

# Study of Traffic Progression Models In Visakhapatnam

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**Abstract-** Management and control of traffic flow on urban arterial streets with traffic signals at intersections represent platoons at the given traffic signals. The platoon characterizing variables such as platoon size, inter-platoon headway and platoon speed has been studied extensively under homogeneous traffic conditions but such similar studies have not been conducted adequately considering the diversity of traffic and lack of lane discipline exhibited under heterogeneous traffic conditions. In this study, field investigation is made by means of manually which traffic flows at several locations on Visakhapatnam. After processing the data, traffic flows at each location and vehicle speed distributions on different links are obtained for the platoon dispersion model. Different platoon dispersion models were used to the observed vehicle speeds and travel times. These models showed that the delay and length of queue at the downstream intersection and flow, average travel of vehicles from the upstream intersection. This study enables better understanding of platoon characterizing variables under heterogeneous traffic conditions facilitating enhanced safety and better operation

**Keywords-** Homogenous Traffic, Platoon Dispersion, Traffic Control, Traffic Flow

## I. INTRODUCTION

### General:

A majority of the metro cities in India are facing the problem of traffic congestion, delays, which have further resulted in pollution. The delays are caused mainly due to the isolated functioning of the traffic signals at closely located intersections. For better regulation of traffic flow at these intersections, the traffic signals need to be coordinated or linked. For the linking of signals, the vehicle movement characteristics from upstream signal to downstream signal need to be considered and simulated. Traffic Progression Models model the vehicle movement characteristics and help in the linking of signals. First, the concept of platoon, platoon variables is discussed and then platoon ratio is defined which is required for determination of arrival type. Then, the

phenomenon of platoon dispersion and platoon dispersion model is introduced for understanding dispersion behavior of the vehicles. Finally, one of the platoon dispersion models i.e., Robertson's platoon dispersion model is discussed, which estimates the vehicle arrivals at downstream locations based on an upstream departure profile.

Like Delhi, there are many Indian cities that drive citizens crazy with traffic congestion. While it is very common to get stuck for 3-3.5 hours in Bangalore roads, Delhi takes some 2 hours to reach a distance of 10 km during peak hours. Some fastest growing Indian cities are only focusing on industrial and urban expansion while sidelining traffic woes. However, if the entire nation takes inspiration from the lesser congested and polluted ones like Kochi, Chandigarh, Surat and Gandhinagar, we will have a complete healthy environment to survive.

### Traffic Congestion & Urban Population Density:

At the regional level, a similar association is apparent. The United States, with the lowest urban population densities, has the least traffic congestion. Latin America, Eastern Europe and China, with higher urban densities, have worse traffic congestion. Density does not explain all the differences, however, especially among geographies outside the United States. Despite its high density, China's traffic congestion is less intense than that of Eastern European and Latin American cities. It seems likely that this is, at least in part due to the better matching of roadway supply with demand in China, with its extensive urban freeway systems. Further, the cities of China often have a more polycentric employment distribution.

Table - 1  
Population Densities: Demographical World Urban Areas

|   | Peak Hour Congestion | Urban Population Density |                     |
|---|----------------------|--------------------------|---------------------|
|   |                      | Per Square Mile          | Per KM <sup>2</sup> |
| Australia & New Zealand   |                      |                          |                     |
| Canada  | 49.2                 | 4,600                    | 1,800               |
| China   | 49.4                 | 3,000                    | 1,900               |
| Eastern Europe  | 64.9                 | 13,700                   | 6,100               |
| Latin America   | 89.8                 | 11,800                   | 4,500               |
| United States   | 89.3                 | 19,600                   | 7,600               |
| Western Europe  | 37.1                 | 3,100                    | 1,200               |
| South Africa  | 47.4                 | 8,700                    | 3,400               |
| Peak Hour Congestion: Average of Tom Tom Peak Hour Congestion Index: 2013 | 32.4                 | 3,300                    | 3,200               |

