# Appraisal of Busy Traffic Intersections and Design of Coordinated Signal System

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***Abstract: Road intersections in series in urban areas lead to discord between opposing traffic flows and cause delays and accidents. To overcome these problems at intersections, the traffic flows across the intersections are controlled by using signals. The fixed timings and isolated operation of signals at each intersection along a street may cause delays on red duration and generate vehicular queue during peak hours. Proper timing and coordination of the signal timings with reference to intersection distance and the average travelling speed of vehicles can boost traffic handling capacity along the streets during busiest hours.***

***This work has been conducted to assess the current operating system of traffic signals and investigate the benefits of these signals coordinatedby using micro-simulation software PTV VISSIM. Initially, the VISSIM simulation was calibrated and the coordinated signals were run for execution based on the prepared model in VISSIM. The traffic flow delays and travel times obtained by the simulation were compared with the corresponding values before coordination. A considerable decrease in delays and travel times was noticed after coordinating the signals along the study street. It is also useful for similar traffic coordination studies elsewhere, subjected to the intervals of intersections and traffic flow characteristics are comparable.***

***Keywords: Delay, Signal coordination, Micro-simulation and VISSIM.***

## I. INTRODUCTION

Traffic signals can be considered as monitors of traffic flow for the particular area. Smooth traffic flow is to be expected on the pavements. Pavement strength and its characteristics are very important. Recent research has concluded many modern techniques to improve the strength of pavements from sub grade to surface using several admixtures (Shaik 2017, Ravindran 2016, Venkat Reddy 2018).

The design of new intersections is immensely important in developing areas. Especially in smart cities improvement of signalized intersections are important (Venkat Reddy 2017).

Coordination of signalized intersection is one of the popular concepts in traffic flow management along a street. Signal coordination cites the interlinking of timings of the signals along the intersections in street so that a platoon of vehicles traveling on the street cross through the intersections without any inconvenience or stopping for series of green lights. The objective of signals coordination is to permit the greatest number of vehicles to pass through the intersections in sequence with few or no stops.

Traffic Signal Priority (TSP) is being adopted for more than three decades to reduce delays at intersection queues (Chang, 2002). The TSP can decrease transit delay and travel time for improving overall quality of the transit service.

As a common observation, inefficiency of any urban traffic system can be attributed to the delay encountered at signalized intersections. It was found that thedelay of buses due to haltingat signalized intersections comprises about 20% of overall transitdelay (Zhang, 2001).

A mixed combination of cyclically time-expanded network and integer linear programming was formulated for simultaneously optimizing both coordination of signals and traffic assignment in an urban street network. This model can be used for evaluating extensive simulation experiments and establish as a traffic simulation model (Kohler and Strehler ,2010).

A study conducted along 12-intersection corridor on Glades Road in Boca Raton in USA to integrating VISSIM, SSAM, and VISGAOST tools for optimizing signal timings to reduce surrogate safety measures and subsequently reduce risks of potential road accidents. In addition to this study, a multiple-objective genetic algorithm was implemented with VISGAOST and identified the relationship between surrogate safety and traffic efficiency. It was found that, the optimized signal timings provided both safety and efficiency in traffic operations (Stevanovic et al, 2011).

oensell and Botteldooren (2011) studies on the Dutch vehicle fleet investigated and studied the influence of traffic signal coordination on vehicle noise and air pollutant emissions by using a microscopic traffic simulation model coupled with emission models. It was found that the largest potential reduction occurs when traffic intensities are close to capacity and the green split is low. This methodology can be used to determine the effects of a wide range of intelligent transportation systems which are integrated as coordinated signal system.

sed on the probabilistic model, a practical signal timing guideline was developed according to the percentage of stops on non-coordinated arterials. This model was developed to precisely estimate the number of stops and has been validated through VISSIM simulation of observed traffic parameters along a signalized arterial in Nevada (NDOT, 2012).

Retiming and coordination of traffic signals along a selected section of a road is one of the most cost-effective means to improve traffic flow, mitigate congestion and reduce air pollution, road-accidents and driver frustration.

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The ability to synchronize multiple intersections that are in series and thereby enhance operation of through and crossing traffic movements in a system is termed as traffic signal coordination (MnDOT, 2013).

