	0
34	186	127	12	41	0	2	1	3	0
35	171	98	17	53	0	2	1	0	0
36	176	111	8	50	2	2	3	0	0
37	144	89	11	38	3	0	3	0	0
38	176	101	9	64	0	1	1	0	0
39	166	107	8	49	1	1	0	0	0
40	198	139	15	38	3	0	3	0	0
41	176	103	9	63	1	0	0	0	0

PLATOON N0	PLATOON SIZE	2W	3W	4W(CAR)	LCV	MINI BUS	BUS	HCV	CYCLE
42	141	89	11	39	0	1	1	0	0
43	185	127	8	48	1	1	0	0	0
44	147	94	13	38	0	2	0	0	0
45	154	81	9	60	2	0	1	1	0
46	153	101	11	37	3	1	0	0	0
47	167	98	17	49	2	0	0	1	0
48	180	111	13	53	0	0	2	1	0
TOTAL	8048	4935	571	2380	68	33	38	16	7
PCU FACTOR	-	0.5	1	1	1.5	3	3	4.5	0.5
PCU	**5809**	**2467.5**	**571**	**2380**	**102**	**99**	**114**	**72**	**3.5**
COMPOSITION OF VEHICLES	**100%**	**61.32 %**	**7.09 %**	**29.57%**	**0.84 %**	**0.41%**	**0.47 %**	**0.20 %**	**0.09%**

Field surveys were done in order to collect the following parameters:

Table: 3 ROAD INVENTORY DATA COLLECTION

COMPONENT	KARGIL PETROL PUMP	CAMBAY CIRCLE
Vehicle direction	Two way	Two way
Lane	Six lane	Six lane
Carriage way condition	Good	Good
Width of carriage way	9 m	9 m
Shoulder width	1.5 m	1.5 m
Median available	Yes	Yes
Median type	Raised	Raised
Width of median	3.50 m	3.50 m
Footpath condition	Good	Good
Footpath width	2 m	2 m
Type of intersection	Four leg intersection	Four leg intersection
Intersection	Signalized	Signalized
Service road	Available	Available
Width of service road	6 m	6 m
Zebra crossing	Available	Available

Table: 4 Vehicle compositions (%) Each category vice Analysis

PLATOON NO	PLATOON SIZE	2W	3W	4W(CAR)	LCV	MINI BUS	BUS	HCV	CYCLE
1	246	67.07	7.32	23.98	1.22	0.41	0.00	0.00	0.00
2	139	58.99	7.19	32.37	0.00	0.00	0.00	1.44	0.00
3	213	61.97	7.98	29.58	0.47	0.00	0.00	0.00	0.00
4	111	47.75	11.71	38.74	1.80	0.00	0.00	0.00	0.00
5	147	76.19	4.08	17.69	0.00	0.00	0.00	0.00	2.04
6	132	45.45	8.33	43.18	1.52	0.00	0.76	0.00	0.76
7	158	59.49	9.49	27.85	1.27	0.63	1.27	0.00	0.00
8	157	55.41	8.28	33.76	0.64	1.27	0.64	0.00	0.00
9	158	65.82	10.76	20.25	1.90	0.00	0.63	0.63	0.00
10	133	42.86	7.52	46.62	1.50	0.75	0.00	0.75	0.00
11	151	64.90	8.61	25.17	0.00	0.66	0.00	0.66	0.00
12	133	52.63	6.77	39.85	0.00	0.00	0.75	0.00	0.00
13	159	71.07	4.40	23.27	0.63	0.63	0.00	0.00	0.00
14	150	50.67	10.00	37.33	0.00	0.67	0.67	0.00	0.67
15	192	58.85	8.85	30.21	1.04	0.52	0.00	0.52	0.00
16	156	56.41	8.33	32.69	1.92	0.00	0.64	0.00	0.00
17	206	73.30	3.40	22.82	0.49	0.00	0.00	0.00	0.00
18	140	50.00	10.71	37.86	0.00	0.71	0.71	0.00	0.00
19	159	70.44	5.66	22.64	0.63	0.63	0.00	0.00	0.00
20	158	61.39	8.23	30.38	0.00	0.00	0.00	0.00	0.00
21	166	59.04	4.82	33.73	1.20	0.00	0.60	0.60	0.00
22	147	52.38	4.76	40.14	2.04	0.68	0.00	0.00	0.00
23	142	61.27	9.15	27.46	1.41	0.00	0.00	0.70	0.00
24	173	65.32	3.47	29.48	0.00	0.00	1.16	0.58	0.00
25	234	66.67	5.56	26.07	1.28	0.00	0.43	0.00	0.00
26	142	51.41	11.27	33.80	2.11	0.00	0.70	0.00	0.70
27	228	64.91	5.26	28.07	0.88	0.44	0.44	0.00	0.00