**Vehicle Growth in India:**

The Indian Automobile market is a promising industrial sector that is growing immensely every passing year. The automobile industry has an enormous opportunity for creating new wealth by delivering value to the world and also to the domestic user. The four-wheeler industry in India has not been able to match up to the performance of its counterparts in other parts of the world. The main reason for this has been the regulatory atmosphere that prevailed till the deregulation in the mid- 1990s. After the liberalization the passenger car segment saw a boom and many companies from India as well as foreign entered the market. With liberalization, Government abolished licensing and removed restrictive trade policies. Automobile industry benefited greatly from these measures. The automobile industry in India happens to be the ninth largest in the world, following Japan, South Korea & Thailand. In 2009, India emerged as the fourth largest exporter of automobiles. Several Indian automobile manufacturers have spread their operations globally as well, asking for more investments in the Indian automobile sector by the MNC’s.

**Need for Study:**

This study enables to better understanding of platoon characterizing variables under heterogeneous traffic conditions facilitating enhanced safety and better operations of traffic in rapid growing cities like Visakhapatnam.

**II. LITERATURE REVIEW**

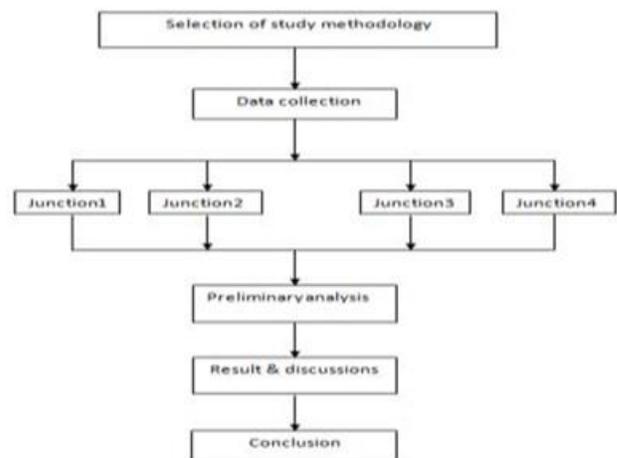
A few researchers in India have developed simulation models to study the characteristics of mixed traffic flow. Marwah and Ramaseshan developed a simulation model to study the interaction between vehicles in mixed traffic streams. The simulated traffic, due to the inherent limitations of the model, consisted of cars and other vehicles, taken one at a time. Thus, the simulated traffic consisted of only two types of vehicles at a time, though there were seven different categories of vehicles in the study stream of traffic.

Agarwal et al. simulated heterogeneous traffic flow through four-legged, right angled uncontrolled intersections.

Katti and Chari modeled the speed profile of the different categories of vehicles under mixed traffic conditions to serve as useful inputs to simulation of mixed traffic. Thus, it can be seen that the few simulation attempts made to model mixed traffic flow are not directly related to the scope of the study reported here.

Lie Yu, studied the platoon dispersion by Transyt’s macroscopic platoon dispersion method in which the determination of its major parameter is based on the empirical values. His study is based on a statistical analysis of link travel time data rather than more traditional goodness of fit tests between the observed and the projected vehicles progression patterns. The calibrations of platoon dispersion parameters using the proposed technique for the field collected data has shown that platoon dispersion parameters are instead different, even on the same street but with different travel times.

**III. RESEARCH METHODOLOGY**



**Robertson's Platoon Dispersion Model**

The basic Robertson's recursive platoon dispersion model takes the following mathematical form