## II. METHODOLOGY

The steps involved and the methodology adopted to conduct this study is presented in Fig.1

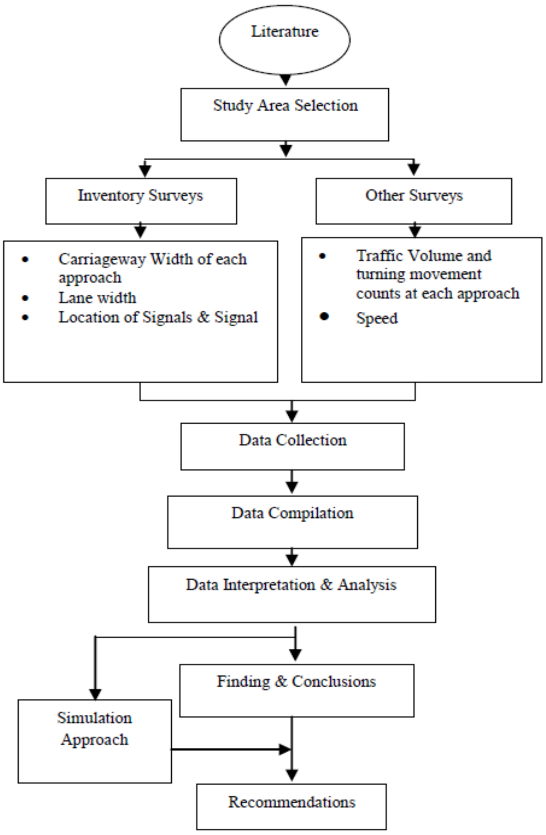


**Fig.1 Methodology Flow Chart**

## III. THE STUDY AREA

The study area considered for this project is in Hyderabad city and the urban arterial street connecting of three signalized 4-legged intersections, RTC X-Roads, Azamabad Junction and VST Junction (Fig.2). These three signalized junctions are spaced apart by 300m and 600m from VST to Azamabad junction and Azamabad to RTC X Roads Respectively.

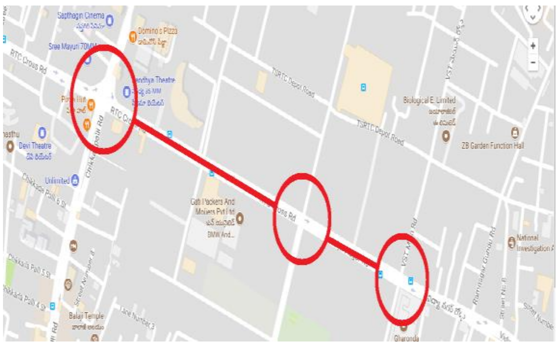

**Fig.2 Google Map showing 3 Signal Junctions**

## IV. DATA COLLECTION

The data collections at these intersections include traffic volume studies, their turning movements and travel time studies. The traffic volume study was conducted by taking video footages from Cyberabad police Commissionerate, Hyderabad. Classified turning movement volume counts of vehicles of each of each junction are presented in Table 1, 2 and 3.

**Table 1 Peak Hour flow rate at RTC X Road Signal junction**

| Approach | Move ment | Peak hour flow rate (vehicle/hour) |
|---|---|---|
| Ashok Nagar | TH | 818 |
| | LT | 228 |
| | RT | 670 |
| Hindi Mahavidyalaya | TH | 622 |
| | LT | 514 |
| | RT | 1126 |
| Koti | TH | 432 |
| | LT | 397 |
| | RT | 284 |
| Secunderabad | TH | 661 |
| | LT | 147 |
| | RT | 275 |

**Table 2 Peak Hour flow rate at Azamabad Signal junction**

| Approach | Move ment | Peak hour flow rate (vehicle/hour) |
|---|---|---|
| RTC X Road signal junction | TH | 1400 |
| | LT | 274 |
| | RT | 313 |
| Hindi Mahavidyalaya | TH | 1619 |
| | LT | 294 |
| | RT | 436 |
| TSRTC Depot road | TH | 139 |
| | LT | 758 |
| | RT | 368 |
| RTC Kalabhavan road | TH | 117 |
| | LT | 193 |
| | RT | 336 |

**Table 3 Peak Hour flow rate at VST Signal junction**

| Approach | Move ment | Peak hour flow rate (vehicle/hour) |
|---|---|---|
| Azamabad Signal Junction | TH | 1117 |
| | LT | 589 |
| | RT | 332 |
| Hindi Mahavidyalaya | TH | 1236 |
| | LT | 1683 |
| | RT | 235 |
| Ramnagar | TH | 81 |
| | LT | 367 |
| | RT | 141 |
| Sri Vaishnavi Enclave road | TH | 206 |
| | LT | 492 |
| | RH | 266 |

