CHAPTER 6 Timing Processes on One Approach

Purpose

The duration of the green interval for an actuated controlled intersection depends on the interaction of the traffic demand and the actuated control settings. In Chapter 6, you will learn about two of these settings that are so crucial to the efficient operation of the intersection: the minimum green time and the passage time. You will consider these two timing parameters in the context of a related component: the placement and length of the detection zone. You will learn that, in practice, you need to decide what conditions you will tolerate. Do you want to risk that the green will terminate too soon and leave some vehicles unserved? Or, do you want to risk that the green will not terminate soon enough, resulting in wasted green time? Balancing these risks is one of the keys to efficient and effective signal timing.

Learning Objectives

When you have completed the activities in this chapter, you will be able to

- Describe the interaction of the minimum green time, the passage time, and the detection zone length in producing efficient intersection operation
- Describe the timing processes for actuated traffic control
- Describe how the length of the detection zone affects the setting of the basic timing parameters
- Relate the length of the detection zone to the duration of the green indication
- Relate the length of the minimum green time to the efficient operation of a phase
- Describe the variation of vehicle headways in a departing queue
- Establish a desired maximum allowable headway
- Relate the maximum allowable headway to unoccupancy time
- Determine the vehicle extension time based on the length of the detection zone and the desired maximum allowable headway
- Select a maximum allowable headway
- Compare headway distributions for one lane and two lane data
- Select passage time values for one lane and two lane approaches
- Contrast design values with those recommended in practice

Chapter Overview

This chapter begins with a *Reading* (Activity #30) on the relationship between the minimum green time, the passage time (or vehicle extension time), and the detection zone length. The chapter then proceeds to eight activities including an assessment of your understanding of the basic concepts of passage time and detection zone length (Activity #31), four discovery activities in which you will learn about the timing processes through observation of simulation, particularly the factors that should be considered when the minimum green time and the vehicle extension time parameters are set, for a given length of the detection zone. In Activity #32, you will see that the detection zone itself can provide some extension of the green as vehicles arrive at the intersection and enter the zone. You will learn in Activity #33 how the minimum green time must be set long enough so that the queue begins to move but short enough so that the phase doesn't extend inefficiently when very short queues are present. You will learn about the variation in headways in a departing queue (Activity #34) and how the headways relate to the unoccupancy time and the vehicle extension time (Activity #35). As part of the two design activities, you will set the maximum allowable headway and the passage time (Activities #36 and #37). The chapter concludes with an *In Practice* activity (Activity #38) in which you compare your design results with the setting of actuated timing values described in the *Traffic Signal Timing Manual*.

Activity List

Number and Title		Type
30	Considering Minimum Green Time, Passage Time, and Detection Zone Length	*Reading*
31	What Do You Know About Detection Zone Length and Passage Time?	*Assessment*
32	Relating the Length of the Detection Zone to the Duration of the Green Indication	*Discovery*
33	Determining the Length of the Minimum Green Time	*Discovery*
34	Understanding the Variation of Vehicle Headways in a Departing Queue	*Discovery*
35	Relating Headway to Unoccupancy Time and Vehicle Extension Time	*Discovery*
36	Determining the Maximum Allowable Headway	*Design*
37	Determining the Passage Time	*Design*
38	Actuated Traffic Control Processes	*In Practice*

ACTIVITY

30 Considering Minimum Green Time, Passage Time, and Detection Zone Length

READING

Purpose

The purpose of this activity is to provide you with the opportunity to learn more about how the selection of the basic actuated traffic control timing parameters (minimum green time and passage time) are related to the length of the detection zone.

Learning Objective

- Describe the interaction of the minimum green time, the passage time, and the detection zone length in producing efficient intersection operation

Deliverables

- Define the terms and variables in the Glossary
- Prepare a document that includes answers to the Critical Thinking Questions

Glossary

Provide a definition for each of the following terms. Paraphrasing a formal definition (as provided by your text, instructor, or another resource) demonstrates that you understand the meaning of the term or phrase.

call	
detection zone	
interval	
maximum allowable headway	
occupancy time	

recall	
unoccupancy time	
h	
L_d	
L_v	
t_o	
t_u	
v	

CRITICAL THINKING QUESTIONS

When you have completed the reading, prepare answers to the following questions.

1. Describe how passage time and the length of the detection zone are related.

2. What is one criterion for terminating a phase?

3. When using a standard loop detector with stop bar presence detection, why is it difficult to determine when a queue has cleared?

4. Explain why the passage time should be decreased when the detection zone length is increased.

5. Explain how variability in the vehicle lengths and speeds affect the determination of the passage time.

6. Describe in your own words the implications of the data presented in Figure 111.

7. Since vehicle headways vary widely and are not constant, even during periods of saturation flow, explain the risks involved in setting the passage time.

8. Summarize your understanding of the headway variability for the four time segments of vehicles departing after the start of green.

9. Describe how the problem of determining passage time changes when considering a two-lane approach.

INFORMATION

Introduction

Consider an actuated traffic control system with stop bar presence detection on a single-lane approach. A vehicle requests service by passing into the detection zone. The request is processed when the associated phase is next in the controller sequence. The timing of the phase is based on the interaction of the vehicle request (or call), the length of the detection zone, and the value of three timing parameters (the minimum green time, the passage time, and the maximum green time) as shown in the traffic control process diagram in Figure 107. In this example, six vehicles are stopped at the intersection at the beginning of green. They travel through the intersection when the green indication begins, as shown by the time-space trajectories, and the detection system responds to these vehicles (box at top left). The detector calls activate the controller timing processes (box at top right), and the signal displays respond to the controller timing processes and logic (box at bottom right). Finally, to "close the loop", the vehicles respond to the display status (box at lower left).

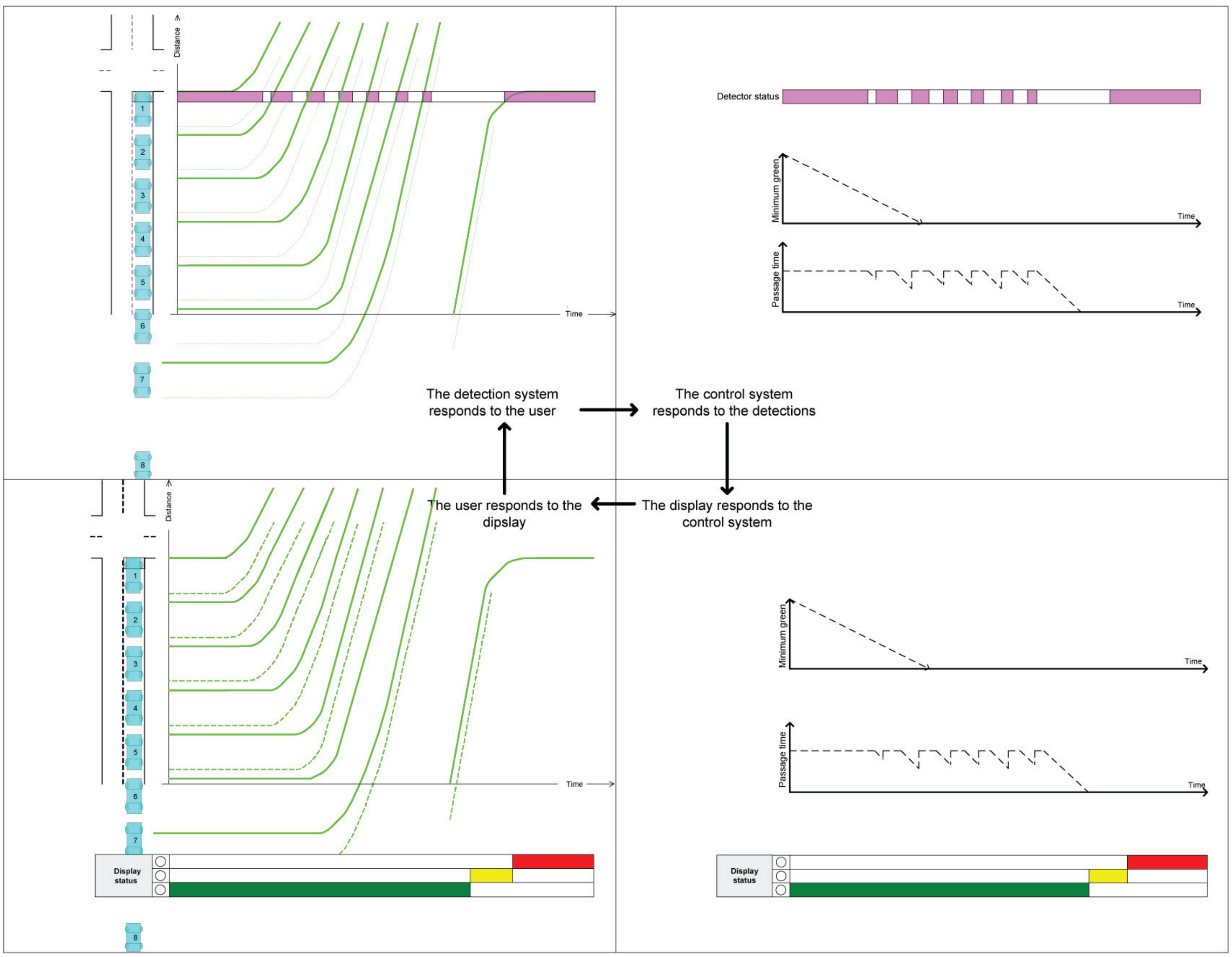


Figure 107. Traffic control process diagram

The purpose of the minimum green timing interval in the case of stop bar presence detection is to make sure the green is displayed for at least as long as driver expectation. Driver expectation can be thought of as a time so short that if the minimum green time is less than this time the public may complain or identify what they perceive to be a problem. The minimum green time does not have to account for a slow moving vehicle because as long as the vehicle is in the detection zone the call will be extended until it clears the stop bar. The minimum green time is generally lowest for left turns, more for side streets, and longest for through movements on the main street.

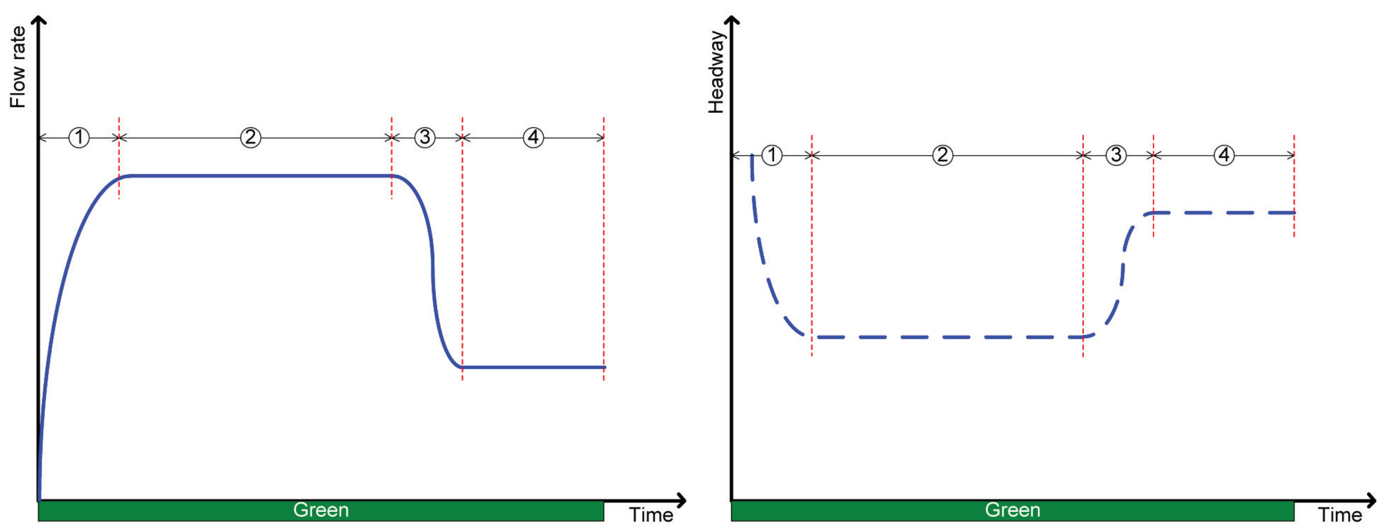
The purpose of the passage timer is to extend the phase as long as the headway between vehicles is less than a specified value called the maximum allowable headway (MAH). The goal is to make sure that green is displayed as long as a queue is present but then to terminate the phase when the queue has cleared.

In this chapter you will learn more about two of these timing parameters, the minimum green time and the passage time. Activities related to the maximum green time are included in Chapter 7.

