



# The Effects of Countdown Signals on Drivers' Behavior at Intersections

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## Abstract

This study examined the effect of countdown signals on driver behavior at intersections based on data collected at five intersections. From the vehicle speed statistics, it was found that drivers tend to speed up to pass an intersection when the remaining time on the countdown timer is running out. It was not such a case when the countdown signal was not in use. As a result, the red-light violation rates for both with and without the countdown signal are not different.

**Discipline:** Civil Engineering

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## 1 Introduction

Road accident is a major problem in Thailand. The 2019 road accident analysis report of TRAMs (Ministry of Transport: MOT) reported that the sum of accidents on the road of MOT is 20,007 times, which is consisted of 3,277 deaths and 18,217 injuries. Accident on MOT roads tends to increase in the past five years. The accidents in 2019, when compared with in 2018, are increasing by 1.85 percent in total with increasing of 6.67 percent in deaths and by 2.71 percent in injuries. From this report, the accident location usually occurred on a straight road 13,557 times (67.53 percent in total), on a curve road 2,530 times (12.65 percent in total), at the intersection with

1,390 times (6.95 percent in total) and the rest is the other location. The accident at the intersection is in the third location where accidents usually occur.

In Thailand, two types of intersections are at grade intersections and grade separation intersections. For grade intersections, there is usually controlled with a different type of traffic control, such as non-signal control, signal control, roundabout, and so on. Signal control is mostly used for urban intersections in Thailand that is installed many types of devices, for example, the sensor, the countdown signal, etc.

The countdown signal is used to help the driver to estimate the signal time, which can reduce the start-up loss time. However, other consequences are the tendency to speed up to go through the intersection, the traffic light violation, driving through the intersection before the green time, and so on. Therefore, the driver's behavior due to using the countdown signal should be researched that can be used without negative results.

This research collected the speed of the car when enters the intersection and when the green light changes to the yellow light, which can be described as how the driver's behavior is responded to the countdown signal, the approaching speed at the intersection and the traffic light violation. The objective of this study is to compare the driver's behaviors between the free flow traffic and the entering traffic at the intersection Also, this study is to compare the traffic light violation between the use of the countdown signal and the non-countdown signal. Finally, this research studies the driver's behavior at the use of the countdown signal when the traffic light changes from green to yellow.

## 2 Methodology

### 2.1 Selection of the Representative Intersection

The scope of the study area is the major highways under the department of highways. The chosen intersections are the intersections along Highways No.12 and Highways No.201 in Khon Kaen province. Five chosen intersections are installed the countdown signals (Figure 1), which are (1) the Aom Sin Bank intersection (2) Chum Pae Municipality intersection (3) the Nong Ruea intersection (4) the Don Mong intersection (5) the Kut Num Sai intersection.



**Figure 1:** Intersection with the countdown signal

The locations of the five intersections are shown in Table 1

**Table 1:** The information about the selected intersections

No.	Common Name	Highways No.	Location
1	Aom Sin Bank intersection	12	Chum Pae, Khon Kaen
2	Chum Pae Municipality intersection	12	Chum Pae, Khon Kaen
3	Nong Ruea intersection	12	Nong Ruea, Khon Kaen
4	Don Mong intersection	12	Nong Ruea, Khon Kaen
5	Kut Num Sai intersection	201	Chum Pae, Khon Kaen

## 2.2 Data Collection

### 2.2.1 Approaching Speed of Cars at Intersection

In this study, the speed is collected by using the speed camera. The collected speed of five selected intersections is when the car enters the intersection in the green to yellow signal changing period. These speeds are collected in two situations, when using the countdown signal and not using the countdown signal. These speeds are collected at least 80 samples for each intersection. Before collecting data, the distance sign is installed at 5 meters intervals from the stop line to 130 meters and the distance exceeds the yellow light distance of about 111 meters (Yellow signal time is 5 minutes). After that, measures speed by using the speed camera from the approaching car at the intersection. The first speed measurement is when the changing signal period is from the green to the yellow signal and then, measured when the car enters the intersection with the same car. The collected data is the speed of the car, the distance from the stop line to the car, the type of vehicle, and the traffic light violation.

### 2.2.2 Free Flow Speed Before the Intersection

Measure the free flow speed before the intersection is done by collecting the mid-block speed so that traffic is not influenced by the intersection. These research intersections are in the urban area and during the construction before the intersection, so the driver's behavior can be affected. The free flow speed is collected with 200 vehicles per intersection that can be compared with the approaching speed as shown in Figure 2.



**Figure 2:** The intersection and the location of measuring the free flow speed

## 2.3 Data Preparation for Analysis

### 2.3.1 Data Preparation for Analysis of the Approaching Speed

The preparation of the collected data is to extract the speed into two groups, when the changing signal period from the green to the yellow light, and the approaching speed at the intersection. Then use these data to compare the use of the countdown signal and not using the

countdown signal. Also, the sample of the vehicle is divided into Group 1 the vehicle in the yellow light period that means no traffic light violation, and Group 2 the vehicle that cannot pass through the intersection within the yellow light that should stop or speed up to pass through the intersection.