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

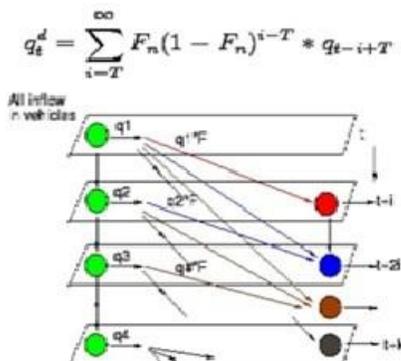
Where,  $q_t^d$ = arrival flow rate at the downstream signal at time t,  $q_{t-d}$ = departure flow rate at the upstream signal at time t-T, T = minimum travel time on the link (measured in terms of unit steps T = Ta), Ta = average link travel time, n = modeling time step duration, Fn is the smoothing factor given by:

$$F_n = \frac{1}{1 + \alpha_n \beta_n T_a}$$

$\alpha_n$  = platoon dispersion factor (unit less) n = travel time factor (unit less) Equation shows that the arrival flows in each time period at each intersection are dependent on the departure flows from other intersections. Note that the

Robertson's platoon dispersion equation means that the traffic flow  $q_t^d$ , which arrives during a given time step at the downstream end of a link, is a weighted combination of the arrival pattern at the downstream end of the link during the previous time step  $q_{t-n}^d$  and the departure pattern from the upstream traffic signal T seconds ago  $q_{t-T}$ .

Fig. 2 gives the graphical representation of the model. It clearly shows that predicated flow rate at any time step is a linear combination of the original platoon flow rate in the corresponding time step (with a lag time of t) and the flow rate of the predicted platoon in the step immediately preceding it. Since the dispersion model gives the downstream flow at a given time interval, the model needs to be applied recursively to predict the flow. Seddon developed a numerical procedure for platoon dispersion. He rewrote Robertson's equation as,



This equation demonstrates that the downstream traffic flow computed using the Robertson's platoon dispersion model follows a shifted geometric series, which estimates the contribution of an upstream flow in the  $(t-i)^{th}$  interval to the downstream flow in the  $t^{th}$  interval. A successful application of Robertson's platoon dispersion model relies on the appropriate calibration of the model parameters. Research has shown that the travel-time factor ( $n$ ) is dependent on the platoon dispersion factor ( $\alpha_n$ ). Using the basic properties of the geometric distribution, the following equations have been derived for calibrating the parameters of the Robertson platoon dispersion model.

$$\beta_n = \frac{1}{1 + \alpha_n} \text{ OR } \alpha_n = \frac{1 - \beta_n}{\beta_n}$$

The above equation demonstrates that the value of the travel time factor ( $n$ ) is dependent on the value of the platoon dispersion factor ( $\alpha$ ) and thus a value of 0.8 as assumed by Robertson results in inconsistencies in the formulation. Further, the model requires calibration of only one of them and the other factors can be obtained subsequently.

$$\beta_n = \frac{2T_a + n - \sqrt{n^2 + 4\sigma^2}}{2T_a}$$

where,  $\sigma$  is the standard deviation of link travel times and  $T_a$  is the average travel time between upstream and downstream intersections. Equation demonstrates that travel time factor can be obtained knowing the average travel time, time step for modeling and standard deviation of the travel time on the road stretch.

$$F_n = n \frac{\sqrt{n^2 + 4\sigma^2} - n}{2\sigma^2}$$

It further permits the calculation of the smoothing factor directly from the standard deviation of the link travel time and time step of modeling. Thus, both  $n$  and  $F_n$  can be mathematically determined as long as the average link travel time, time step for modeling and its standard deviation are given.

**Data Collection**

In Visakhapatnam 4junctions are used for data collection. They are

- 1) Maddilapalem to Satyam junction
- 2) Satyam junction to Gurudwar
- 3) Gurudwar to fourth town
- 4) Fourth town to Akkayyapalem

**IV. RESULTS**

**Location -1 (maddilapalem to satyam junction)**

Table - 2  
Upstream side (morning time)

| TIME        | Factor Name    | 0 meters  | 300 meters | 600 meters |
|-------------|----------------|-----------|------------|------------|
| 7AM TO 8AM  | n              | 0.88<br>2 | 0.965      | 0.928      |
|             | F <sub>n</sub> | 0.78<br>0 | 0.923      | 0.852      |
| 8AM TO 9AM  | n              | 0.94<br>7 | 0.906      | 0.977      |
|             | F <sub>n</sub> | 0.88<br>8 | 0.816      | 0.948      |
| 9AM TO 10AM | n              | 0.94<br>7 | 0.947      | 0.979      |
|             | F <sub>n</sub> | 0.88<br>8 | 0.888      | 0.953      |