### A. Travel Time survey

Travel times were measured in these routes by conducting moving car method. The details of the travel times and the details are presented below.

| Direction of traffic flow | Trip 1 | Trip 2 | Trip 3 |
|---|---|---|---|
| Azamabad signal junction to VST signal junction (300m) | 1m 3sec | 1m 2 sec | 1m 7sec |
| RTC X Road signal to VST signal junction ( 900m ) | 1m 51sec | 1m 56 sec | 1m 54sec |
| Travel time from RTC X Road signal junction to VST signal junction (1200m) | 2m 54sec | 2m 58sec | 3m 1sec |
| Average speed of travel from RTC X Road signal junction to VST signal junction (1200m) | 18.62 km/hr | 18.20 km/hr | 17.90 km/hr |

The Average speed from RTC X Road junction to VST signal junction is 18.54 Kmph.

Signal Timings

The current signal timings of the three junctions are given below, the green time of all 3 junctions and their four approaches are given. These timings must be cross checked with the proposed new design and should be optimized based on coordination principles.

**Table 4 Existing Green times of 3 signal junction**

| Junction | Approach | Green time |
|---|---|---|
| RTC X RoadJunction | North | 30 seconds |
| | South | 30 seconds |
| | East | 20 seconds |
| | West | 20 seconds |
| Azamabad signaljunction | North | 24 seconds |
| | South | 22 seconds |
| | East | 15 seconds |
| | West | 15 seconds |
| VST signalJunction | North | 22 seconds |
| | South | 24 seconds |
| | East | 20 seconds |
| | West | 15 seconds |

## V. DATA ANALYSIS

For signal timing analysis, the traffic volume data and geometric data collected are summarized. The inputs considered and the Webster's method of optimum cycle length and the signal timing of the three intersections are presented below:

**RTC X Road signal junction:**

| Junction leg | NORTH | | SOUTH | | EAST | | WEST | |
|---|---|---|---|---|---|---|---|---|
| Direction of traffic | TH | RT | TH | RT | TH | RT | TH | RT |
| (PCU/hr) | 547 | 446 | 416 | 753 | 288 | 189 | 442 | 184 |
| Total (q) (PCU/hr) | 993 | | 1169 | | 477 | | 626 | |
| Width (w) | 7.75 | | 8.5 | | 6.53 | | 9.46 | |
| Saturation (s) | 4069 | | 4463 | | 3428 | | 4967 | |
| y = (q/s) | 0.244 | | 0.262 | | 0.139 | | 0.126 | |

**Azamabad signal junction:**

| Junction leg | NORTH | | SOUTH | | EAST | | WEST | |
|---|---|---|---|---|---|---|---|---|
| Direction of traffic | TH | RT | TH | RT | TH | RT | TH | RT |
| (PCU/hr) | 936 | 209 | 1083 | 293 | 93 | 46 | 77 | 226 |
| Total (q) (PCU/hr) | 1145 | | 1376 | | 339 | | 303 | |
| Width (w) | 8.58 | | 9.67 | | 7.05 | | 5.6 | |
| Saturation (s) | 4505 | | 5077 | | 3701 | | 2940 | |
| y = (q/s) | 0.254 | | 0.271 | | 0.091 | | 0.103 | |

**VST signal junction:**

| Junction leg | NORTH | | SOUTH | | EAST | | WEST | |
|---|---|---|---|---|---|---|---|---|
| Direction of traffic | TH | RT | TH | RT | TH | RT | TH | RT |
| (PCU/hr) | 742 | 220 | 821 | 156 | 53 | 141 | 136 | 176 |
| Total (q) (PCU/hr) | 962 | | 977 | | 194 | | 312 | |
| Width (w) | 8.20 | | 7.55 | | 3.5 | | 5.1 | |
| Saturation (s) | 4305 | | 3964 | | 1890 | | 2380 | |
| y = (q/s) | 0.223 | | 0.246 | | 0.102 | | 0.131 | |

### B. Traffic signal coordination

After the above signal design, we must coordinate the stretch of 900m of inbound traffic from south to north by using VISSIM (Fig. 3). This simulation model was developed in Germany by PTV AG. It is a microscopic simulation model which can simulate different modes of vehicle operations along the streets. This tool comprises of traffic simulator and signal state generator. VISSIM can also interface to traffic signal controllers type NEMA (ATAC, 2003). Time space diagram: Coordination is necessary for the signal stretch taken. The average travel time in these junctions is taken as 31kmph.The cycle lengths for RTC X Road signal junction, Azamabad signal junction and VST signal junctions are 120 seconds, 103 seconds, and 98 seconds respectively. The green time for south leg is 33seconds, 31seconds and 26seconds. Distance between intersections is 300m and 600m from VST to Azamabad and Azamabad to RTC X Road respectively.