### 2.3.2 Data Preparation for Analysis of the Free Flow Speed Before the Intersection

The data used in this study is only from the passenger car and the van. These free-flow speeds are used to compare with the approaching speed at the intersection to see the difference and the factor related to this analysis.

## 3 Analysis and Results

### 3.1 Comparison of Free Flow Speed with Approaching Speed at the Intersection

To analyze for determine the average speed of the vehicle to know the driver's behavior at mid-block of road that is far from the intersection is free to flow speed for these five intersections. Then, using t-Test: Two-Sample Assuming Unequal Variances to compare with the approaching speed at the intersection. At a 95% confidence level, it can be found that the free flow speed is more than the approaching speed at the intersection. The reason for this is due to the geometry of the intersection and the urban area, so the driver reduces the speed. The analysis is shown in Table 2 and Table 3

**Table 2:** Free flow speed at the intersection

Intersection	Sample	Min.	Max.	SD.	Free Flow Speed
Aom Sin Bank	200	65	125	10.15	85.6
Chum Pae Municipality	200	60	125	10.61	85.5
Nong Ruea	200	60	105	9.65	82.7
Don Mong	200	70	148	11.94	88.8
Kut Num Sai	200	63	121	10.7	83.1

**Table 3:** Approaching speed at the intersection

Intersection	Sample	Min.	Max.	SD.	Approaching Speed
Aom Sin Bank	108	33	92	11.4	65.4
Chum Pae Municipality	128	20	115	12.97	66.7
Nong Ruea	126	41	95	11.27	69.6
Don Mong	105	49	95	10.12	74.3
Kut Num Sai	118	32	85	11.33	63.8

### 3.2 Comparison of the Driver's Behavior about Traffic Signal Violation of Vehicle

To analyze the driver's behavior and whether they will stop or violate the traffic signal and compare this between using the countdown signal and not using the countdown signal for these five intersections. This analysis has divided the group of vehicles into two groups, Group 1 the vehicle in the yellow light period, and Group 2 the vehicle that cannot pass through the intersection within the yellow light used to analyze the statistic about the effects of the countdown

signal to the decision of driver by calculating the percent of the vehicle that stop or pass through within the yellow light period.

### 3.2.1 The Driver's Behavior with the Countdown Signal

In 404 vehicles of five intersections with the countdown signal, the results are shown that 153 vehicles are Group 2 that should stop at the intersection. However, this group of vehicles traffic light violations about 101 vehicles (66% of Group 2) and the rest stops at the stop line 52 vehicles (34% of Group 2). For Group 1, 521 vehicles can pass through the intersection within the yellow light period. This found that 172 vehicles pass through the intersection (69% of Group 1) and 79 vehicles stop at the stop line (31% of Group 1). The results are shown in Table 4.

**Table 4:** Comparison of traffic light violations between stopped vehicles and passed through the vehicle with the countdown signal

Intersection	Group 2 Vehicle exceeds the yellow light distance (Vehicle)			Group 1 Vehicle in the yellow light distance (Vehicle)		
	Pass through	Stop	Total	Pass through	Stop	Total
Aom Sin Bank	23	20	43	28	9	37
	53%	47%	100%	76%	24%	100%
Chum Pae Municipality	5	2	7	54	19	73
	71%	29%	100%	74%	26%	100%
Nong Ruea	33	1	34	34	15	49
	97%	3%	100%	69%	31%	100%
Don Mong	26	19	45	19	17	36
	58%	42%	100%	53%	47%	100%
Kut Num Sai	14	10	24	37	19	56
	58%	42%	100%	66%	34%	100%
Total	101	52	153	172	79	251
	66%	34%	100%	69%	31%	100%

### 3.2.2 The Driver's Behavior Without the Countdown Signal

**Table 5:** Comparison of traffic light violations for not using the countdown signal

Intersection	Group 2 Vehicles exceed the yellow light distance (Vehicle)			Group 1 Vehicle in the yellow light distance (Vehicle)		
	Pass through	Stop	Total	Pass through	Stop	Total
Aom Sin Bank	10	0	10	48	22	70
	100.0%	0.0%	100.0%	68.6%	31.4%	100.0%
Chum Pae Municipality	5	2	7	54	19	73
	71.4%	28.6%	100.0%	74.0%	26.0%	100.0%
Nong Ruea	10	0	10	49	21	70
	100.0%	0.0%	100.0%	70.0%	30.0%	100.0%
Don Mong	28	4	32	32	16	48
	87.5%	12.5%	100.0%	66.7%	33.3%	100.0%
Kut Num Sai	17	3	20	50	10	60
	85.0%	15.0%	100.0%	83.3%	16.7%	100.0%
Total	70	9	79	233	88	321
	88.6%	11.4%	100.0%	72.6%	27.4%	100.0%