Table - 3  
Downstream side (morning time)

| TIME        | Factor Name | 0 meters  | 300 meters | 600 meters |
|-------------|-------------|-----------|------------|------------|
| 7AM TO 8AM  | n           | 0.96<br>5 | 0.806      | 0.963      |
|             | Fn          | 0.93<br>3 | 0.682      | 0.923      |
| 8AM TO 9AM  | n           | 0.97<br>9 | 0.978      | 0.947      |
|             | Fn          | 0.95<br>3 | 0.951      | 0.888      |
| 9AM TO 10AM | n           | 0.94<br>2 | 0.947      | 0.961      |
|             | Fn          | 0.87<br>8 | 0.888      | 0.913      |
|             | Fn          | 0.847     | 0.921      | 0.912      |
| 6PM TO 7PM  | n           | 0.932     | 0.956      | 0.949      |
|             | Fn          | 0.859     | 0.906      | 0.892      |

Table - 4  
Upstream side (Evening time)

| TIME       | Factor Name | 0 meters  | 300 meters | 600 meters |
|------------|-------------|-----------|------------|------------|
| 4PM TO 5PM | n           | 0.99<br>0 | 0.958      | 0.979      |
|            | Fn          | 0.97<br>8 | 0.909      | 0.953      |
| 5PM TO 6PM | n           | 0.92<br>4 | 0.921      | 0.912      |

Table - 5  
Downstream side (Evening time)

| TIME       | Factor Name | 0 meters | 300 meters | 600 meters |
|------------|-------------|----------|------------|------------|
| 4PM TO 5PM | n           | 0.974    | 0.953      | 0.965      |
|            | Fn          | 0.942    | 0.899      | 0.923      |
| 5PM TO 6PM | n           | 0.934    | 0.962      | 0.944      |
|            | Fn          | 0.852    | 0.909      | 0.872      |
| 6PM TO 7PM | n           | 0.908    | 0.951      | 0.965      |
|            | Fn          | 0.818    | 0.895      | 0.923      |

Location-2 (satyam junction to gurudwar)

Table - 6  
Upstream side (morning time)

| TIME        | Factor Name | 0 meters | 275 meters | 550 meters |
|-------------|-------------|----------|------------|------------|
| 7AM TO 8AM  | n           | 0.895    | 0.925      | 0.900      |
|             | Fn          | 0.785    | 0.836      | 0.793      |
| 8AM TO 9AM  | n           | 0.936    | 0.991      | 0.916      |
|             | Fn          | 0.856    | 0.979      | 0.820      |
| 9AM TO 10AM | n           | 0.957    | 0.969      | 0.975      |
|             | Fn          | 0.899    | 0.925      | 0.939      |

Table - 7  
Downstream side (morning time)

| TIME        | Factor Name | 0 meters | 275 meters | 550 meters |
|-------------|-------------|----------|------------|------------|
| 7AM TO 8AM  | n           | 0.929    | 0.936      | 0.955      |
|             | Fn          | 0.844    | 0.856      | 0.895      |
| 8AM TO 9AM  | n           | 0.924    | 0.924      | 0.924      |
|             | Fn          | 0.857    | 0.857      | 0.857      |
| 9AM TO 10AM | n           | 0.960    | 0.944      | 0.960      |
|             | Fn          | 0.907    | 0.872      | 0.907      |

