Abridgment

Traffic Characteristics During Signal Change Intervals

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ABSTRACT

Driver and traffic characteristics associated with change intervals were studied at five intersections in the Tucson metropolitan area. The field studies were conducted to document the influence of (a) the variation in the duration of the yellow interval, (b) the effect of enforcement, and (c) intersection approach grades. Before and after studies were used at two of the intersections to evaluate the influence of extending the duration of the yellow interval. Generally, the major difference that resulted from a 4-sec yellow interval rather than 3 sec was the reduction in the percentage of the last vehicles through the intersection that entered on the red signal indication. The effect of enforcement was tested with a police vehicle located at the intersection approach. Although there was a reduction in the percentage of vehicles that entered the intersection on the red signal interval, other measures of driver and traffic characteristics generally showed no significant difference.

In 1981, a study entitled An Evaluation of Driver Behavior at Signalized Intersections was undertaken by the University of Arizona and Arizona State University for the Arizona Department of Transportation. The results of that study were published in January 1983 by the Arizona Department of Transportation in a report entitled An Evaluation of Driver Behavior at Signalized Intersections. A summary of that study was published in a paper by Wortman and Matthias (1).

Based on this previous work, additional research was proposed that would be undertaken in two phases. Phase I involved additional field studies of traffic characteristics and driver behavior that involved conditions and situations not included in the earlier research. The intent of the field studies was to provide information on the influence of (a) the variation in the duration of the yellow interval, (b) the effect of enforcement, and (c) intersection approach grades. Phase II of the research will focus on the development of guidelines for signal change intervals on the basis of the current status of knowledge and available information. This paper summarizes the findings of the Phase I portion of the research project.

DATA COLLECTION

Time-lapse photography techniques were utilized to record the driver behavior and traffic characteristics at selected intersections. Vehicles were filmed before the onset of the yellow signal interval, during the change interval, and until the vehicle either cleared the intersection or stopped. The camera was located so that it was possible to record the intersection and the signal indication as well as the operation of the approaching vehicles within about 350 to 400 ft of the intersection. Given the onset of the yellow signal indication, the study focused on the last vehicle to pass through the intersection and the first vehicle to stop.

DESCRIPTION OF STUDY INTERSECTIONS

Four intersections in the Tucson area were included in the field studies. At each of the intersections, one approach was observed and the study approach was located on the first street listed for each of the intersections. The following list provides detailed information for each of the intersections:

1. First Avenue and Roger Road (North Approach)
   a. Change interval: base condition--3 sec of yellow plus 2 sec of all-red; extended Yellow Condition--4 sec of yellow plus 2 sec of all-red.
   b. Approach configuration: two through lanes with an exclusive left-turn lane.
   c. Left-turn signalization: left turns permitted on a permissive basis during the through movement.
2. Wilmot Road and Broadway Boulevard (North Approach)
   a. Change interval: base condition--3 sec of yellow plus 2 sec of all-red; extended yellow condition--4 sec of yellow plus 2 sec of all-red.
   b. Approach configuration: three through-lanes with exclusive right- and left-turn lanes.
   c. Left-turn signalization: exclusive leading left-turn phase and permissive left turns during the through movement.
3. Swan Road and River Road (North Approach)
   a. Change interval: 5 sec of yellow plus 2 sec of all-red.
   b. Approach configuration: two through lanes plus a left-turn lane.
   c. Left-turn signalization: left turns on a permissive basis during the through movement.
4. Oracle Road and River Road (North Approach)
   a. Change interval: 4.5 sec of yellow plus 2 sec of all-red.
   b. Approach configuration: three through-lanes plus a left-turn lane.
   c. Left-turn signalization: turns permitted during an exclusive leading turn phase.

The First Avenue site was used to test the influence of enforcement. This intersection was selected for this part of the study primarily because pre-

vious observations at this site from the earlier study (1) revealed a relatively high percentage of drivers who entered the intersection during the all-red portion of the change interval. For this part of the research effort, a before and after approach was utilized. Following completion of the initial data collection, observations were made with a police vehicle parked along the side of the intersection approach.

Before and after studies were also used to examine the influence of the extension of the yellow interval. These studies were undertaken at the First Avenue and Wilmot Road sites. At each of these locations, the existing change interval consisted of a 3-sec yellow interval plus a 2-sec all-red phase. Field data were collected for the base conditions, and then the yellow interval was extended to 4 sec. The all-red phase was not changed.

The Swan Road and Oracle Road intersections were utilized to provide data about driver behavior where significant downgrades were involved. The intersection approach on Swan Road was approximately 2.0 percent, and the Oracle Road approach was about 2.6 percent.

DATA REDUCTION

For each of the vehicles that were the first to stop after the beginning of the yellow interval, the following information was extracted from the film:

1. The distance from the intersection at the beginning of the yellow interval,
2. The location of the vehicle when the brakes were applied (as indicated by the brake lights),
3. The location of the vehicle when it stopped,
4. The time required for the vehicle to stop,
5. The response time (determined as the time between the beginning of the yellow interval and the application of the brakes), and
6. Type of vehicle if other than a passenger car or light truck.