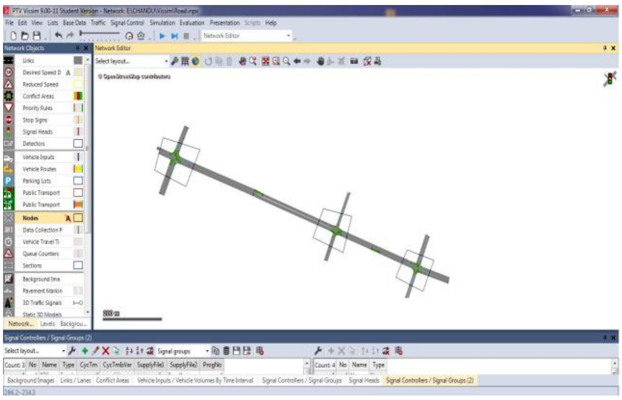

**Fig. 3 Network diagram for the three signalized junctions**

The green time is taken as bandwidth in signal coordination diagram by default and the corresponding red and amber times are indicated. The offset is determined as:

Offset for 300m = 300 / (31*(1000/3600) = 35 seconds.

Offset for 900m = 900 / (31* (1000/3600) = 104 seconds.

The time interval is taken as 20 seconds on x-axis

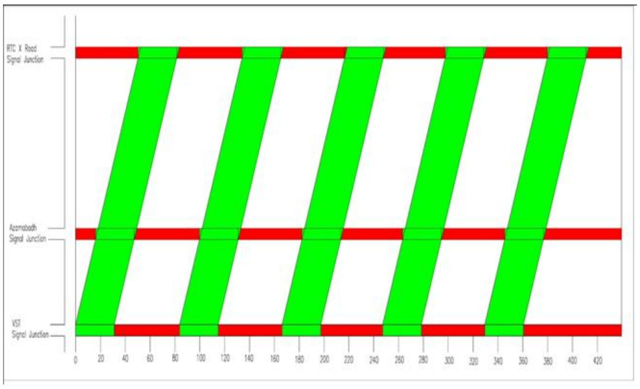


**Figure 4 One-way coordination diagram for three signalized junctions**

Presentation of One-way Coordination Diagram

Presenting one-way coordination is simpler than two-way coordination. In the above diagram (Fig.5), the x-axis and y-axis is drawn taking x- axis as time interval of 20 seconds till 420 seconds and y-axis as distance between the intersections at 300m marking horizontal line parallel to x axis, and at 600m parallel to Azamabad signal junction. At VST signal junction, at 0 seconds the green time is started marking 26 seconds this is called as bandwidth. After 26 seconds is marked, the red time continues, followed by green time and so on. This bandwidth extends through next signal and till third signal; the through band meets from VST to Azamabad signal junction at offset of 35 seconds. And there the green time is marked of 31 seconds, followed by red time and so on...up to 3 to 4 cycles. And at third signal junction at 900m with offset of 104 seconds, the green time of 33 seconds is drawn followed by red time and so on. The through band indicates the continuous movement of vehicles without any stopping.

(a) Since the cycle length and phases are not equal it will not align the through bands uniformly. Hence thismust be adjusted such that is has at least are always in same position relative to each other.

(b) Since the offsets are different i.e. 0 at first junction, 35 seconds at 2nd junction and 104 seconds at 3rd junction, the signal turns green after some time after it turns green in the first junction. If the offsets have been same or zero, then all the signal would show green at same time.

(c) There are two ways in which coordination can be achieved, one of the ways is to stop the west bound traffic at certain intersection and allow the east bound traffic to flow without any stopping or allow for west bound traffic to flow but east bound traffic will have to be stopped at one intersection.

(d) Another method is to allowboth the ways to travel without stopping by reducing the bandwidth and due to this the right turn flow must be stopped while the through flow continuous in both ways.Allowing both ways to travel reduces the bandwidth considerably.