A Theoretical Foundation: Traffic Flow Theory for Queue Clearance

The traffic flow process of queue clearance can be represented as a flow profile diagram, as shown in Figure 108a. In the first segment of the green interval (noted as "1" in the figure), the flow rate increases as the queue begins to move from the stop bar into the intersection. This time period is characterized by the start-up lost time parameter described in the Highway Capacity Manual (HCM), and includes the first four vehicles in queue. In the second segment of the green interval, beginning with the fifth vehicle in queue, vehicles depart at the saturation flow rate. The HCM suggests an ideal value of 1900 vehicles per hour of green for the saturation flow rate.

When the queue has cleared, vehicles arrive at and depart from the intersection at a constant rate, with no delay. This is shown as the fourth segment of the green interval where the flow is represented as uniform. The segment between the queue clearance period (the second segment) and the period after the queue has cleared (the fourth segment) is the transition, or third, segment. It is during this third segment, after the queue has been served, that the phase should be terminated and service transferred to the next phase in the controller sequence. This process can also be represented in terms of headways, as shown in Figure 108b. The headway during the second segment is the saturation headway.



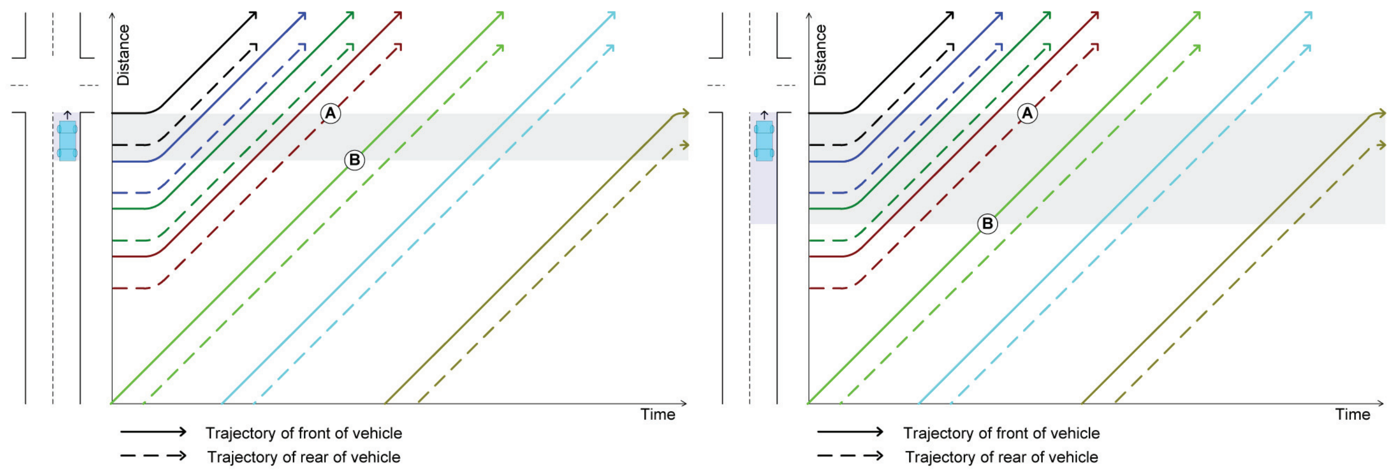
a. Departure flow profile diagram

b. Departure headway profile diagram

Figure 108. Departure flow and headway profiles

Headway and Unoccupancy Time

In the field, traffic control systems don't typically measure flow rates or headways but rather whether the detection zone is occupied or not. Unoccupancy time is defined as the time that the detection zone is not occupied by a vehicle. Figure 109 shows a time space diagram representation of vehicles departing in a queue at the beginning of green and then arriving and departing without delay after the queue has cleared for two different detection zone lengths (shown in gray shade). When the unoccupancy time reaches the passage time set in the controller, the phase is terminated. The unoccupancy time depends directly on the length of the detection zone, as well as the vehicle speed (which may vary over time) and vehicle length. In Figure 109a, with a shorter detection zone, the horizontal distance between points A and B represents the unoccupancy time, the time between the fourth vehicle leaving the detection zone and the fifth vehicle arriving in the detection zone. In Figure 109b, with a longer detection zone, the event represented by point B occurs before that represented by point A (vehicle 5 arrives in the detection zone before vehicle 4 leaves the zone), so the unoccupancy time is zero.



a. Short detection zone

b. Long detection zone

Figure 109. Time-space diagram for long and short detection zones

Maximum Allowable Headway (MAH)

Bonneson and McCoy (2005) established the concept of the MAH as the maximum headway that will be tolerated in the traffic stream before the phase is terminated. The analytical relationship between the unoccupancy time and the MAH can be developed as follows.

The headway (h) between two vehicles traveling on an intersection approach and through a detection zone consists of two parts, the time that the detection zone is occupied by the first vehicle and the time that the zone is unoccupied after the first vehicle leaves the zone and before the second vehicle arrives into the zone.

$$h = t_o + t_u$$

where t_o is the occupancy time and t_u is the unoccupancy time. The time that the detector is occupied (t_o) is equal to the length of the detection zone (L_d) plus the length of the vehicle (L_v), divided by the speed at which the vehicle is traveling (v).

$$t_o = \frac{L_d + L_v}{v}$$

Thus, we can write the unoccupancy time (t_u) as follows:

$$t_u = h - \frac{L_d + L_v}{v}$$

This relationship is shown graphically in Figure 110. The occupancy time (t_o) is the time that it takes vehicle 1 to travel its own length plus the length of the detection zone. The unoccupancy time (t_u) is the time from when vehicle 1 leaves the detection zone until vehicle 2 arrives in the detection zone. The headway (h) is the sum of the occupancy time and the unoccupancy time.

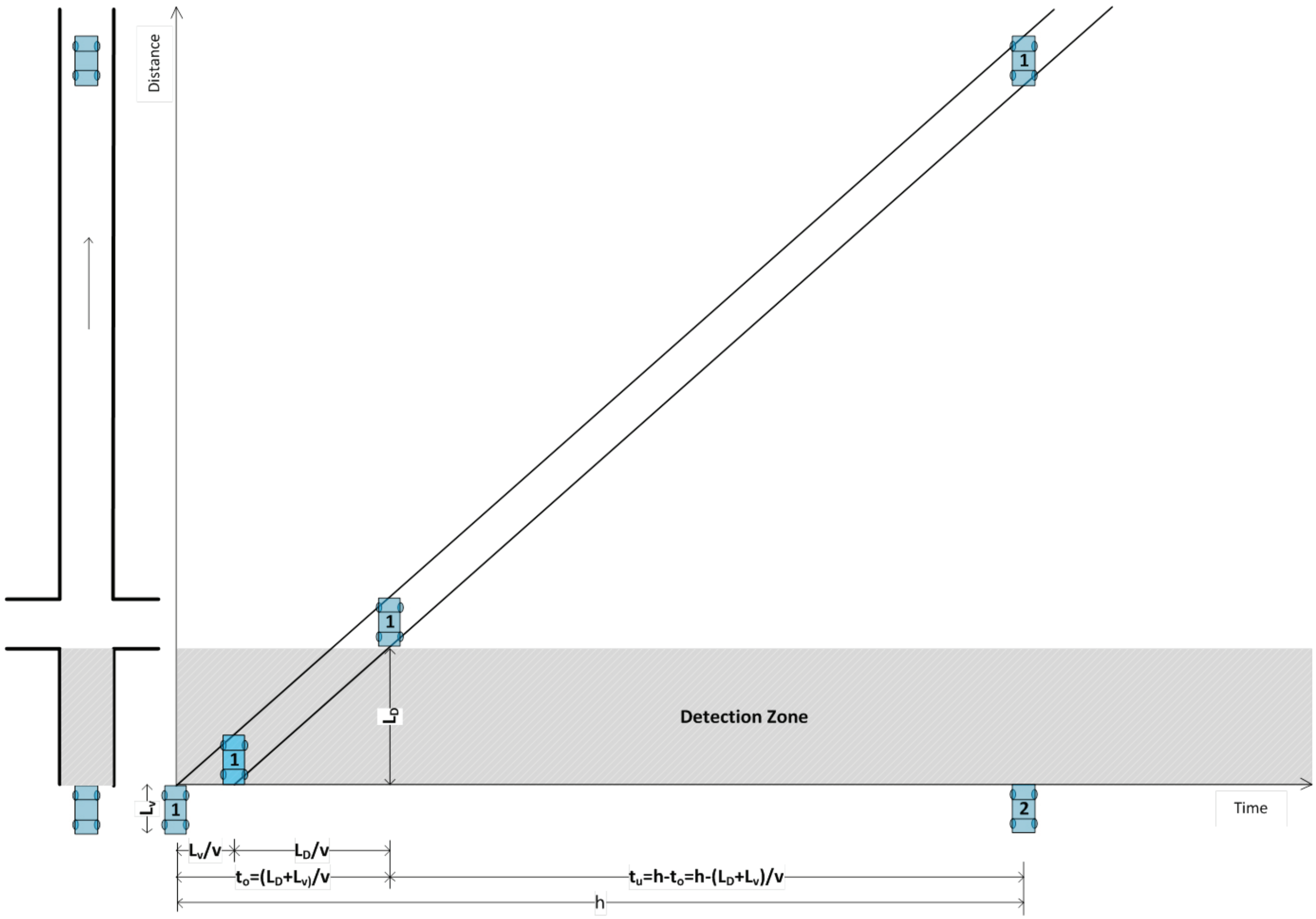


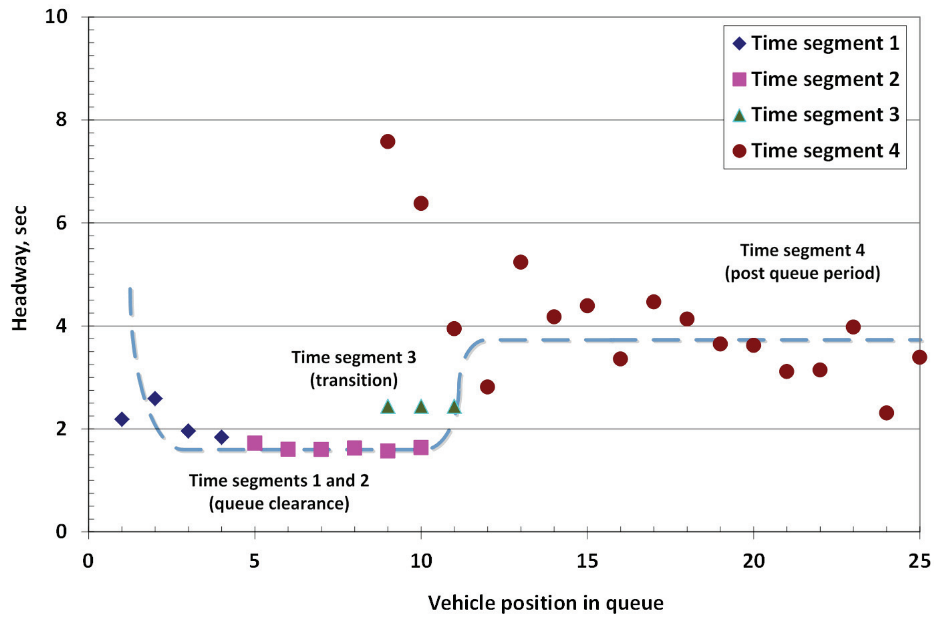
Figure 110. Headway, occupancy time, and unoccupancy time

A Stochastic Perspective Using Simulation Data

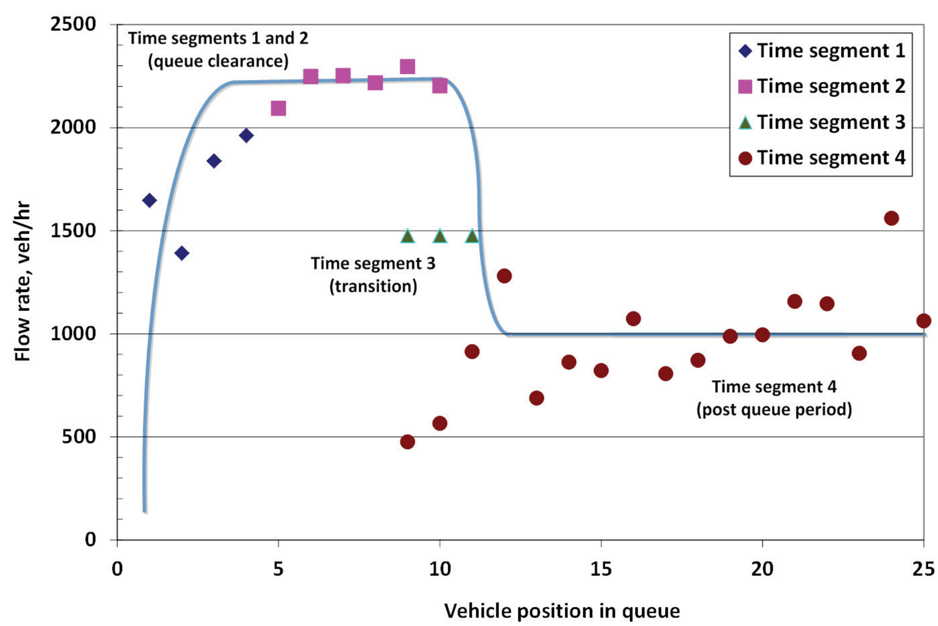
The reality is that queue clearance is a messy process with field measured values of headway and flow rate varying significantly about the theoretical values shown in Figure 108. Drivers respond to the change to green at different rates, and once they begin to move, they establish varying following distances behind the preceding vehicle. Since our desire is to extend the green only as long as a queue is present, and to terminate the green when the queue has cleared, we need to better understand the stochastic nature of this process. This involves understanding the headway, flow rate, and unoccupancy time distributions during queue clearance (time segments 1 and 2), the transition period (time segment 3) and the post-queue period (time segment 4).