In addition, the behavior of the last vehicle to pass through the intersection after the beginning of the yellow was determined by making the following observations:

1. The location of the vehicle at the beginning of the yellow interval,
2. The time elapsed from the onset of the yellow interval until the vehicle entered the intersection,
3. The type of vehicle if other than a passenger car or light truck, and
4. If the vehicle entered the intersection on the red signal indication.

RESULTS

The results that are reported generally represent the descriptive statistics that describe the observed traffic and driver characteristics for each aspect of the data collection. Some limited comparative analyses were undertaken with respect to the influence of enforcement and the extension of the yellow interval. Further analyses will be undertaken in Phase II of the project.

OBSERVED TRAFFIC AND DRIVER CHARACTERISTICS

For each of the intersection approaches and the various studies conducted at a particular approach, descriptive statistics were computed for

1. Approach speeds,
2. Distance from the intersection at the beginning of the yellow interval,
3. Response time,
4. Deceleration rate, and
5. Percent of vehicles entering on the red signal indication.

Table 1 contains a summary of the observed values for each of these parameters at the study sites.

An analysis of the influence of the distance from the intersection, approach speed, or deceleration rate on the response time supported the findings of earlier work. As was found in the earlier work by Wortman and Matthias (1), there is little relationship between the response time and these individual variables.

Although the percentage of vehicles entering the intersection during the red signal decreased when the police vehicle was present, the extension of the yellow interval was a more effective treatment. At both sites where the yellow interval was extended, the percentage of vehicles entering on the red indication was significantly reduced.

THE EFFECT OF ENFORCEMENT

The effect of enforcement was analyzed by comparing the traffic and driver characteristics at the First

TABLE 1 Observed Driver and Traffic Characteristics

	Last Vehicle Through the Intersection				First Vehicle to Stop			
Intersection Approach	Posted Speed Limit (mph)	Mean Approach Speed (mph)	Mean Distance at Beginning of Yellow (ft)	Percent Entering on Red	Mean Approach Speed (mph)	Mean Distance at Beginning of Yellow (ft)	Mean Response Time (sec)	Mean Deceleration Rate (ft/sec^2)
First Avenue								
Base condition	45	38.5	131	18.4	37.9	265	1.3	11.9
With police car	45	38.3	115	8.6	37.7	260	1.4	12.5
Before extension	45	39.8	136	15.6	38.2	247	1.2	12.9
After extension (dry)	45	40.3	118	1.5	42.1	238	1.1	12.1
After extension (wet)	45	40.3	119	0.0	35.9	242	1.3	11.0
Wilmot Road								
Before extension	40	35.1	106	9.8	35.8	240	1.4	13.2
After extension	40	32.1	101	3.0	32.9	223	1.3	12.0
Swan Road	45	46.3	205	3.6	47.5	309	1.0	8.3
Oracle Road	50	42.9	146	1.4	41.3	274	1.1	10.1

Avenue site by using the base condition and condition with the police vehicle at the site. There were no significant differences in the parameters except that the distance from the intersection at the onset of the yellow signal indication for the last vehicle through the intersection decreases when the police vehicle was at the site.

THE EFFECT OF EXTENDING THE YELLOW INTERVAL

At the two intersections where the yellow interval was extended, the data obtained from the before-and-after studies yielded mixed results. For the First Avenue site, the mean speed of the first vehicle to stop was significantly higher during the after condition. Also, the mean distance from the intersection at the onset of the yellow interval was significantly less for the last vehicles through the intersection. These significant differences could be the result of differences in the traffic stream rather than the effect of the extension of the yellow interval. At this site, all other differences were not significant. In contrast, the mean approach speeds, response time, and deceleration rate at the Wilmot Road site were significantly lower in the sample taken after the extension of the yellow interval.

As has been indicated previously, the extension of the yellow did reduce the percentage of vehicles entering on the red signal indication. These results tend to support the findings and conclusions of Stimpson, et al. (2). In their study, it was found that extensions of the yellow duration substantially reduced the frequency of potential intersection conflicts.

THE EFFECT OF WET PAVEMENT

Although the sample size for the wet conditions was quite small, a comparative analysis of the wet and dry conditions at the First Avenue site was made. For this analysis, only the observations made after the extension of the yellow were made. There were no significant differences except that the approach speeds of the first vehicles to stop were significantly lower.

CONCLUSIONS

Although further analysis of the data base will be undertaken in a later phase of the project, several conclusions can be drawn based on this part of the study. The conclusions can be summarized as follows:

1. The presence of the police vehicle at the study site generally did not affect the measured traffic characteristics and driver behavior. With the police vehicle at the site, the percentage of vehicles entering the intersection during the red signal indication was reduced. The extension of the duration of the yellow signal interval, however, was more effective in reducing this percentage.
2. An analysis of traffic characteristics and driver behavior at the two study sites revealed somewhat mixed results when the duration of the yellow interval was extended. At both sites, however, the percentage of vehicles entering during the red signal indication was reduced following the extension of the yellow interval.
3. Data collected at the sites with significant downgrades did indicate lower deceleration rates and response times when compared with the other sites.
4. Based on the limited observations at the one site, the wet condition did not have a significant effect except that the approach speed of the stopping vehicles was lower with the wet pavement.
5. No relationship was found between response time and the distance from the intersection at the onset of the yellow interval, approach speed, or deceleration rate. Further analysis will be required to determine if response time is a combined function of several of these variables.

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