Table - 8  
Upstream side (Evening time)

| TIME       | Factor Name | 0 meters | 275 meters | 550 meters |
|------------|-------------|----------|------------|------------|
| 4PM TO 5PM | n           | 0.969    | 0.975      | 0.933      |
|            | Fn          | 0.924    | 0.939      | 0.892      |
| 5PM TO 6PM | n           | 0.951    | 0.959      | 0.962      |
|            | Fn          | 0.888    | 0.903      | 0.909      |
| 6PM TO 7PM | n           | 0.944    | 0.940      | 0.951      |
|            | Fn          | 0.872    | 0.864      | 0.888      |

Table - 9  
Downstream side (Evening time)

| TIME       | Factor Name | 0 meters | 275 meters | 550 meters |
|------------|-------------|----------|------------|------------|
| 4PM TO 5PM | n           | 0.959    | 0.957      | 0.934      |
|            | Fn          | 0.903    | 0.899      | 0.852      |
| 5PM TO 6PM | n           | 0.957    | 0.927      | 0.962      |
|            | Fn          | 0.899    | 0.840      | 0.909      |
| 6PM TO 7PM | n           | 0.934    | 0.962      | 0.944      |
|            | Fn          | 0.852    | 0.909      | 0.872      |

Location-3 (gurudwar to fourth town)

Table - 10  
Upstream side (morning time)

| TIME        | Factor Name | 0 meters | 150 meters | 300 meters |
|-------------|-------------|----------|------------|------------|
| 7AM TO 8AM  | n           | 0.913    | 0.939      | 0.897      |
|             | Fn          | 0.706    | 0.773      | 0.670      |
| 8AM TO 9AM  | n           | 0.921    | 0.943      | 0.951      |
|             | Fn          | 0.768    | 0.787      | 0.732      |
| 9AM TO 10AM | n           | 0.972    | 0.975      | 0.939      |
|             | Fn          | 0.881    | 0.895      | 0.837      |

Table - 11  
Downstream side (morning time)

| TIME        | Factor Name | 0 meters | 150 meters | 300 meters |
|-------------|-------------|----------|------------|------------|
| 7AM TO 8AM  | n           | 0.963    | 0.911      | 0.889      |
|             | Fn          | 0.852    | 0.700      | 0.633      |
| 8AM TO 9AM  | n           | 0.946    | 0.953      | 0.881      |
|             | Fn          | 0.794    | 0.816      | 0.636      |
| 9AM TO 10AM | n           | 0.959    | 0.936      | 0.929      |
|             | Fn          | 0.837    | 0.766      | 0.745      |

Table - 12  
Upstream side (Evening time)

| TIME       | Factor Name | 0 meters | 150 meters | 300 meters |
|------------|-------------|----------|------------|------------|
| 4PM TO 5PM | n           | 0.875    | 0.911      | 0.953      |
|            | Fn          | 0.626    | 0.700      | 0.816      |
| 5AM TO 6PM | n           | 0.914    | 0.889      | 0.921      |
|            | Fn          | 0.780    | 0.633      | 0.768      |
| 6PM TO 7PM | n           | 0.913    | 0.918      | 0.931      |
|            | Fn          | 0.706    | 0.719      | 0.752      |

Table - 13  
Downstream side (Evening time)

| TIME       | Factor Name | 0 meters | 150 meters | 300 meters |
|------------|-------------|----------|------------|------------|
| 4PM TO 5PM | n           | 0.941    | 0.959      | 0.946      |
|            | Fn          | 0.780    | 0.837      | 0.794      |
| 5AM TO 6PM | n           | 0.921    | 0.884      | 0.916      |
|            | Fn          | 0.708    | 0.642      | 0.713      |
| 6PM TO 7PM | n           | 0.916    | 0.900      | 0.929      |
|            | Fn          | 0.713    | 0.676      | 0.745      |

Location-4 (fourth town to akkayapalem)