To gain a perspective on this problem, the results from a set of simulation runs using the VISSIM microscopic simulation model are presented here (Kyte, Urbanik, & Amin, 2007). For these simulations, the queue at the beginning of green ranged from eight to ten vehicles. The traffic control was set to fixed time so that additional vehicles would be served after this initial queue had cleared and a comparison between headways of vehicles in the departing queue and during the post queue period could be made.

Figure 111a shows the mean headways measured for the first 25 vehicles passing the stop bar at the beginning of green. The dashed line represents the theoretical departure headways shown previously in Figure 109b. The simulation data are shown varying about this theoretical line, the kind of stochastic variation that we expect to see in the field. The headways measured during queue clearance vary in a narrow range about the theoretical line. However, the headways during the post queue period have a much wider variation with some almost as low as values that were measured during queue clearance. Figure 111b shows the mean flow rates for these same positions in queue, based on the headways shown in Figure 111a.



a. Headway data



b. Flow rate data

Figure 111. Simulated data (and theoretical line) by vehicle position 111

This stochastic variation has two implications in the selection of the MAH. First, even headways in the departing queue have some variation reflecting differences in driver characteristics. Second, headways in the post queue period may be similar to those during the queue clearance period, thus making it difficult to determine, just based on headway values, which period you are observing.

Multiple lane approaches

How does the problem of setting the passage time change if there is more than one lane on the intersection approach? Often the detection scheme is such that the control system only knows that a call has been received on an approach, not which lane the call comes from. This means that the headway distribution that the traffic control system "sees" is the combined distribution of both lanes. This situation is illustrated in Figure 112 which shows an example of the departure of vehicles over a 30 second period for two lanes individually (Lane 1 and Lane 2) and then taken together (both lanes). In the figure, the headway between any two vehicles is represented by the horizontal distance between the points representing the two vehicles. Two example headways are noted in lanes 1 and 2. For lane 1, the headway is 8.0 seconds, while for lane 2 it is 3.0 seconds. However, if we measure the headways using vehicles from both lanes together (as shown for the three vehicles from lanes 1 and 2 "boxed" together), the consecutive headways would be 0.3 seconds and 2.7 seconds. The picture given with data combined from both lanes is a different one than the headways shown for lanes 1 and 2 separately. And, the conclusion would be different as well. The detection system would "see" three closely spaced vehicles (0.3 and 2.7 seconds) and conclude something different than if the headways are measured from each lane separately (8.0 and 3.0 seconds).

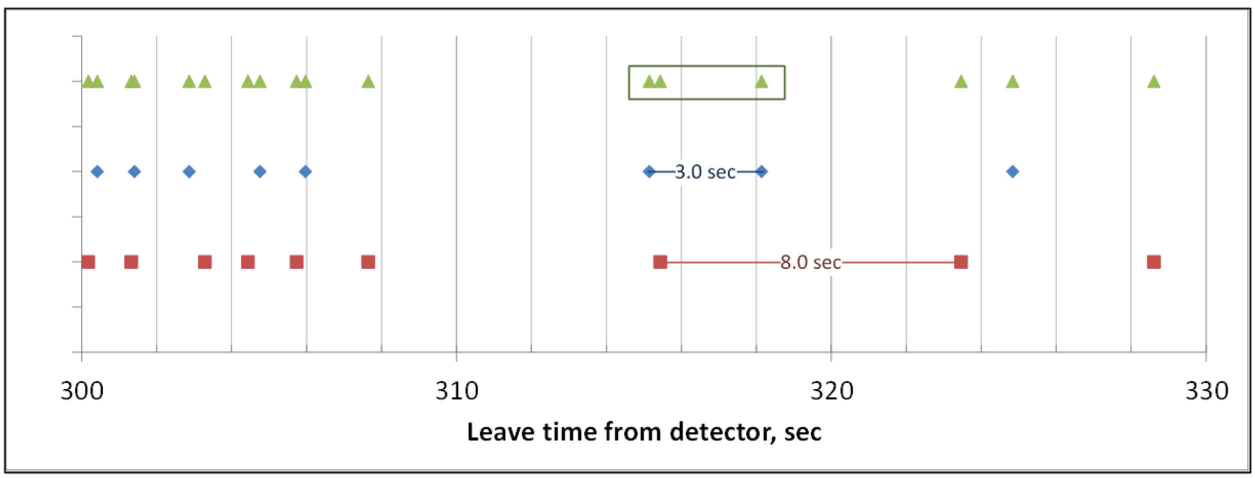


Figure 112. "Leave time" for lane 1, lane 2, and both lanes together

Let's now consider the headway density and cumulative density functions in a departing queue measured for one lane separately and for two lanes combined for an intersection approach, as shown in Figure 113 and Figure 114. While the density functions look similar, the two-lane data are shifted to the left, compared to the one-lane data. The mean value for the one lane data is 1.73 seconds and 0.84 seconds for the two lane (combined) data.

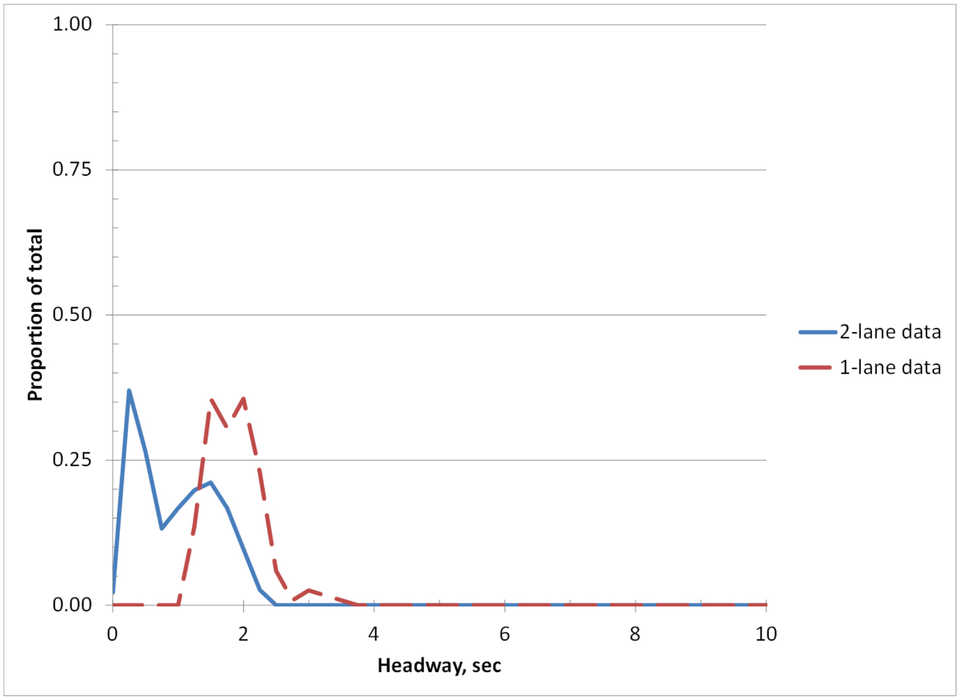


Figure 113. Headway density function, one lane and two lane data

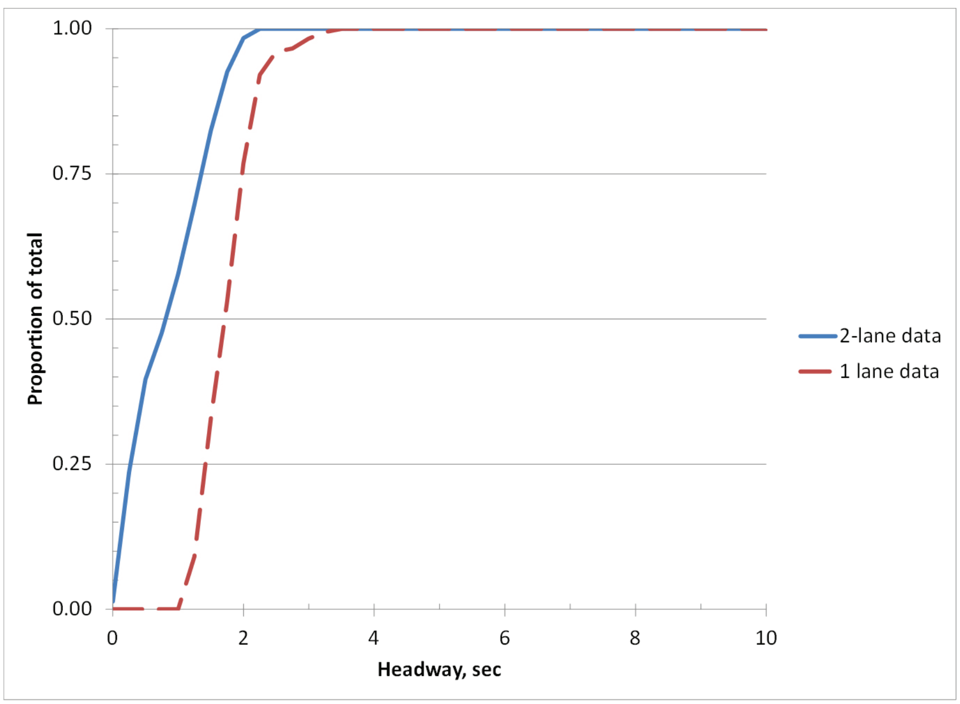


Figure 114. Cumulative headway density function, one lane and two lane data

What are the implications of these headway distribution differences when it comes to setting the passage time? If we assumed a vehicle speed of 25 miles per hour (36.75 feet per second), an average vehicle length of 20 feet and a detection zone length of 22 feet, we could calculate the resulting unoccupancy time for both the one lane and two lane conditions for a given value of headway. Let's consider three cases, in which 99, 95, and 90 percent of the vehicles in the queue would be served by a given MAH. The resulting calculations for the unoccupancy time (and thus the passage time) are shown in Table 15, based on the equation that we considered earlier for the calculation of the unoccupancy time.

Percentile	1-Lane		2-Lane	
	Headway (sec)	Unoccupancy time (sec)	Headway (sec)	Unoccupancy time (sec)
99	3.1	2.0	2.1	1.0
95	2.4	1.3	1.8	0.7
90	2.2	1.1	1.7	0.6

Table 15. Maximum allowable headways and unoccupancy times for 1-Lane and 2-Lane conditions

This example shows that the unoccupancy times (and thus the passage times) are from 0.5 to 1.0 second lower for the 2-lane case than for the 1-lane case. The clear implication is that the passage time for a 2-lane approach should be lower than for a 1-lane approach if we are to achieve the same efficiency in signal timing and meet our objective of providing sufficient green time to serve a clearing queue but not vehicles that arrive after the queue has cleared.

Conclusion

The minimum green time establishes the minimum time that the green will be displayed for a phase. The passage time parameter determines how long the green will be extended after the minimum green timer has expired and is directly related to the MAH and the length of the detection zone. The stochastic variation of headways in the vehicle stream means that the challenge in selecting the MAH (and thus the passage time) is to balance two risks. The first risk (if the MAH is too short) is that the phase will be terminated too early if the queue is still clearing. The second risk (if the MAH is too long) is that the phase will be extended past the time that the queue has cleared. Selecting the MAH, and then the passage time, is the balance in risks that the transportation engineer must determine. Finally, we need to consider shorter passage times for a 2-lane approach than the value we would consider for a one-lane approach. The activities to follow will give you specific experiences in dealing with each of these issues.