## VI. RESULTS

The following results are obtained from the above analysis

(a) From the above analysis from the data, the signals have a very less green time for the given traffic volume, the green time of VST signal junction should be increased from 22 seconds to 26 seconds.

(b) The green time of East leg of VST signal junction should be reduced from 20 seconds to 12 seconds, because the traffic flow is meager. This reduced 8 seconds should be added to North leg and South leg approaches.

(c) The green time from Azamabad signal junction from VST to RTC X Roads should be increased from 24 seconds to 31 seconds, reducing east leg approach from 15 seconds to 11 seconds.

(d) At RTC X Road signal junction, the green time from Azamabad signal junction to RTC X Roads should be increased from 30 seconds to 33 seconds, reducing east leg approach signal from 24 seconds to 19 seconds.

(e) At RTC X Roads signal junction, the green time of south leg approach should be increased from 30 to 35 seconds, reducing west approach signal from 22 seconds to 17 seconds

(f)The one-way signal coordination of the three signalized junctionsis almost possible with progression speed of 31 kmph for the distance of 300m.

The bandwidths of each signal junctions are taken as 26 seconds at VST signal junction, 22 seconds at Azamabad signal junction, and 33 seconds at RTC X Roads signal junction, which are green times of respective intersection.

## VII. SUMMARY AND CONCLUSIONS

The summary of the current study and the conclusions drawn based on the data analysis are presented below:

## VIII. SUMMARY

The above study, data collection, analysis and results carried out are for three signalized junctions at one of the busiest vehicular traffic stretch at RTC X Road, VST signal junction, and Azamabad signal junction. These junctions have more traffic volume due to many commercial activities around it. The works carried out are measurement of geometric data of roads, traffic volume counts and travel time study. Since these are the main routes and inbound towards the city of Hyderabad and Secunderabad, HCV and multi axle vehicles are not allowed into these stretches. The types of vehicle considered for the study are two wheelers, three wheelers, cars and buses. All the parameters are calculated for peak hour traffic flow only. Signal design is carried out by Webster method, all the green times and towards north bound towards city should be changed to work more efficiently.

From the above study, the following summary can be drawn, the change in green times for all the three signal junctions is given below, some of the signal timings are changed or increased or decreased accordingly to give more priority to the major corridor

**Table 4Summary of green times of signals and the delay reductions**

| Intersection | Approach | Green time | | Improvement (%) |
|---|---|---|---|---|
| | | Before | After | |
| RTC X Road junction | N | 30 sec | 33 sec | 10.00% |
| | S | 30 sec | 35 sec | 16.67% |
| | E | 24 sec | 19 sec | 20.83% |
| | W | 22 sec | 17 sec | 22.72% |
| Azamabad | N | 24 sec | 31 sec | 29.16% |

| | | | | |
|---|---|---|---|---|
| signal junction | S | 22 sec | 33 sec | 50.00% |
| | E | 15 sec | 11 sec | 26.66% |
| | W | 15 sec | 13 sec | 13.33% |
| VST signal junction | N | 22 sec | 26 sec | 18.18% |
| | S | 24 sec | 29 sec | 20.83% |
| | E | 20 sec | 12 sec | 40.00% |
| | W | 15 sec | 15 sec | 0.00% |

All the green times are increased accordingly, the above values after design improves the signal system efficiency.

The traffic signal coordination is done by simple progressive system. The progression speed is taken as 31kmph. Therefore, all the vehicles should strictly limit the speed to 31kmph in order pass the green bandwidth. The distance between junctions is 300m and 600m Respectively; the offset is taken as 35 seconds from VST to Azamabad signal junction, and 104 seconds from Azamabad signal junction to RTC X Roads signal junction. The speed of traffic flow is also improved by 40%.

## IX. CONCLUSIONS

The following conclusions can be drawn based on the present work.

(a) Due to traffic signal coordination in this stretch, the speed of the vehicles should be increased by 40%

(b) As the speed of vehicles in the stretch increases, the travel time can be reduced considerably due to coordination.

(c) More delays are occurring at side legs of VST and Azamabad signal junction as the roads are very narrow.

(d) The U turns should not be allowed in middle of the road, at it makes the group of vehicles to stop until the vehicle clears the road.

(e) The coordination should be used only during peak hours, during non peak hours it is not useful as it makes other junctions wait which is not efficient during non peak hours.

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