PLATOON N0	PLATOON SIZE	2W	3W	4W(CAR)	LCV	MINI BUS	BUS	HCV	CYCLE
28	225	61.33	5.33	30.67	1.33	0.00	1.33	0.00	0.00
29	130	60.00	6.15	29.23	1.54	0.77	1.54	0.00	0.77
30	189	60.32	8.99	28.57	0.53	1.06	0.53	0.00	0.00
31	144	61.81	8.33	27.08	2.08	0.00	0.00	0.69	0.00
32	216	63.43	6.02	29.17	0.46	0.93	0.00	0.00	0.00
33	194	60.31	7.73	29.90	0.52	1.03	0.52	0.00	0.00
34	186	68.28	6.45	22.04	0.00	1.08	0.54	1.61	0.00
35	171	57.31	9.94	30.99	0.00	1.17	0.58	0.00	0.00
36	176	63.07	4.55	28.41	1.14	1.14	1.70	0.00	0.00
37	144	61.81	7.64	26.39	2.08	0.00	2.08	0.00	0.00
38	176	57.39	5.11	36.36	0.00	0.57	0.57	0.00	0.00
39	166	64.46	4.82	29.52	0.60	0.60	0.00	0.00	0.00
40	198	70.20	7.58	19.19	1.52	0.00	1.52	0.00	0.00
41	176	58.52	5.11	35.80	0.57	0.00	0.00	0.00	0.00
42	141	63.12	7.80	27.66	0.00	0.71	0.71	0.00	0.00
43	185	68.65	4.32	25.95	0.54	0.54	0.00	0.00	0.00
44	147	63.95	8.84	25.85	0.00	1.36	0.00	0.00	0.00
45	154	52.60	5.84	38.96	1.30	0.00	0.65	0.65	0.00
46	153	66.01	7.19	24.18	1.96	0.65	0.00	0.00	0.00
47	167	58.68	10.18	29.34	1.20	0.00	0.00	0.60	0.00
48	180	61.67	7.22	29.44	0.00	0.00	1.11	0.56	0.00

VII. PLATOON RATIO

The platoon ratio denoted as Rp, is a numerical value used to quantify the quality of progression on an approach. The platoon ratio represents the ratio of the number of vehicles arriving during the green phase to the proportion of the green interval of the total cycle. This is given by,

$$Rp = P*(C/g)$$

P = Proportion of vehicles arriving on green,
g/C = Proportion of green time available,
C = Cycle length

Its value ranges from 0.5 to 2.0. It is used in the calculation of delays, capacity of an approach. The arrival types range from 1 (worst platoon condition) to 6 (the best platoon condition). The platoon ratio approximates the arrival type and the progression quality. For example HCM (2000) has suggested the following relationship between platoon ratio and arrival which is as shown in Table

Table : 5 Relationship between Arrival Type and Platoon Ratio

Arrival	Range of platoon	Default (R_p) value	Progression quality
type	(R_p) ratio		
1	≤ 0.50	0.333	Very poor
2	$> 0.50 - 0.85$	0.667	Unfavourable
3	$> 0.85 - 1.15$	1.000	Random arrivals
4	$> 1.15 - 1.50$	1.333	Favourable
5	$> 1.5 - 2.00$	1.667	Highly favourable
6	> 2	2.000	Exceptional