ACTIVITY 31

What Do You Know About Detection Zone Length and Passage Time?

ASSESSMENT

Purpose

The purpose of this activity is to test your understanding of the relationship between detection zone length and the basic actuated timing parameters.

Learning Objectives

- Describe the timing processes for actuated traffic control
- Describe how the length of the detection zone affects the setting of the basic timing parameters

Deliverable

- Prepare a completed spreadsheet with the results of your analysis from the following tasks

  Tab 1: Title page with activity number and title, authors, and date completed

  Tab 2: Answers to the Critical Thinking Questions

  Tab 3: Tool prepared in Task 1 and results from Tasks 2, 3, and 4

Critical Thinking Questions

When you have completed the reading, prepare answers to the following questions.

1. What is the relationship (in equation form) between unoccupancy time and maximum allowable headway (MAH)? What are some of the issues involving the computation of the unoccupancy time for a given intersection approach? Provide your answer in a complete paragraph.

2. What is the process for setting the passage time, given the MAH? Describe in complete sentences.

3. What are the pros and cons of a detection zone that is 100 feet in length? Provide your answer in one or more complete paragraphs.

4. How would the determination of the MAH change if you considered lane by lane detection for a two-lane approach (that is, detectors in each lane, operating independently)?

TASK 1

Prepare a spreadsheet tool that implements the relationship between the MAH, detection zone length, and unoccupancy time as shown in Figure 110. The tool should accept the following parameters as input: vehicle speed (mph), detector length (ft), vehicle length (ft), and headway (s). The spreadsheet should produce the unoccupancy time(s) as an output. The spreadsheet should also show a graph that shows the relationship for two vehicles traveling at a specified headway (as shown Figure 110).

TASK 2

Using your spreadsheet tool with a MAH of three seconds, determine the unoccupancy times that would result from detection zone lengths varying from 6 feet to 90 feet. Assume a vehicle length of 20 feet and a speed of 30 miles per hour. If the length of your detection zone was 60 feet, what value of passage time would you select and why?

TASK 3

Using your spreadsheet tool, what would you set the passage time to be, given the following conditions? Describe the assumptions that you made and the method that you used to answer this question.

- L_D = 22’
- L_v = 19’ (80 percent of the vehicles), 30’ (15 percent of the vehicles), or 55’ (5 percent of the vehicles)
- v = 29 mi/hr (mean)
- h = 1.5 – 2.9 sec, mean = 2.2 sec, 85^{th} percentile = 2.5 sec

TASK 4

Using your spreadsheet tool, what would you set the passage time to be, given the following conditions? Describe the assumptions that you made and the method that you used to answer this question.

- L_D = 60’
- L_v = 19’ (80 percent of the vehicles), 30’ (15 percent of the vehicles), or 55’ (5 percent of the vehicles)
- v = 29 mi/hr (mean)
- h = 1.5 – 2.9 sec, mean = 2.2 sec, 85^{th} percentile = 2.5 sec

Student Notes:

ACTIVITY 32 Relating the Length of the Detection Zone to the Duration of the Green Indication

DISCOVERY

PURPOSE

The purpose of this activity is to give you the opportunity to learn how the detection zone length affects the operation of a phase.

LEARNING OBJECTIVE

- Relate the length of the detection zone to the duration of the green indication

REQUIRED RESOURCE

- Movie file: A32.wmv

DELIVERABLE

- Prepare a document that includes your answers to the Critical Thinking Questions

CRITICAL THINKING QUESTIONS

As you begin this activity, consider the following questions. You will come back to these questions once you have completed the activity.

1. How do you know when the detector is active and when it is inactive?

2. When does the phase terminate for the southbound direction for each of the two cases?

3. Why does the phase terminate for each of the two cases?

4. Do you think that the phase is operating efficiently or not for the two cases? Why or why not?

5. Do you think that the quality of service provided to the motorist is good or not? Why or why not?

6. If the phase terminates too early or extends too long, what solutions should be considered?

INFORMATION

In this activity, you will consider two cases, one in which the southbound approach has a 22 foot detection zone and another in which the approach has a 66 foot detection zone, each representing a zone length sometimes used in practice. In both cases, the detection zones end at the stop bar. See Figure 115. The vehicle extension time and minimum green time are set to zero. The detectors are both operating in presence mode. You will observe how and when the phase terminates for both cases, and the status of the controller at several points in the simulation.

It is important to understand that both detectors are operating in the presence mode. This means that as long as the detection zone is occupied, a call is sent to the controller for the assigned phase. If a constant call is sent to a phase that is green, it will continue to remain green as long as the phase has not "maxed out."

The vehicle extension time and minimum green time parameters have both been set to zero for phase 4, the phase serving the southbound through approach movement. This means that you need to focus only on the detection zone length and how it affects the duration of the green indication.

Vehicles are present on the southbound approach on Line Street (phase 4), and the eastbound and westbound approaches on State Highway 8 (phases 2 and 6).

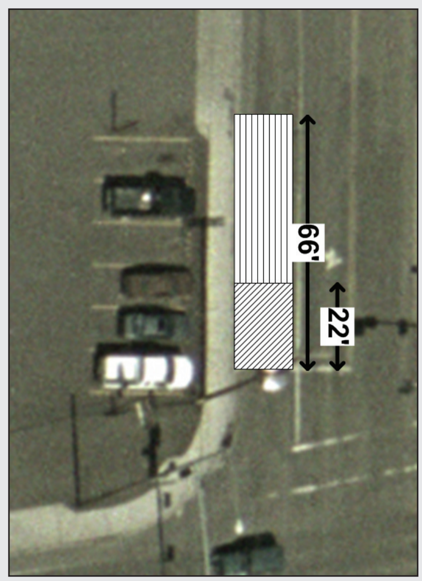


Figure 115. Two detection zone alternatives on Line Street SB approach

TASK 1

Open the movie file, A32.wmv. Pause the playback. The simulation window shows the animation of vehicles traveling through the intersection as well as other data (see Figure 116):

- The current simulation time is noted in the lower left
- The detection zones (and their numbers) are shown in each approach lane as boxes

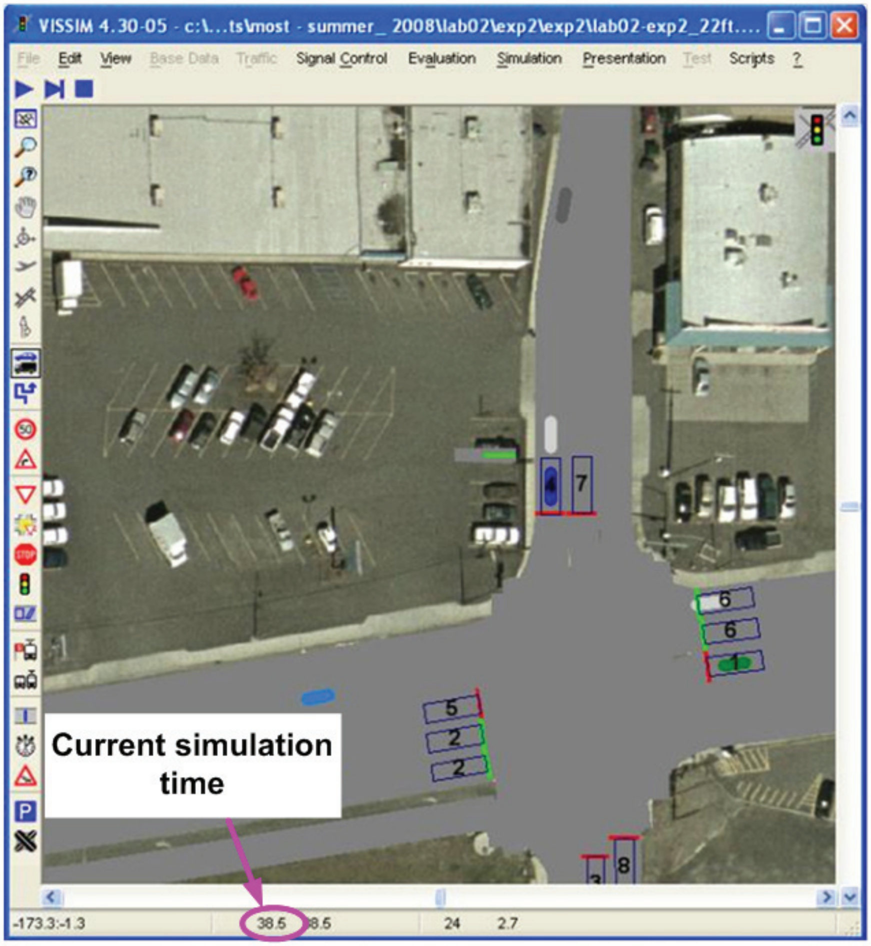


Figure 116. Features of animation window

Task 2

Start the movie file. Pause the movie when the simulation time is 49.0. Observe the conditions at the intersection and in the controller for both cases. See Figure 117.

- For the southbound approach, four vehicles are in queue for both cases
- Point B on the controller status screen shows the status for phases 2 and 6, the current active phases in rings 1 and 2. The red clearance timer is active, with a current value of 0.7 seconds. And, phases 2 and 6 have gapped out, as noted in the status screen.
- The controller status screen shows that phase 4 has an active call (noted by the "C" at point A) and is in "phase next" status (noted by the "N"). This means that when phase 2 has terminated, phase 4 will be the next phase to be served.

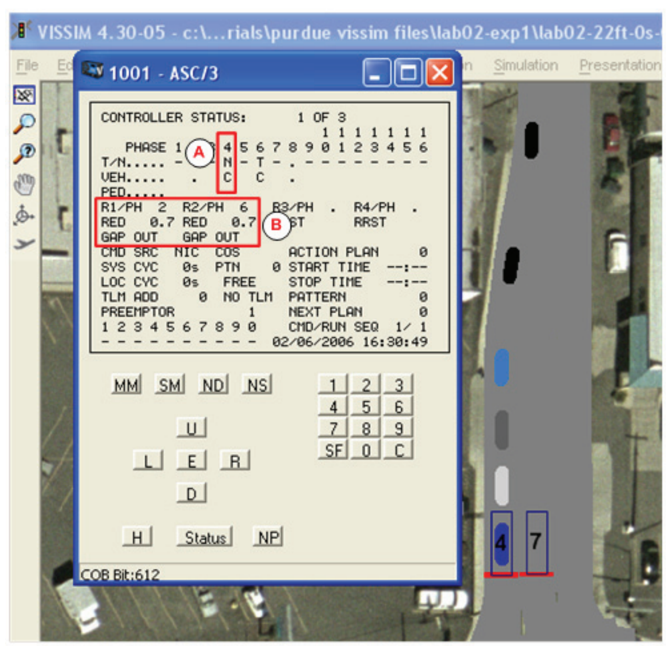


Figure 117. ASC/3 status screen at t = 49.1 for both cases

Task 3

Observe the simulation at $t = 49.9$. Record your observations on the status of phase 4. What is the color of the active indication?

Task 4

Observe the simulation from $t = 54.1$ to 54.3.

- Observe the simulation on the left of the screen (the 22 foot detector case)
- Record your observations of the controller status window, noting in particular the status of any calls, the timing status of phase 4, and the timing processes and timing parameter values for phase 4
- Also, record the status of the queue being served

Task 5

Observe the simulation from $t = 60.1$ to 61.4.

- Observe the simulation on the right of the screen (the 66 foot detector case)
- Record your observations of the controller status window, noting in particular the status of any calls, the timing status of phase 4, and the timing processes and timing parameter values for phase 4
- Also, record the status of the queue being served

ACTIVITY

33 Determining the Length of the Minimum Green Time

DISCOVERY

Purpose

The purpose of this activity is to help you learn to visualize the role of the minimum green time during the early portion of the green and to see how the setting of this parameter can result in efficient or inefficient timing.

Learning Objective

- Relate the length of the minimum green time to the efficient operation of a phase

Required Resource

- Movie file: A33.wmv

Deliverable

- Prepare a spreadsheet that includes:

  Tab 1: Title page with activity number and title, authors, and date completed

  Tab 2: Your answers to the Critical Thinking Questions

  Tab 3: The data that you collected in Table 16 and Table 17

Critical Thinking Questions

As you begin this activity, consider the following questions. You will come back to these questions once you have completed the activity.