Table - 14

| Upstream side (morning time) |             |          |            |            |
|------------------------------|-------------|----------|------------|------------|
| TIME                         | Factor Name | 0 meters | 300 meters | 600 meters |
| 7AM TO 8AM                   | n           | 0.932    | 0.947      | 0.965      |
|                              | Fn          | 0.860    | 0.888      | 0.923      |
| 8AM TO 9AM                   | n           | 0.936    | 0.923      | 0.963      |
|                              | Fn          | 0.867    | 0.856      | 0.912      |
| 9AM TO 10AM                  | n           | 0.963    | 0.936      | 0.926      |
|                              | Fn          | 0.912    | 0.867      | 0.904      |

Table - 15  
Downstream side (morning time)

| TIME        | Factor Name | 0 meters | 300 meters | 600 meters |
|-------------|-------------|----------|------------|------------|
| 7AM TO 8AM  | n           | 0.934    | 0.933      | 0.953      |
|             | Fn          | 0.863    | 0.899      | 0.904      |
| 8AM TO 9AM  | n           | 0.965    | 0.947      | 0.947      |
|             | Fn          | 0.923    | 0.888      | 0.888      |
| 9AM TO 10AM | n           | 0.985    | 0.985      | 0.923      |
|             | Fn          | 0.967    | 0.967      | 0.856      |

Table - 16  
Upstream side (Evening time)

| TIME       | Factor Name | 0 meters | 300 meters | 600 meters |
|------------|-------------|----------|------------|------------|
| 4PM TO 5PM | n           | 0.961    | 0.944      | 0.963      |
|            | Fn          | 0.904    | 0.881      | 0.912      |
| 5AM TO 6PM | n           | 0.940    | 0.899      | 0.928      |
|            | Fn          | 0.874    | 0.805      | 0.852      |
| 6PM TO 7PM | n           | 0.928    | 0.958      | 0.932      |
|            | Fn          | 0.852    | 0.909      | 0.859      |

Table - 17  
Downstream side (Evening time)

| TIME       | Factor Name | 0 meters | 300 meters | 600 meters |
|------------|-------------|----------|------------|------------|
| 4PM TO 5PM | n           | 0.934    | 0.933      | 0.968      |
|            | Fn          | 0.863    | 0.904      | 0.929      |
| 5AM TO 6PM | n           | 0.940    | 0.899      | 0.928      |
|            | Fn          | 0.874    | 0.805      | 0.852      |
| 6PM TO 7PM | n           | 0.968    | 0.947      | 0.947      |
|            | Fn          | 0.929    | 0.888      | 0.888      |

V. CONCLUSION

Based on the experimental study following general concluding remarks drawn during morning hours i.e. from 7A.M-10 A.M study hour and evening hours i.e. 4P.M – 7 P.M are:

1. In the bay madilipalem to satyam junction n and Fn has been gradually increased by 30-50 % and 12-15% when compared to early hour factor because of the MNC offices situated in and around Satyam Junction.

- In the bay satyam to gurudwar junction n and Fn has been gradually increased by 50-60 % and 25-30% when compared to early hour factor because of the connecting point junction of RTC complex.
- In the bay gurudwar to fourth town junction n and Fn has been gradually increased by 30-50 % and 12-15% when compared to early hour factor because of the schools situated in the arterial roads connected.
- In the bay fourth town to Akkayapalem junction n and Fn has been gradually increased by 30-50 % and 12-15% when compared to early hour factor because of the vehicles coming to port stadium situated near by and market area.
- In the bay madilipalem to satyam junction n and Fn has been gradually increased by 20 % and 20-30% when compared to early hour factor because of the closing of regular shift of MNC offices situated in and around Satyam Junction.
- In the bay satyam to gurudwar junction n and Fn has been gradually increased by 22 % and 5-10% when compared to early hour factor because of the college buses and student connecting point junction of RTC complex
- In the bay gurudwar to fourth town junction n and Fn has been gradually increased by 10 % and 30% when compared to early hour factor because of the schools situated in the arterial roads connected.
- In the bay fourth town to Akkayapalem junction n and Fn has been gradually increased by 20 % and 20-25% when compared to early hour factor because of the vehicles coming to port stadium situated nearby for walking and market area.

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