Table: 6 Platoon Ratio Calculations

TOTAL VEHICLES IN THE MORNING = 8048							
PLATOON NO	PLATOON SIZE	P = PROPOSITION OF VEHICLES %	C=CYCLE TIME	G = GREEN TIME	Rp=P*(C/g)	RANGE OF PLATOON RATIO	PROGRESSI ON QUALITY
1	246	5	160	100	8	> 2	Exceptional
2	139				8	> 2	Exceptional
3	213	4	160	100	6.4	> 2	Exceptional
4	111				6.4	> 2	Exceptional
5	147	4	120	100	4.8	> 2	Exceptional
6	132				4.8	> 2	Exceptional
7	158	4	135	90	6	> 2	Exceptional
8	157				6	> 2	Exceptional
9	158	4	205	115	7.1	> 2	Exceptional
10	133				7.1	> 2	Exceptional
11	151	4	205	115	7.1	> 2	Exceptional
12	133				7.1	> 2	Exceptional
13	159	4	210	120	7	> 2	Exceptional

14	150				7	> 2	Exceptional
15	192	5	185	120	7.7	> 2	Exceptional
16	156				7.7	> 2	Exceptional
PLATOON NO	**PLATOON SIZE**	**P = PROPOSITION OF VEHICLES %**	**C=CYCLE TIME**	**G = GREEN TIME**	**Rp=P*(C/g)**	**RANGE OF PLATOON RATIO**	**PROGRESSION QUALITY**
17	206	5	185	100	9.25	> 2	Exceptional
18	140				9.25	> 2	Exceptional
19	159				9.25	> 2	Exceptional
20	158	6	155	70	13.28	> 2	Exceptional
21	166				13.28	> 2	Exceptional
22	147				13.28	> 2	Exceptional
23	142	4	175	105	6.66	> 2	Exceptional
24	173				6.66	> 2	Exceptional
25	234	6	190	95	12	> 2	Exceptional
26	142				12	> 2	Exceptional
27	228				12	> 2	Exceptional
28	225	6	163	100	9.78	> 2	Exceptional
29	130				9.78	> 2	Exceptional
30	189				9.78	> 2	Exceptional
31	144	5	174	87	10	> 2	Exceptional
32	216				10	> 2	Exceptional
33	194	5	193	70	13.78	> 2	Exceptional
34	186				13.78	> 2	Exceptional
35	171	4	215	120	7.16	> 2	Exceptional
36	176				7.16	> 2	Exceptional
37	144	6	309	120	15.45	> 2	Exceptional
38	176				15.45	> 2	Exceptional
39	166				15.45	> 2	Exceptional
40	198	5	241	130	9.26	> 2	Exceptional
41	176				9.26	> 2	Exceptional
42	141	4	253	125	8.096	> 2	Exceptional
43	185				8.096	> 2	Exceptional
44	147	6	202	110	11.01	> 2	Exceptional
45	154				11.01	> 2	Exceptional
46	153				11.01	> 2	Exceptional
47	167	4	200	110	7.27	> 2	Exceptional
48	180				7.27	> 2	Exceptional

VIII. PLATOON DISPERSION EFFECT FOR MIXED TRAFFIC FLOW

The aim for the dispersion of platoon is the difference between vehicle speeds. For the reason that one vehicle's travel time on a fixed-length road section is contrariwise connected to its speed, both speed and travel time can be used to study the platoon dispersion miracle Platoon dispersion models put on the dispersion of a traffic stream as it travels downstream using approximating vehicle arrivals at downstream locations based on an upstream vehicle exit profile and a preferred traffic-stream speed.

Dispersion has been originate to be a function of the travel time after a signal to a downstream signal (or other downstream location) and the length of the platoon. The extended the travel time between signals, the more the dispersion. This is automatically logical since the extended the travel time, the more time (chance) there is for different drivers to deviate from the average travel time.

There are two kinds of mathematical models relating the dispersion of the platoon, specifically:

1. Normal Distribution Model - proposed by Pacey
2. Geometric Distribution Model - proposed by Robertson

One and only of the geometric distribution models is the Robertson's platoon dispersion model, which has convert a almost general standard platoon dispersion model and has been understood in several traffic simulation software. Research has previously been accompanied on the applicability of platoon dispersion as a consistent traffic movement model in urban street networks.