1. When is the minimum green time too long?

2. How long should the minimum green time be in order to get vehicles moving during the early portion of green?

3. What are the respective roles of minimum green time and vehicle extension time in producing efficient operations?

INFORMATION

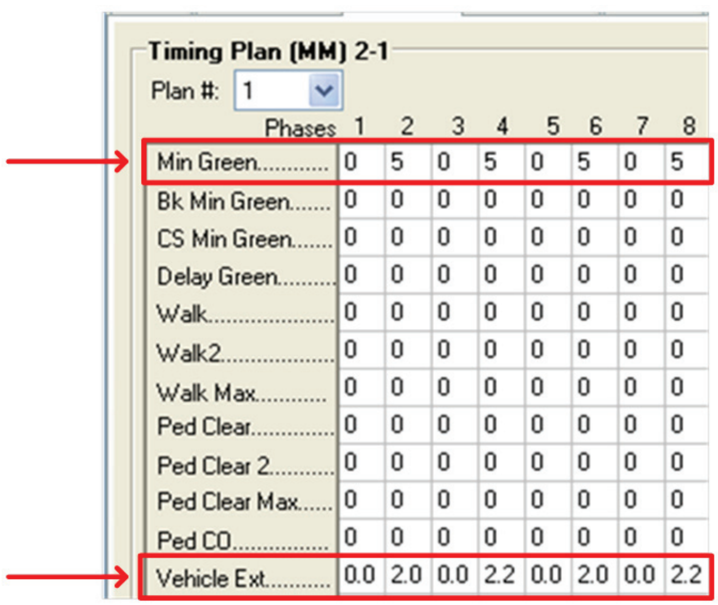
In this activity, you will see the importance of the minimum green time during the early portion of the green indication, and how you can define the roles of the minimum green time and the vehicle extension time to ensure efficient intersection operations. You will again observe the operation of the southbound approach of Line Street, at State Highway 8, and make observations about the operation. You will again consider stop bar detection, with a detection zone length of 22 feet.

TASK 1

Open the movie file, A33.wmv.

TASK 2

Figure 118 shows the controller screen for the ASC/3 database editor. Observe that the minimum green time is set to 5 seconds for phase 4 for the first case and 10 seconds for phase 4 for the second case. The vehicle extension time is set to 2.2 seconds for phase 4.



Timing Plan (MM) 2-1

Plan #: 1

Phases	1	2	3	4	5	6	7	8
Min Green............	0	5	0	5	0	5	0	5
Bk Min Green.......	0	0	0	0	0	0	0	0
CS Min Green.......	0	0	0	0	0	0	0	0
Delay Green..........	0	0	0	0	0	0	0	0
Walk......................	0	0	0	0	0	0	0	0
Walk2.....................	0	0	0	0	0	0	0	0
Walk Max............	0	0	0	0	0	0	0	0
Ped Clear..............	0	0	0	0	0	0	0	0
Ped Clear 2...........	0	0	0	0	0	0	0	0
Ped Clear Max......	0	0	0	0	0	0	0	0
Ped CO................	0	0	0	0	0	0	0	0
Vehicle Ext..........	0.0	2.0	0.0	2.2	0.0	2.0	0.0	2.2

Figure 118. ASC/3 Database Editor

Task 3

Observe the timing and the termination of the southbound phase for the two cases.

- Advance the simulation until the start of green for phase 4 (the phase serving the southbound movement). Record the simulation time in Table 16 that corresponds to the start of green for both cases.
- Record the simulation time that the vehicle in queue leaves the detection zone
- Record the time that green ends (yellow begins) for both cases
- Reflect on the data that you recorded and the implications of these data
- Record your observations
- Remember, you will often observe a 0.1 second difference between the information shown in the controller status window and the indication status in the VISSIM window. This difference, resulting from communications latencies between the ASC/3 controller software and the VISSIM software, will not substantially affect your results.

Data to record	Case 1	Case 2
Start of green		
Back of vehicle leaves zone		
Start of yellow/end of green		
Difference between "start of yellow/end of green" and "back of vehicle leaves zone"		

Table 16. Data collection table

Task 4

Observe vehicle start-ups for case 1 only, the left side.

- Move the simulation to $t = 89.2$
- At this point ($t = 89.2$), observe the status of the traffic for the SB approach and the status of the timing process for both phase 2 and phase 4 for case 1 (on the left) only
- Record your observations
- Advance the simulation until case 1 (minimum green = 5.0 seconds) reaches the start of green for phase 4. This should occur at $t = 89.5$ seconds.
- For case 1, record the times that each of the four vehicles in the queue on the southbound approach first begin to move and when they enter the detection zone. Use Table 17 to record these data. Watch the simulation carefully to note the time step that each vehicle begins to move.

Vehicle #	Start of green	Vehicle begins to move	Vehicle enters detection zone
	89.5		
1			
2			
3			
4			

Table 17. Data collection table

ACTIVITY
34 Understanding the Variation of Vehicle Headways in a Departing Queue

DISCOVERY

Purpose

The purpose of this activity is to give you the opportunity to learn the degree to which vehicle headways vary in the departing queue.

Learning Objectives

- Describe the variation of vehicle headways in a departing queue
- Establish a desired maximum allowable headway (MAH)

Required Resource

- Movie file: A34.wmv

Deliverable

- Prepare a spreadsheet that includes:

  Tab 1: Title page with activity number and title, authors, and date completed

  Tab 2: Your answers to the Critical Thinking Questions

  Tab 3: The data that you collected in Table 18

Critical Thinking Questions

As you begin this activity, consider the following questions. You will come back to these questions once you have completed the activity.

1. How much variation is there in the headways between vehicles in the departing queue?

2. Based on the headways that you observed in the departing queue, what is your recommendation for the desired MAH?

INFORMATION

In previous activities, you learned that when the minimum green and vehicle extension times are set to zero, the phase will terminate immediately when the detection zone becomes unoccupied. You also learned that the detection zone length alone will not guarantee good quality of service to the motorist, since the phase may terminate before the entire queue has been served. This is especially true for the shorter 22 foot detection zone, in which it is difficult to have more than one vehicle in the zone at the same time. Finally, you learned that the minimum green time should be long enough to make sure that the queue immediately upstream of the detection zone begins to move, and enters the detection zone before the green indication prematurely ends.

In this activity, the detection zone length is 22 feet. The minimum green time is set to 7 seconds. The vehicle extension time is set to 5 seconds, a very conservative (high) value. You will observe the operation of the southbound movement, developing an understanding of the normal variation of headways in a departing queue. You will also identify the desired maximum allowable headway, the longest headway in a departing queue that you are willing to tolerate without terminating the green indication. This will help you to understand how to establish the vehicle extension time, which will be covered in Activities #36 and #37.

TASK 1

Open the movie file: "A34.wmv."

TASK 2

Observe and record headways for one cycle.

- When the simulation time reaches $t = 66.1$ seconds, pause and observe the status of the traffic flow and the timing processes; record your observations
- Begin the simulation again
- Record the following values in Table 18 for phase 4 serving the southbound through movement
  - Record the simulation clock time that the indication changes to green ("Start of green" in the table)
  - Record the clock time that the front of each vehicle reaches the stop bar
  - Compute the headway for each vehicle (the time difference between when this vehicle enters the intersection and when the previous vehicle entered the intersection) and record your results in the table

Vehicle number	Start of green	Time front of vehicle reaches stop bar	Headway
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Table 18. Data collection table

Student Notes:

ACTIVITY
35 Relating Headway to Unoccupancy Time and Vehicle Extension Time

DISCOVERY

PURPOSE

The purpose of this activity is to give you the opportunity to learn how to determine the vehicle extension time based on the detection zone length and the desired maximum allowable headway (MAH).

LEARNING OBJECTIVES

- Relate the MAH to unoccupancy time
- Determine the vehicle extension time based on the length of the detection zone and the desired MAH

REQUIRED RESOURCE

- Movie file: A35.wmv

DELIVERABLE

- Prepare a spreadsheet that includes the following information:

  Tab 1: Title page with activity number and title, authors, and date completed

  Tab 2: Answers to the Critical Thinking Questions

  Tab 3: A brief summary of your observations from the tasks which follow. Note any patterns that you see between the headway data and the unoccupancy time data. What would be the basis of a relationship between these two parameters?

  Tab 4: The data that you collected in Table 19

CRITICAL THINKING QUESTIONS

As you begin this activity, consider the following questions. You will come back to these questions once you have completed the activity.

1. What is your recommendation for the vehicle extension time, based on your recommended desired maximum headway? Explain your answer.

2. If the detection zone length was longer than 22 feet, would your recommended vehicle extension time value be higher or lower? Explain your answer.

INFORMATION

In Activity #34, you observed the normal variation in headways in a departing queue, and based on these observations, you selected a MAH that represents the longest headway in a departing queue that you are willing to tolerate without terminating the green indication. In this activity, you will relate this headway to its equivalent unoccupancy time. You will then select a vehicle extension time based on this unoccupancy time that, in combination with the detection zone length, ensures both efficient operation and good service quality. In this activity, the detection zone length is 22 feet and the minimum green time is set to 7 seconds. The vehicle extension time is set to 5 seconds.

TASK 1

Open the movie file: "A35.wmv."

TASK 2

Collect data.

- The minimum green time is set to 7 seconds and the vehicle extension time is set to 5 seconds
- Move the simulation time to 66.0
- Run the simulation and observe the operation of the southbound approach
- At *t* = 66.1 seconds, advance the simulation. Record the following values in Table 19 for phase 4 (serving the SB through movement)
  - Record the simulation clock time that the display changes to green ("Start of green" in the table)
  - Record the clock time that the front of each vehicle enters the zone and the rear of each vehicle exits the zone. The entry time for the first vehicle is noted in the table ("14.0").
  - Record the clock time that the display changes to yellow ("Start of yellow" in the table)
  - Compute the unoccupancy time for each vehicle pair and record the value in the "Unoccupancy time" column. The unoccupancy time is the difference in the clock time that the front of the vehicle enters the zone and the clock time that the rear of the previous vehicle exits the zone. If the value is negative, a zero should be entered.

Vehicle Number	Start of green	Start of yellow	Front of vehicle enters zone	Rear of vehicle exits zone	Headway	Unoccupancy time
1			14.0		1.2	
2					2.4	
3					1.7	
4					1.9	
5					1.8	
6					1.8	
7					1.7	
8					1.9	
9					1.4	
10					1.7	

Table 19. Data collection table

Student Notes:

ACTIVITY

36 Determining the Maximum Allowable Headway

DESIGN

Purpose

The purpose of this activity is to give you the opportunity to determine the maximum allowable headway (MAH) for your intersection.

Learning Objective

- Select an MAH

Required Resources

- VISSIM input file created in Activity #28
- Phase Termination Analysis Excel template

Deliverable

- Prepare an Excel spreadsheet that includes the phase termination analysis results and data analysis outcomes, as well as the results from Task 5. The Excel worksheet should follow the formatting outlined below:

  Tab 1: Title page with activity number and title, authors, and date completed

  Tab 2: Raw data from the MER file

  Tab 3: Headway data for both lanes

  Tab 4: Headway distribution analysis showing frequency data, frequency plot, and cumulative frequency plot for one lane

  Tab 5: Data for the phase termination analysis

  Tab 6: Phase termination analysis using template including a summary table containing the number of occurrences of each termination type

  Tab 7: Summary of phase termination analysis including selection of and justification for the MAH

Critical Thinking Questions

1. How does increasing the MAH affect the likelihood of a Type 1, Type 2, or Type 3 termination?

2. Describe the differences that you observe in the frequency distributions for queued and non-queued vehicles from your data analysis.

3. What is the result of a phase termination analysis?

4. What is the basis for your selection of the MAH? Use the results from your phase termination analysis in explaining your answer.

INFORMATION

The MAH is the largest headway that you will tolerate in a departing queue before the phase should terminate. The choice of this headway involves balancing two conflicting and competing issues: if the headway that you select is too small, then you run the risk of terminating the phase too soon and not serving all of the vehicles in the queue that formed during red. However, if the headway that you select is too large, then you run the risk of allowing the phase to extend too long, serving not just the initial queue but also vehicles that arrive after the initial queue has cleared. One problem comes in recognizing that some of the headways that you observe after the queue has cleared might be in the same range as those that you observed during the queue clearance. Conversely, a slowly reacting driver in a vehicle that is part of a departing queue will result in a headway that is longer than the normal saturation headway. The choice that you make in the value of the MAH will have some risk of both conditions: A Type 1 termination, or cycle failure, when not all of the initial queue is served or a Type 2 termination, an inefficient extension of the green, resulting in longer delays on the other approaches. While the ideal goal is to achieve a Type 3 termination (when the phase terminates just after the queue has cleared) each time a phase terminates, your challenge is to find a MAH that balances the risks of the Type 1 and Type 2 terminations.