In 400 vehicles without the countdown signal, the results are found that 79 vehicles is in the exceeding yellow light distance (Group 2) 70 vehicles are traffic light violations (89% of Group 2) and 9 vehicles are stopping at the stop line (11% of Group 2). For Group 1, there are 321 vehicles in Group 1 with 233 vehicles passing through the intersection (73% of Group 1) and 88 vehicles stopping at the stop line (27% of Group 1). The results are shown in Table 5

### 3.3 Comparison of Approaching Speed at the Intersection

This analysis is to compare the average speed for the countdown signal and not using the countdown signal of these five intersections. As divided the data into two groups, Group 1: Vehicle in the yellow light distance and Group 2: Vehicle exceeding the yellow light distance, theses collected data is used to analyze the speed when the driver saw the change of green to yellow signal and speed when the vehicle is entering the intersection. This analysis is using t-Test: Paired Two Sample Means to compare the average speed with these collected speeds. At a 95% confidence level, the analysis results of the countdown signal and not using the countdown signal are as follows:

#### 3.3.1 Approaching Speed for the Countdown Signal

For 273 collected vehicles, the results found that 101 vehicles in Group 2 should reduce their speed to stop at the intersection. However, some of these vehicles in Group 2 significantly accelerated their speed from 71.9 km/hr to 76.8 km/hr. For Group 1, 172 vehicles can pass through the intersection without speeding up. These vehicles in Group 1 also significantly accelerated their speed through the intersection from 66.7 km/hr to 69.5 km/hr. These results are shown in Table 6

**Table 6:** Approaching speed for using the countdown signal

Intersection	Group 2 The speed of the vehicle exceeds the yellow light (km/hr)				Group 1 Speed of vehicle in the yellow light (km/hr)			P.
	At changing the signal from Green to Yellow	At the intersection	Number of Vehicles (Vehicle)	P.	At changing the signal from Green to Yellow	At the intersection	Number of Vehicles (Vehicle)	
Aom Sin Bank	68.6	76.4	23.0	4.5E-5	63.6	67.7	28.0	0.026
Chum Pae Municipality	74.0	74.2	5.0	0.462	66.9	70.1	54.0	0.001
Nong Ruea	73.7	76.3	33.0	0.039	69.5	70.8	34.0	0.169
Don Mong	74.8	80.2	26.0	4.0E-4	71.0	74.6	19.0	0.006
Kut Num Sai	67.6	73.8	14.0	0.007	64.1	66.5	37.0	0.002
Total	71.9	76.9	101.0	5.9E-9	66.7	69.6	172.0	1.8E-6

#### 3.3.2 Approaching Speed For not Using the Countdown Signal

For 312 collected vehicles, the results found that 96 vehicles are in Group 2 which should reduce the speed to stop at the intersection. These vehicles are used at constant approaching speeds from 67.8 km/hr to 67.6 km/hr. And, the total collected data in Group 1 are 216 vehicles that

also have the constant speed to pass through the intersection from 62.5 km/hr to 62.3 km/hr. These results are shown in Table 7

**Table 7: Approaching speed for not using the countdown signal**

Intersection	Group 2 The speed of the vehicle exceeds the yellow light (km/hr)				Group 1 Speed of vehicle in the yellow light (km/hr)			P.
	At changing the signal from Green to Yellow	At the intersection	Number of Vehicles (Vehicle)	P.	At changing the signal from Green to Yellow	At the intersection	Number of Vehicles (Vehicle)	
Aom Sin Bank	58.5	58.4	10	0.473	58.3	60.2	47	0.086
Chum Pae Municipality	66.2	67.1	31	0.292	64	60.3	38	0.05
Nong Ruea	64.3	65.4	10	0.284	63.4	64.9	49	0.089
Don Mong	73.6	72	28	0.078	69.2	71.2	32	0.069
Kut Num Sai	68.9	68	17	0.317	60.2	57.6	50	0.04
Total	67.8	67.6	96	0.376	62.5	62.3	216	0.369

## 4 Conclusion

From this study, it can be concluded as following

The roadside environment and geometry of highways can be used to reduce the free flow speed for entering the signalized intersection in the urban area and the changing geometry.

From the five collected speeds at the intersection, the intersection with the countdown signal causes an increase in speed more than the intersection without the countdown signal.

For the driver's behavior entering the intersection, the intersection with the countdown signal does not cause an increase the traffic light violation more than the intersection without the countdown signal.

From this study, the suggestion for installing the countdown signal is as follows

The countdown signal should be used with the medium average speed at the intersection and the signal plan should be calculated for the geometry of highways. The reason is that drivers' behavior tend to speed up when passing through the intersection. Also, the driver tends to quickly go from the intersection because of knowing the changing period to the green signal.

Before installing the countdown signal, the traffic data should be collected that is the free flow speed before the intersection and at the intersection. If the speed is not more than the speed limit and the speed is reduced at the intersection, this intersection can be considered to use the countdown signal. This can be caused by the geometry of highways and the roadside environment.

## 5 Availability of Data and Material

Data can be made available by contacting the corresponding author.

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