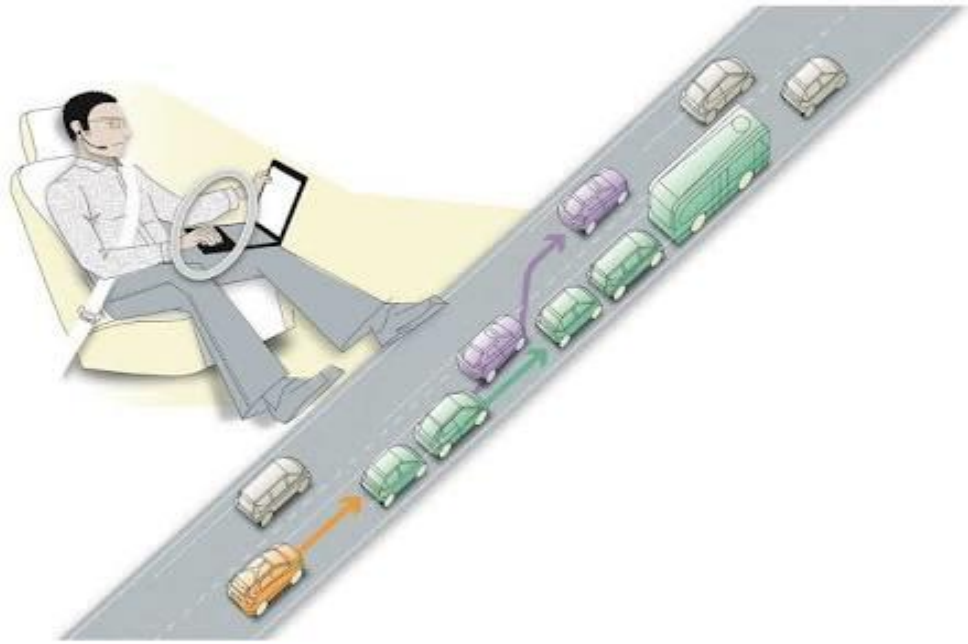

Fig: 9 platoon dispersion (source:phys.org)

The most widely used platoon dispersion model is Robertson's (1969) model. This model has become a virtual universal standard platoon dispersion model and has been implemented in various traffic simulation software, including TRANSYT (Robertson, 1986), SCOOT (Hunt *et al*., 1989), SATURN (Hall *et al*., 1980), and TRAFLO (Lieberman *et al*., 1980). A successful application of Robertson's platoon dispersion model requires an appropriate calibration of the models parameters. Specifically, Guebert and Sparks (1989) showed that the accurate calibration of the Robertson platoon dispersion model parameter was critical in developing effective and efficient traffic signal timing plans. Despite the significant impact the platoon dispersion parameters have on the signal timings that are estimated by the TRANSYT-7F software, the software manual does not provide an analytical framework for the calibration of the platoon dispersion model parameters.

Robertson's platoon dispersion model is primarily characterised by two parameters; a platoon dispersion factor (α) and a travel time factor (β). Mathematical form of the model is given in Eq. 1.

$$q_t^d = F_n \times q_{t-T} + (1 - F_n) \times q_{t-n}^d \qquad (1)$$

$$F_n = \frac{1}{1 + T_a \alpha \beta} \tag{2}$$

$$T = \beta T_a \tag{3}$$

where, q^d_t is arrival flow rate at the downstream signal at time t, q^d_{t-T} is departure flow rate at the upstream signal at time t-T, T is lag time (time gap between initiation of green at upstream stop-line and arrival of first vehicle at downstream stop-line), T_a is average link travel time, n is modelling time step duration, and F_n is smoothing factor.

From Eq. 1, it may be inferred that downstream arrivals in each time step are dependent on the departures from an upstream intersection. Downstream arrivals, q^d_t is a weighted combination of arrival during the previous time step , q^d_{t-T} and the departure from upstream intersection T s ago, q_{t-T}.
Since, Robertson's model estimates the downstream flow at a given time interval, the model needs to be applied recursively to predictthe flow. Seddon rewrote the Eq. 1 as,

$$q_t^d = \sum_{i=T}^{\infty} F_n (1 - F_n)^{i-T} \times q_{t-i+T} \tag{4}$$

Equation 4 demonstrates that predicted downstream arrivals follow a shifted geometric series, which estimates the contribution of an upstream flow in (t−i)th interval to the downstream flow in t-th interval.