So what is a phase termination analysis? A phase termination analysis is a tool that looks at the headway data generated by a simulation model from a stream of vehicles departing from an intersection and, given a value of the MAH, classifies each phase termination into one the three types described above. The first part of the analysis involves the stream of headways for the departing vehicles, with the stream separated into vehicles that were a part of the queue (noted by Q) and those that arrived after the queue had cleared (noted by NQ). An example of the headway data are shown in the first two columns of Figure 119. Note that when you collect your headway data in this activity, the passage time will be set to a very high value (5 seconds) so that you can observe a sufficient sample of both queued and non-queued vehicles and their resulting headways departing after the beginning of green. The high passage time provides you with enough vehicles (and resulting headways) to allow you to study different values of MAH and their effects on phase termination.

The next step in the analysis involves superimposing a value for the MAH that determines when the display would change from green to red. The display would continue as “green” as long as the headway in the data stream is less than the MAH, but would change to “red” (for simplicity, we’ve skipped “yellow” here) when a headway exceeded this value. The “Ideal Signal Display”, column 3 in Figure 119, shows the display that would result from the MAH that has been selected: the green would be displayed until a headway occurs that is greater than the MAH. The “Change Occurs” column (column 4) shows when the change from green to red would occur.

The third part of the analysis, the “Termination Outcomes”, determines whether this display change occurs when queued vehicles are still being served (a Type 1 termination) or whether the green would continue to be displayed even when non-queued vehicles would be served (a Type 2 termination). In this example, the two queued vehicles are served, but the first three non-queued vehicles are served as well. The display doesn’t change to red until the sixth headway (7.79 seconds), which is the first headway in this example to exceed the MAH of 3.0 seconds.

In summary, the phase termination analysis subjects the simulated headway data stream to a range of values of the MAH to determine how effective each MAH value would be in serving these vehicles. We know whether each vehicle is a part of the queue or not, and we can determine for a given MAH if a vehicle would be served or not. In addition to the information described above, the phase termination analysis as shown in Figure 119 also provides:

- The Outcome Distribution for the value of the MAH selected; in this example there are three Type 1, five Type 3, and nine Type 2 terminations
- The Percentile is the percentage of vehicles with headways that are less than the MAH (in this example, 98.2%)
- The “Results” summarizes the Percentiles and the number of terminations for each type for four MAH values (ranging from 1.5 seconds to 3.0 seconds)

MAH	Percentile
3.0	98.2%

Headway (sec)		Signal Information		Termination Outcomes		
Queued	NonQueued	Ideal Signal Display	Change Occurs	Type 1	Type 3	Type 2
1.15		Green				
1.96		Green				
	1.15	Green				
	1.3	Green				
	1.91	Green				
	7.79	Red	Change			1
	8.03	Red				
	5.14	Red				

Outcome Distribution	
Type 1 Termination	3
Type 3 Termination	5
Type 2 Termination	9

Results of Phase Termination Analysis				
Headway	1.5	2.0	2.5	3.0
Percentile	32.0%	76.4%	95.9%	98.2%
Type 1 Termination	17	14	6	3
Type 3 Termination	0	1	6	5
Type 2 Termination	0	2	5	9

Figure 119. Example phase termination analysis procedure

TASK 1

Initial steps.

- Make a copy of the folder that includes your VISSIM data files from Activity #28. Name this new folder “a36”. Use this VISSIM file as the basis for your analysis and design of the passage time.
- Select one approach on one of the major streets of your intersection for your headway study

- Increase the volume on this link to produce "beginning of green" queue lengths of 10 to 15 vehicles per cycle per lane
- Set the passage time to 5.0 seconds on the approach that you have selected
- Establish "data collection" points just downstream of the signal head for the two lanes on the approach that you selected previously. For instructions on how to add a Data Collector in VISSIM see the VISSIM tutorial.
- Select and configure the "Data Collection" evaluation file. To do this, make sure to check "raw data" in configuration box.

Task 2

Headway data.

- Run VISSIM
- Open and parse the MER file in tab 2 of your Excel template
- Copy the parsed data to tab 3 of your Excel file. Keep only three columns: CP, t(leave), and tQueue. Delete the other columns. Figure 120 shows the layout of the MER file after it has been opened in Excel and parsed.

Data Collection (Raw Data)

File: f:\sweet and us95 high volume\team1_lab3.inp
Comment:
Date: Monday, May 28, 2012 12:21:31 PM
VISSIM: 5.30-08 [29295]

Data Collection Point 1: Link 1 Lane 2 at 143.633 m, Length 0.000 m.
Data Collection Point 2: Link 1 Lane 1 at 143.610 m, Length 0.000 m.

Data C.P.	t(enter)	t(leave)	VehNo	Type	Line	v[m/s]	a[m/s²]	Occ	Pers	tQueue	VehLength[m]
2	16.42	-1	2	100	0	14.3	-0.29	0.08	1	0	4.5
2	-1	16.73	2	100	0	14.2	-0.29	0.03	1	0	4.5
1	66.77	-1	6	100	0	1.4	2.77	0.03	1	42.7	4.5
2	66.82	-1	7	100	0	1.5	2.93	0.08	1	42.6	4.5
1	-1	68.1	6	100	0	5.2	2.6	0	1	42.7	4.5
2	-1	68.13	7	100	0	5.2	2.55	0.03	1	42.6	4.5
1	69.57	-1	8	100	0	6.5	2.86	0.03	1	42.1	4.5
2	69.85	-1	14	100	0	6.9	2.95	0.05	1	30.8	4.5
1	-1	70.18	8	100	0	8.2	2.71	0.08	1	42.1	4.5
2	-1	70.44	14	100	0	8.5	2.82	0.04	1	30.8	4.5
1	71.62	-1	10	100	0	8.6	2.4	0.08	1	38.5	4.5

Keep three columns:
- Data C.P, designating the data collection point or lane
- t(leave), the time that the vehicle leaves the data collection point
- tQueue, the time that the vehicle spends in queue

Figure 120. VISSIM MER file in Excel

- Eliminate all rows in which t(leave) equals "–1" or in which t(leave) is less than 300
- Separate the data into two separate tables, one for each of the two data collection points (lanes 1 and 2)
- Add a new column for each table that identifies whether the vehicle was a part of the queue or not. This can be done by putting a Q or NQ in the cell adjacent to the tQueue data. Figure 121 shows an example of the determination of Q or NQ based on whether tQueue is zero or greater than zero using an Excel logic function.
- In a new column, compute the headway between each vehicle pair as shown in Figure 122

Data C.P.	t(leave)	VehNo	tQueue	Q/NQ
2	300.42	161	11.8	Q
2	301.41	164	10	Q
2	302.87	167	8.9	Q
2	304.76	171	4.5	Q
2	305.97	176	2	Q
2	315.15	184	0	NQ
2	318.14	187	0	NQ
2	324.84	190	0	NQ

If(tQueue>0,"Q","NQ")

Figure 121. Example determination whether a vehicle is in a queue or not (Q or NQ)

Data C.P.	t(leave)	VehNo	tQueue	Q/NQ	Headway
2	300.42	161	11.8	Q	
2	301.41	164	10	Q	1.0
2	302.87	167	8.9	Q	1.5
2	304.76	171	4.5	Q	1.9
2	305.97	176	2	Q	1.2
2	315.15	184	0	NQ	9.2
2	318.14	187	0	NQ	3.0
2	324.84	190	0	NQ	6.7

Figure 122. Example calculation of headway based on the "leave" times of two consecutive vehicles

Task 3

Headway distribution analysis.

- Using the headway data created in Task 2 for one of the lanes only, create frequency (histogram) and cumulative frequency plots using 0.25 second bins in tab 4 of the Excel template. Figure 123 shows an example of the data used to create the frequency and cumulative frequency plots including (for headway bins from 0.00 to 2.00 seconds) the frequency (number), the percent frequency, the cumulative frequency, and the percent cumulative frequency.

Bin	*Frequency*	*Freq%*	*CumFreq*	*CumFreq%*
0.00	0	0.000	0	0.000
0.25	0	0.000	0	0.000
0.50	0	0.000	0	0.000
0.75	0	0.000	0	0.000
1.00	0	0.000	0	0.000
1.25	16	0.136	16	0.090
1.50	42	0.356	58	0.328
1.75	36	0.305	94	0.531
2.00	42	0.356	136	0.768

Figure 123. Example frequency and cumulative frequency headway data

- Figure 124 and Figure 125 show the resulting frequency and cumulative frequency plots based on the frequency data shown in Figure 123

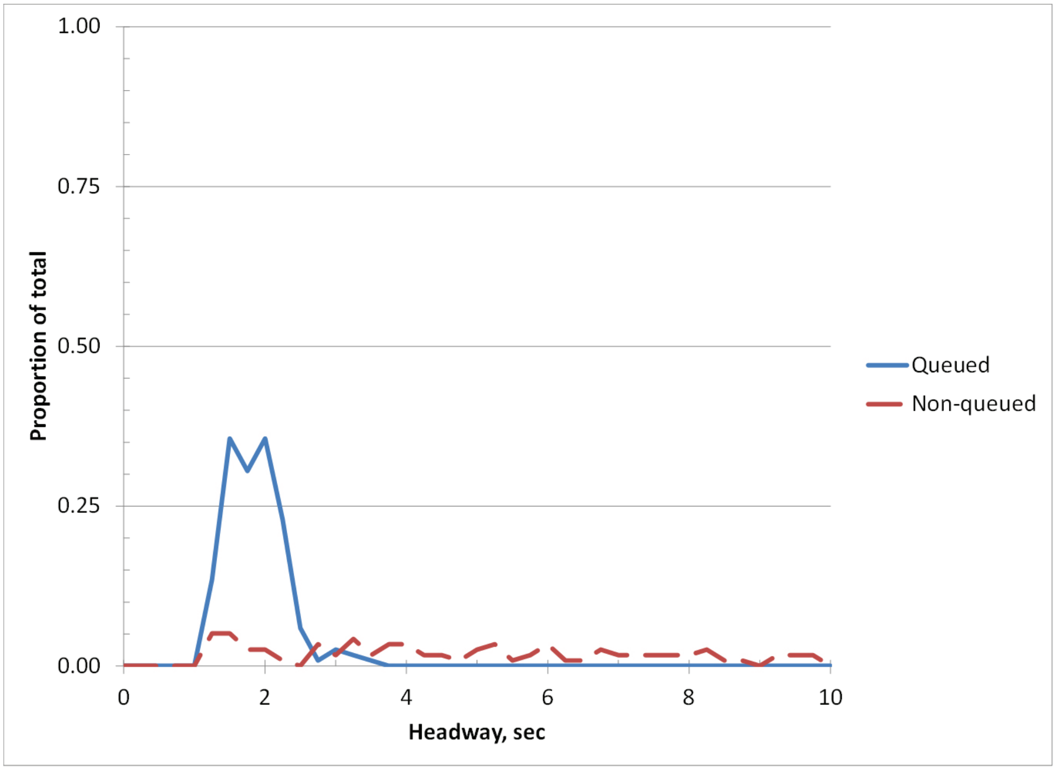


Figure 124. Headway frequency plot for queue and non-queued vehicles

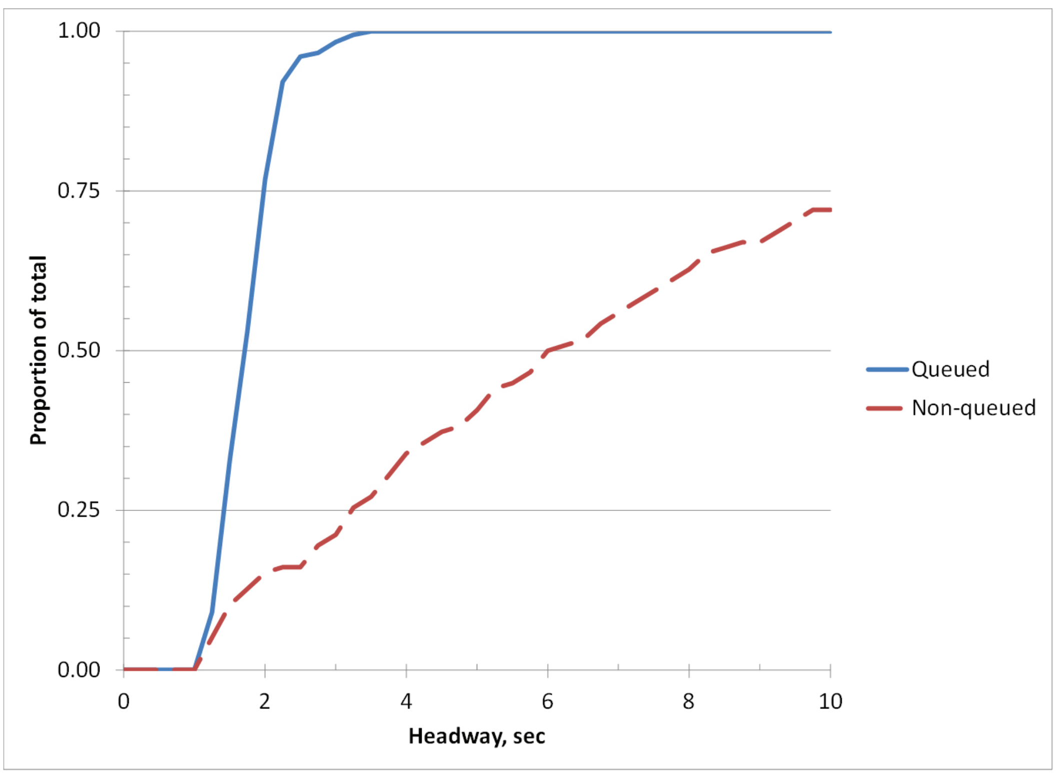


Figure 125 Headway cumulative frequency plot for queued and non-queued vehicles

TASK 4

Phase termination analysis.

- Create the data that you will need for the phases termination analysis in tab 5. Figure 126 shows two columns that have been created that place the queued and non-queued headway in the appropriate columns.

							Headway (sec)	
Data C.P.	t(leave)	VehNo	tQueue	Q/NQ	Headway		Queued	Nonqueued
1	300.18	163	9.6	Q				
1	301.33	165	9.1	Q	1.1		1.15	
1	303.29	169	5	Q	2.0		1.96	
1	304.44	174	0	NQ	1.1			1.15
1	305.74	177	0	NQ	1.3			1.3
1	307.65	179	0	NQ	1.9			1.91
1	315.44	186	0	NQ	7.8			7.79
1	323.47	189	0	NQ	8.0			8.03
1	328.61	193	0	NQ	5.1			5.14

Figure 126. Creation of input data for phase termination analysis

- Copy the headways for the queued and non-queued vehicles into the two input columns in the phase termination analysis spreadsheet template to tab 6 of your Excel template. The data should be pasted as "values." Figure 127 shows the headway data that have been pasted into the first two columns of the phase termination analysis template. The Signal Information and Termination Outcomes are calculated based on these input data.

Headway (sec)		Signal Information		Termination Outcomes		
Queued	NonQueued	Ideal Signal Display	Change Occurs	Type 1	Type 3	Type 2
1.15		Green				
1.96		Red	Change	1		
	1.15	Red				
	1.3	Red				
	1.91	Red				
	7.79	Red				
	8.03	Red				
	5.14	Red				

Figure 127. Outcomes for phase termination analysis showing type 1 termination

- Use the Phase Termination Analysis template to determine the Termination Outcomes for a range of possible MAH. Enter a value in the MAH cell and record the resulting number of Types 1, 2, and 3 terminations in the "results" section of the template. Each time you enter a new value for the MAH, a new set of outcomes will be calculated. Figure 128 shows the results of a phase termination analysis for four MAH cases, ranging from 1.5 seconds to 3.0 seconds. When the MAH was set to 1.5 seconds, the phase terminated before the queue had cleared for all 17 phases, and only 32 percent of the vehicles would be served. At the other extreme, if the MAH was set to 3.0 seconds, the phase would extend past the time the queue had cleared in 9 of the 17 cases (Type 2 terminations).

MAH	Percentile
3.0	98.2%

Headway (sec)		Signal Information		Termination Outcomes		
Queued	NonQueued	Ideal Signal Display	Change Occurs	Type 1	Type 3	Type 2
1.15		Green				
1.96		Green				
	1.15	Green				
	1.3	Green				
	1.91	Green				
	7.79	Red	Change			1
	8.03	Red				
	5.14	Red				

Outcome Distribution	
Type 1 Termination	3
Type 3 Termination	5
Type 2 Termination	9

Results of Phase Termination Analysis

Headway	1.5	2.0	2.5	3.0
Percentile	32.0%	76.4%	95.9%	98.2%
Type 1 Termination	17	14	6	3
Type 3 Termination	0	1	6	5
Type 2 Termination	0	2	5	9

Figure 128. Phase termination analysis results for four example maximum allowable headways

TASK 5

Select the MAH.

- Write a goal statement for the selection of the MAH based on your desired balance of type 1 and type 2 terminations
- Select your MAH using your goal statement and the analysis that you have completed as the basis for your selection

ACTIVITY

37 Determining the Passage Time

DESIGN

Purpose

The purpose of this activity is to give you the opportunity to select and justify design values for passage time.

Learning Objectives

- Compare headway distributions for one lane and two lane data
- Select passage time values for one lane and two lane approaches

Required Resource

- Excel template and results from Activity #36

Deliverable

- Excel spreadsheet that includes the selected design parameters (passage time), as well as justification for these values. This should be the same Excel file that you used for Activity #36 with the following tabs added:

  Tab 8: Headway analysis for two lane data

  Tab 9: Phase termination data

  Tab 10: Phase termination analysis for two lane data

  Tab 11: Performance data from VISSIM

  Tab 12: Analysis and summary based on Tasks 6, 7, and 8

Critical Thinking Questions

1. What are the differences in the headway distributions that you prepared for the one lane approach and two lane approach conditions? Describe them in complete sentences.

2. Would the passage time for a two lane approach be lower or higher than for a one lane approach? Provide justification for your answer.

3. Can you think of a situation in which your answer to question #2 would change? If so, describe that situation.

Information

In Activity #36, you selected a value for the maximum allowable headway (MAH) that balanced early phase termination with inefficient extension of the phase for a one lane approach. In this activity you will consider the effect of a two lane approach, and how this might change the selection of the MAH.

Figure 129 and Figure 130 compare the headway distributions for one lane and two lane approaches for vehicles that were a part of a queue that existed at the beginning of the green. The headways are lower for the two lane case than for the one lane case since they are measured for consecutive vehicles that sometimes can depart from the approach at nearly the same time. In this latter case, a headway between two vehicles departing from the same approach but from different lanes could be near zero. For the case shown here, the mean headway for the two lane case is 0.8 seconds, while the mean for the one lane case is 1.7 seconds.

A phase termination analysis also shows the differences between the one lane and two lane cases, and why the MAH should be lower for the two lane case. Figure 131 and Figure 132 show the percent phase terminations for Types 1 and 2 terminations for the one lane and two lane data.

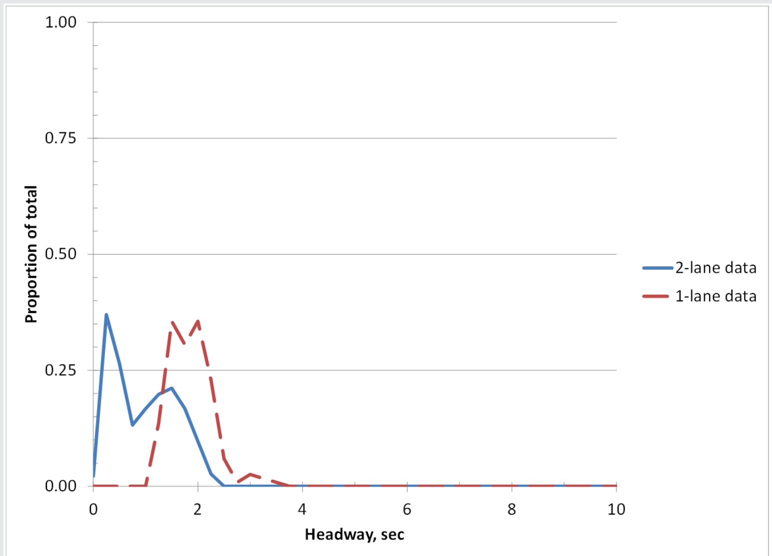


Figure 129. Headway density function, one lane and two lane data

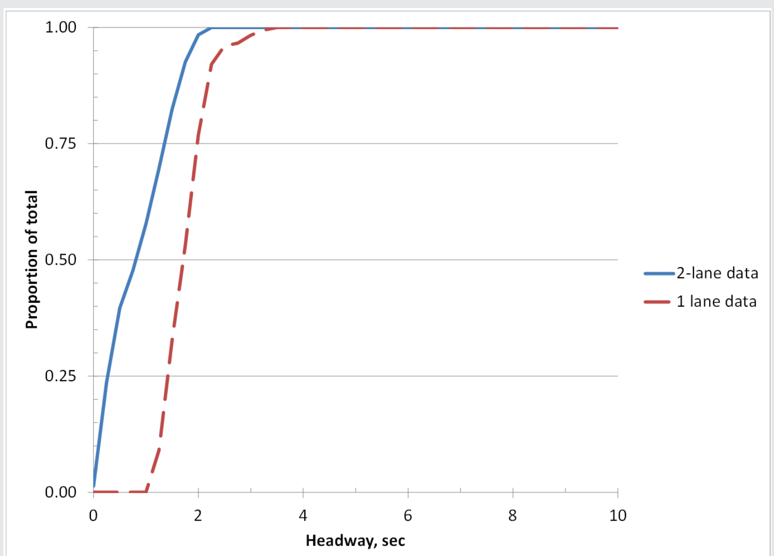


Figure 130. Cumulative headway density function, one lane and two lane data

In Figure 131 for example, the likelihood of a Type 1 termination (the phase terminates before the queue has cleared) for a given MAH is higher for the one lane case than for a two lane case. Stated another way, a smaller MAH can be used for a two lane case than for a one lane case to achieve the same result.

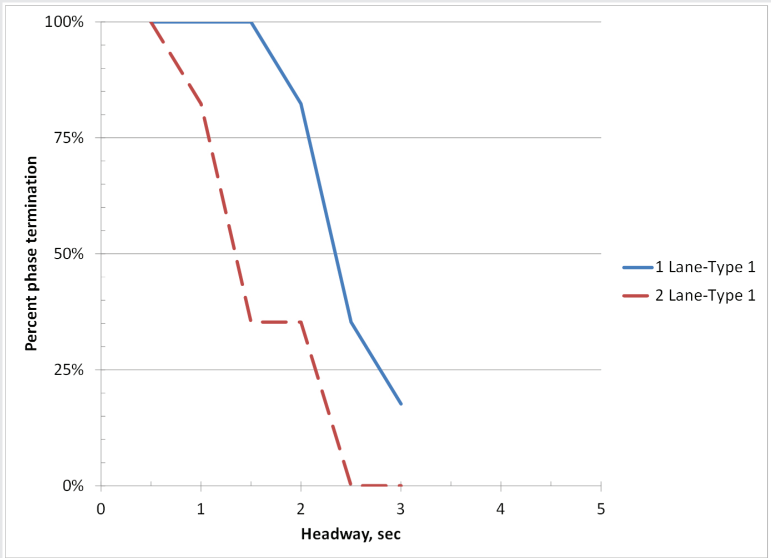


Figure 131. Frequency distribution for Type 1 terminations for the one lane and two lane cases

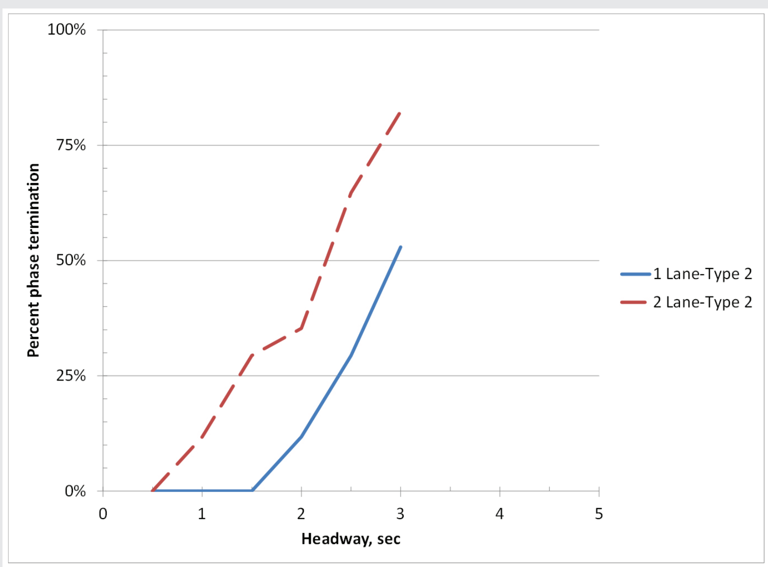


Figure 132. Frequency distribution for Type 2 terminations for the one lane and two lane cases.

TASK 1

Initial steps.