As mentioned earlier, accuracy of prediction of Robertson's dispersion model relies on its calibration for local roadway and traffic condition. Improper calibration of α and β may result an ineffective signal timing plan. Manar and Bass showed that using a suggested value of α instead of using a locally calibrated value may result in additional delay for an arterial corridor. Due to the significant impact of model parameters (α, β) on effective implementation of signal timing plan, several studies were carried out on calibration of these parameters, which could be categorised in two groups. In first group of studies, investigations were carried out to calibrate the model parameters for site specific roadway and traffic condition. In second group of studies, efforts were given to make the calibration procedure more generalised. Basic elements of the dispersion model such as size of modelling time step, and statistical features of travel time were investigated to generalise the calibration framework.

IX. Identification of Vehicle Platoons

While departing across the stop-line, vehicles are separated by time headway. Individual vehicle headway generally varies within the range of 0.5–10 s. In the present study, vehicles separated by larger time headway at stop-line are grouped to identify the distinct vehicle platoons. It is assumed that mutual interaction of vehicles within a platoon do not have any effect on its preceding or following vehicle platoon. The threshold value of time headway at stop-line, based on which vehicle platoons are identified is termed as critical headway. With a large critical headway, variances of platoon variables get increased, whereas use of a small critical headway results too many platoons and insufficient platoon information. El-Reddy et al. and Bie et al.used 4 s time interval as critical headway to identify the vehicle platoons at stop-line. In the context of present study, which deals with a non-lane based traffic system, distributions of platoon size are studied for three different headways viz. 2 s, 3 s and 4 s to obtain a suitable value of 'critical headway'. For non-lane based traffic system, headway is defined as the time gap between the two vehicles while passing across the stop-line

X. Calibration of Robertson's Dispersions Model

Downstream arrivals for a given upstream discharge profile is estimated using Eq. 4. To minimise the error between observed arrivals and estimated arrivals, platoon dispersion factor (α) is calibrated for a fixed value of travel time factor (β) (equals to 0.8). For calibration of α, following objective function (Eq. 6) is minimised using best fit approach.

$$f(\alpha) = \sum_{t=1}^{n} \left[q'_d(t) - q_d^t(t) \right]^2 \tag{6}$$

where, q_d' (t) is observed arrival at downstream section during time step t and $q_d^t(t)$ is observed arrivals at downstream section during time step t. Minimum value of f(α) is obtained using solver tool (Generalized Reduced Gradient nonlinear method) in Microsoft Excel spread sheet. To investigate the sensitivity of the model error, calibration is carried out for all adopted modelling step sizes viz. 3 s, 4 s and 6 s. Root mean square error (RMSE) (in vehicle/s) is estimated for each modelling step size.

XI. Results and Discussion

For different critical headway platoons were identified at stop line. With 2s critical headway highest number of platoon 48 nos. was identified. Where as for 3s and 4s critical headway, number of platoon observed are 29 and 36 respectively. For 2 s and 3 s headway platoon size distribution is highly skewed in left i.e., number of smaller sized platoons are more for 2 s and 3 s headway. However, with 4 s headway, distribution of platoon size is reasonable balanced. Nearly equal shares (15 %) are observed for platoon size 11–20, 20–30 and 30–40. Therefore, with 4 s headway, platoon size distribution was reasonable enough to give adequate platoons information and hence, 4 s is selected as threshold value of critical headway. Identified vehicle platoons were further analysed to measure the dispersion at different downstream section. The methodology proposed in this paper can be applied in other signalized intersection where the 3 impacts of the percentage of two wheelers or other factors need to be considered. the calibrated values of α, β, and F differ significantly from the default values suggested by the TRANSYT Users' Guide. The calibrated values of α are much smaller than the default value 0.25. The values of β are larger than the default value 0.8. This difference can be attributed partially to the influence of buses at the intersection

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