- Open the Excel spreadsheet that you used in Activity #36
- Create new tabs for the following work:

  Tab 8: Headway analysis for two lane data

Tab 9: Phase termination data

Tab 10: Phase termination analysis for two lane data

Tab 11: Performance data from VISSIM

Tab 12: Analysis and summary based on Tasks 6, 7, and 8

TASK 2

Collect speed data.

- Review the speed data collected in the MER file as part of Activity #36
- Prepare a statistical analysis of the data, including a determination of the mean value and a density plot. Identify the speed data that represents vehicles traveling through the intersection after the queue begins to move after the start of green.
- Based on this analysis, select a speed value that you think is appropriate for the calculation of the passage time

TASK 3

Headway distributions for two lane data

- Using the data file created in Activity #36, create frequency (histogram) and cumulative frequency plots using 0.25 second bins based on the data for both lanes combined into one data set. These data should be placed in Tab 8 of your Excel file.
- Figure 133 and Figure 134 show examples of the resulting frequency and cumulative frequency plots for two lane data for both queued and non-queued vehicles

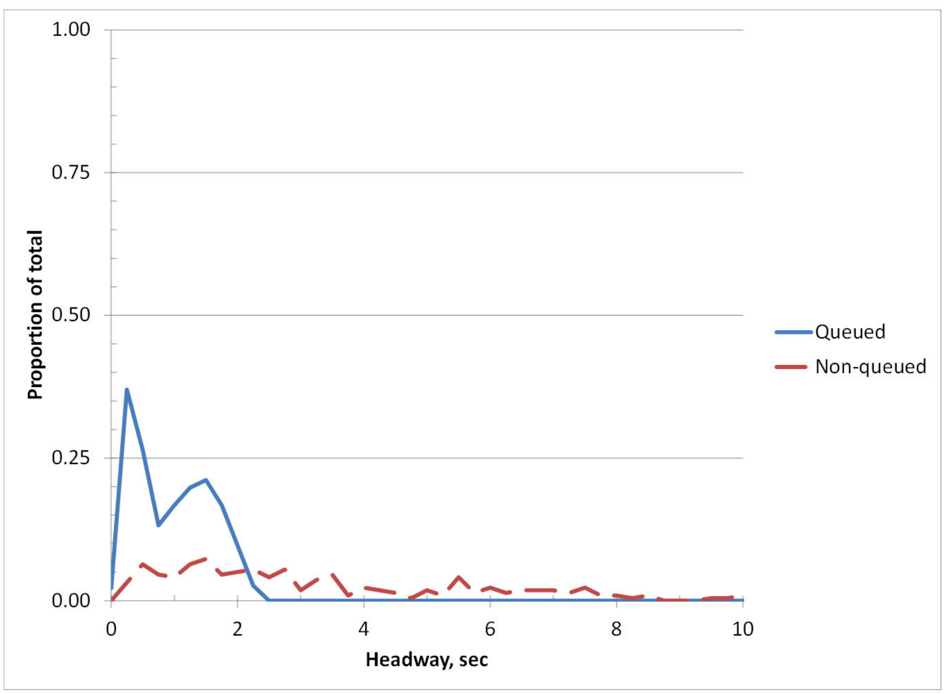


Figure 133. Headway frequency plot for queue and non-queued vehicles

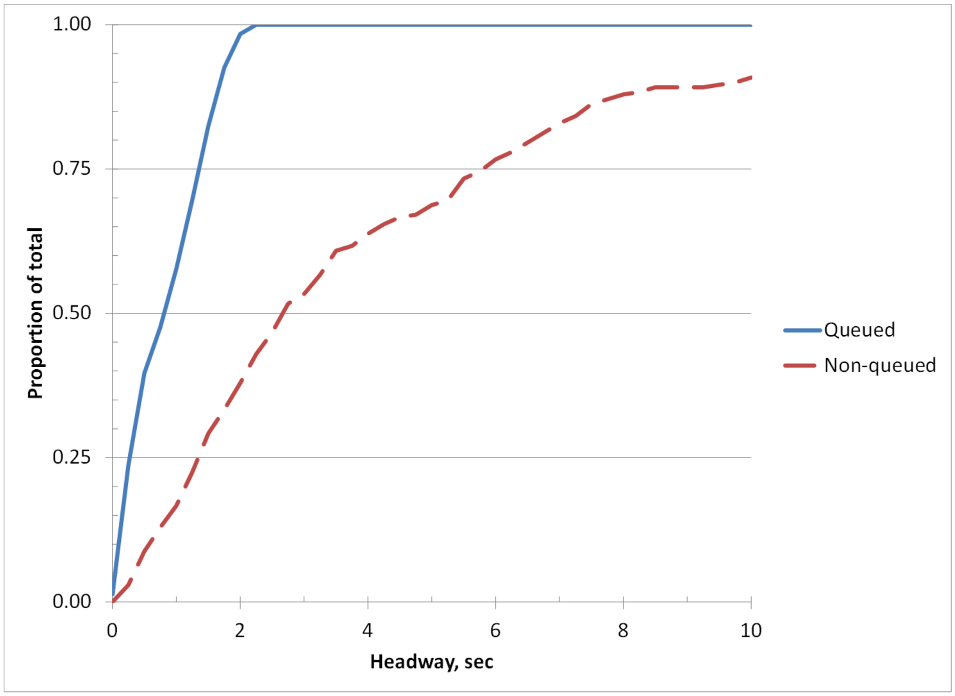


Figure 134. Headway cumulative frequency plot for queued and non-queued vehicles

TASK 4

Phase termination analysis.

- Create the data that you will need for the two lane phases termination analysis in tab 9. Figure 135 shows two columns that have been created that place the queued and non-queued headways in the appropriate columns.

							Headway (sec)	
Data C.P.	t(leave)	VehNo	tQueue	Q/NQ	Headway		Queued	Nonqueued
1	300.18	163	9.6	Q				
2	300.42	161	11.8	Q	0.24		0.24	
1	301.33	165	9.1	Q	0.91		0.91	
2	301.41	164	10	Q	0.08		0.08	
2	302.87	167	8.9	Q	1.46		1.46	
1	303.29	169	5	Q	0.42		0.42	
1	304.44	174	0	NQ	1.15			1.15
2	304.76	171	4.5	Q	0.32		0.32	
1	305.74	177	0	NQ	0.98			0.98
2	305.97	176	2	Q	0.23		0.23	
1	307.65	179	0	NQ	1.68			1.68
2	315.15	184	0	NQ	7.5			7.5
1	315.44	186	0	NQ	0.29			0.29
2	318.14	187	0	NQ	2.7			2.7
1	323.47	189	0	NQ	5.33			5.33
2	324.84	190	0	NQ	1.37			1.37
1	328.61	193	0	NQ	3.77			3.77

Figure 135. Creation of input data for phase termination analysis

- Copy (and paste as "values") the headways for the queued and non-queued vehicles into the two input columns in the phase termination analysis spreadsheet template for the two lane analysis (tab 10 of your Excel file). Figure 136 shows the headway data that have been pasted into the first two columns of the spreadsheet. The Signal Information and Termination Outcomes are calculated based these input data.

Headway (sec)		Signal Information		Termination Outcomes		
Queued	NonQueued	Ideal Signal Display	Change Occurs	Type 1	Type 3	Type 2
0.24		Green				
0.91		Green				
0.08		Green				
1.46		Green				
0.42		Green				
	1.15	Green				
0.32		Green				
	0.98	Green				
0.23		Green				
	1.68	Green				
	7.5	Red	Change			1
	0.29	Red				
	2.7	Red				
	5.33	Red				
	1.37	Red				
	3.77	Red				

Figure 136. Outcomes for phase termination analysis showing type 1 termination

- Use the Phase Termination Analysis template to determine the Termination Outcomes for a range of possible values for the MAH for the two lane case. Enter a value in the MAH cell and record the resulting number of Types 1, 2, and 3 terminations. Figure 137 shows the results of a phase termination analysis for four MAH cases, ranging from 0.5 seconds to 2.0 seconds. When the MAH was set to 0.5 seconds for example, the phase terminated before the queue had cleared for all 17 phases, and only 39 percent of the vehicles would be served. At the other extreme, if the MAH was set to 2.0 seconds, the phase would extend past the time the queue had cleared in 6 of the 17 cases.

MAH	Percentile
3.0	#N/A

Headway (sec)		Signal Information		Termination Outcomes		
Queued	NonQueued	Ideal Signal Display	Change Occurs	Type 1	Type 3	Type 2
0.24		Green				
0.91		Green				
0.08		Green				
1.46		Green				
0.42		Green				
	1.15	Green				
0.32		Green				
	0.98	Green				
0.23		Green				
	1.68	Green				
	7.5	Red	Change			1
	0.29	Red				
	2.7	Red				
	5.33	Red				
	1.37	Red				
	3.77	Red				

Outcome Distribution

Type 1 Termination	0
Type 3 Termination	3
Type 2 Termination	14

Results of Phase Termination Analysis

Headway	0.5	1.0	1.5	2.0
Percentile	38.9%	57.0%	81.9%	98.1%
Type 1 Termination	17	14	6	6
Type 3 Termination	0	1	6	5
Type 2 Termination	0	2	5	6

Figure 137. Phase termination analysis results for four example maximum allowable headways

Task 5

Select the MAH.

- Write a goal statement for the selection of the MAH based on your desired balance of type 1 and type 2 terminations for the two lane case
- Select the MAH for the two lane case using your goal statement and the analysis that you have completed as the basis for your selection

Task 6

Compare one lane and two lane data.

- Compare the mean values of the headway distributions for the queued and non-queued vehicles for the one lane and two lane cases, and the frequency distributions for these two cases
- Compare the results of the phase termination analyses for both the one lane and two lane cases

Task 7

Compute passage times.

- Compute the passage times for the one and two lane cases using the MAH values that you have selected and the speed value that you determined in Task 2. Assume an average vehicle length of 20 feet and a detection zone length of 22 feet.

Task 8

Observe the VISSIM simulation using new values of passage time.

- Set the passage times that you selected in Task 7 into your VISSIM network for both the one lane and two lane approaches
- Set the detection zone lengths to 22 feet and the minimum green time to 5 seconds
- Gather the performance data (average delay and average queue length) and summarize these data for the individual approaches and for the intersection
- Observe the operation and make conclusions about what you see, and compare this with your performance data

Student Notes:

ACTIVITY

38 Actuated Traffic Control Processes

IN PRACTICE

Purpose

The purpose of this activity is to give you the opportunity to compare the results of your design work (Activities #36 and #37) to the range of values discussed in the *Traffic Signal Timing Manual*.

Learning Objective

- Contrast design values with those recommended in practice

Required Resource

- *Traffic Signal Timing Manual*

Deliverables

Prepare a document that includes

- Answers to the Critical Thinking Question
- Completed Concept Map

Link to Practice

Read the section on “Phase Intervals and Basic Parameters” and “Actuating Timing Parameters” from the *Traffic Signal Timing Manual* as assigned by your instructor.

Critical Thinking Question

When you have completed the reading, prepare answers to the following question:

1. Describe the differences between your selected passage time value and the value ranges described in the *Traffic Signal Timing Manual*.

In My Practice...

by Tom Urbanik

In practice, you must resolve theoretical calculations with the realities of drivers and the technology that is deployed. The practical goal is efficient control without generating complaints or trouble calls due to an occasional short-timing of a phase. The activities that you have completed in this chapter included the issue of a slow truck causing a phase to gap out. In practice an inattentive driver could also fail to reset the passage timer in a detector design using small area (e.g., 6' by 6' loop) detection. This could occur if the detection zone was between two cars and the second car did not move over the detection zone before the passage timer expired. While this problem is largely overcome by using presence detection, it is still possible for the detection zone to be located between the two vehicles.

Although partially addressed in Activity #37 for two lanes, the complexity of multi-lane detection which sends the detector call to a single phase timer, makes selection of the passage time problematic. The passage time model you considered in Activity #36 was for a single lane. It does not account for calls on two or more lanes. Straggling cars in three lanes may look like closely spaced cars in a single lane. The partial solution is to adjust the passage time down (which could result in the phase occasionally running too short) or using a single lane value which can result in extending the phase even though the flow rate is much less than saturation flow.

So, the traffic signal timing engineer has to balance these practical issues in application of the model by making adjustments to the ideal passage setting or using advanced features. While not extensively used (unfortunately), there are advanced features to address these issues. Although these advanced features are not included in this course, they can be found in the *Traffic Signal Timing Manual*.

CONCEPT MAP

Terms and variables that should appear in your map are listed below.

call	occupancy time	maximum allowable headway	h	t_o
detection zone	recall		L_d	t_u
interval	unoccupancy time		L_v	v

Student Notes: