ACTIVITY 58

Integrating Information, Justifying Choices, and Communicating Results

READING

PURPOSE

The purpose of this activity is to give you the opportunity to consider issues relating to your final design report.

LEARNING OBJECTIVES

- Integrate information from previous work
- Justify design choices
- Communicate results

DELIVERABLES

- Define the terms 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.

level of aggregation	
measures of effectiveness	

CRITICAL THINKING QUESTIONS

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

1. When we talk about integrating information, what do we mean? Provide an example from everyday life.

2. Identify a kind of information that you often see presented. Describe two ineffective ways of presenting that information. Why are those ways ineffective?

3. What criteria make for an effective oral presentation or report? Name at least five, describing how each contributes to the effectiveness of the presentation or report.

4. Why is there not one "right" answer to a problem that you might observe that will apply to all traffic conditions (for example: short or long queues, low or high volumes)? Explain.

INFORMATION

The Design Process

What is engineering design? More specifically, what is traffic signal timing design? While you may not have thought about the design process explicitly as you have completed the preceding 57 activities in this book, design is exactly what you have been doing. You have defined a problem, analyzed the performance of an existing signal timing plan, and evaluated the performance of your final design elements. Let's step back for a minute and look back to what you have considered, from several perspectives: the components of the traffic control system and how these components interact, the inputs to the system that you have access to and control of, and the way the system performs based on changes that you make to it.

As you learned in Chapter 1, the traffic signal control system can be represented by four components: users, detectors, controllers, and displays. The users arrive at the intersection, and their arrivals are sensed by detectors. The detectors transmit what they have sensed to the controller. The controller determines which users to serve, in what sequence, and for how long, and specifies which users are currently being served (and those that are not) by driving the displays. The displays provide information on what actions are appropriate for the users to take. There is a clear process of interaction and influence among and between these four components (see Figure 175).

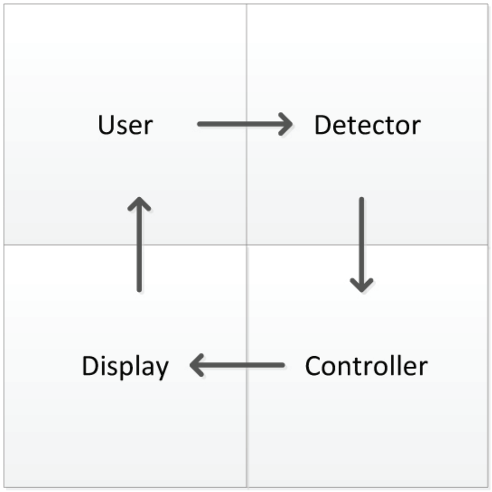

Figure 175. Traffic control process model

But which of these components can you influence in this design process and what are the results of the design choices that you make? We will consider these issues in the list below.

1. You have little or no influence on the number of users that arrive at the intersection during a given interval of time. So the user demand is generally a "given" that you must assume. You also have little influence over the types of users that arrive at the intersection, though you might give priority to certain types of users over others. For our work, the number of users has been specified as a flow rate (in vehicles per hour), and we have focused on users who drive cars or trucks.
2. You do have direct influence on the detection component. You can specify the technology (for example, inductive loops, video, or microwave), where the technology is located, and the manner in which it senses the arrival or presence of users. We have focused on one technology in this project: inductive loops that are embedded in the pavement and that sense the presence of vehicles that have arrived at the intersection. We have assumed that the loops are located at the stop bar and that they are 22 feet long. So while you as a traffic engineer do have influence on the detector design, as part of this project you were given a completely specified detection component to assume.
3. You have direct influence on the controller component. You can specify the controller type (NEMA, 2070, other), the sequence in which the phases are served, the timing processes and durations of the timing intervals, and whether the intersection operates in isolation or as part of a coordinated system. Through a series of experiments and observations that encompassed the previous activities, you determined the phasing plan (through specifying the ring barrier diagram) and you specified the duration of the minimum green, passage time, maximum green, yellow, and red clearance timing intervals for each phase.
4. You have direct influence on the display component. Within guidelines from the *Manual of Uniform Traffic Control Devices* and the *Traffic Signal Timing Manual*, you can specify the types and locations of the displays and indications. However, the specification of the displays and indications were beyond the scope of your work in this design project and you assumed standard vehicle displays with green, yellow, and red indications.

This information is summarized in Table 26, where each component is described, how much influence or control the designer in general has over each component, and what your role was for each component as part of this design project.

Component (attributes)	Degree of influence or control of component by designer	Your degree of influence or control of component in your design project
User (automobiles, trucks, pedestrians, transit, trains)	None or little	None (user volume assumed)
Detectors (technology, detection area, location)	High (technology type, detection area, location)	None (assumed inductance loops, presence detection, located at stop bar, 22 feet in length)
Controller	High (phase sequence, timing processes, timing durations)	High (selected/determined phase sequence, basic actuated timers, timer durations, yellow interval, red clearance interval)
Display (indications)	High (type, location)	None (display configuration assumed)

Table 26. Your design role in the traffic signal control system

So, how did the system perform, given the geometric layout of the intersection, the volume and type of users, the specification of the detection system, the controller timing plan, and the vehicle displays that you assumed? You used several methods to describe the performance of the system including (1) description of what you observed while watching the simulation and (2) analysis of the data that VISSIM generated including standard performance measures (delay and queue length). In this reading, we will explore some of these issues in more detail, including integrating different kinds of information, using various kinds of measures of effectiveness, presenting data, using experimental results to make design choices, and communicating your results.

Integrating Different Kinds of Information

In Chapter 5, we introduced the notion of "learning to see." What we meant was this: a traffic engineer should spend time in the field observing the flow of traffic and, based on these observations, determine if traffic is flowing well or if the quality of flow could be improved. For example, we could observe that a queue spills out of a left turn pocket impeding the flow of traffic in the adjacent through lanes. Or we could observe that a short queue that forms on the through lanes clears quickly after the beginning of green. Both of these observations are statements about the quality of the flow of traffic that might lead us to, in the first example, ideas that change the sequence of phases or the duration of one or more timing intervals, or, in the second example, to do nothing because the system is already performing in an acceptable manner.

We can quantify these observations by adding numeric performance data that we collect during field observations or from a simulation run. While measures of effectiveness will be discussed in the next section of this Reading, let's first explore two examples that illustrate the integration of visual observations with numeric performance data.

Example #1: Queue spillback from left turn pocket

Consider the two cases of the operation of a left turn lane shown in Figure 176. Figure 176a shows a queue that spills out of the left turn lane and into the adjacent through lanes. By contrast, in Figure 176b, the left turn queue is served without impeding the through traffic flow. Both observations are valuable and lead us to make different conclusions about the quality of flow. But can we supplement these observations with performance data that we collect from the field or from a simulation run? The answer is yes, as shown in Table 27, where the delay and queue length data for both conditions are shown. In the first example, there is an average of four vehicles in the queue while in the second example the average is only one vehicle in the queue.

a. LT lane queue spillback **b.** No LT spillback

Figure 176. Queue spillback from left turn pocket

Case	Average delay (sec/veh)	Average queue length (vehicles)
Queue spillback	27	4
No queue spillback	5	1

Table 27. Comparison of numeric performance data for different flow conditions (Example #1)

Example #2: Queue doesn't clear before end of green

Now consider two cases of the operation of a through lane shown in Figure 177. Figure 177a shows a queue that doesn't clear before the end of green. By contrast, in Figure 177b, the queue does clear before the end of green. As in the example #1, Table 28 shows the delay and queue length data for both conditions, data that can be integrated with the visual observations made from Figure 177.

a. Queue at end of green **b.** Short queue that will clear before end of green

Figure 177. Queue in through lane

Case	Average delay (sec/veh)	Average queue length (vehicles)
Queue doesn't clear	35	14
Queue clears	12	2

Table 28. Comparison of numeric performance data for different flow conditions (Example #2)

Measures of Effectiveness

A measure of effectiveness or MOE is a parameter that describes the performance of the system, or how effective the system is in meeting the needs of its users. For an isolated signalized intersection, two measures are commonly used for this purpose.

- The average delay per vehicle is the average additional travel time experienced by users if they weren't impeded by other vehicles or the control system. Average delay includes users that experience delay as well as those that do not. Theoretically, if no user travels at less than his or her desired speed, the average delay would be zero.
- Average queue length is the average length of the queue during the period of measurement or observation. If any vehicle arrives during red, and must stop or queue, the average queue length would be non-zero.

Both of these measures can be used by the traffic engineer to describe intersection performance. But since users can also directly experience delay and observe the length of the queue on an intersection approach, these MOEs have value over those that can't be directly experienced by the user. An example of the latter is the degree of saturation or volume/capacity ratio. The traffic engineer can measure the volume on an intersection approach, calculate the capacity of the approach, and then determine the volume/capacity ratio to help in the evaluation of the performance of the intersection. However, the user cannot directly experience this parameter.

It is also useful to look at MOEs at different levels of aggregation. For example, we can measure delay for vehicles in one lane, for all of the lanes on a given approach, and for all vehicles traveling through the intersection. When we want to understand performance at a detailed level (in order to identify and develop solutions for a specific problem), the lane or approach is the appropriate level or view. If, however, we want to broadly compare the performance of an intersection under two different signal timing designs, we could use the average delay for each of the designs. Each level of aggregation is important and tells a different part of the "performance story." Three figures from Chapter 5 (Figure 178, Figure 179, and Figure 180) are repeated here to illustrate these three levels of aggregation.

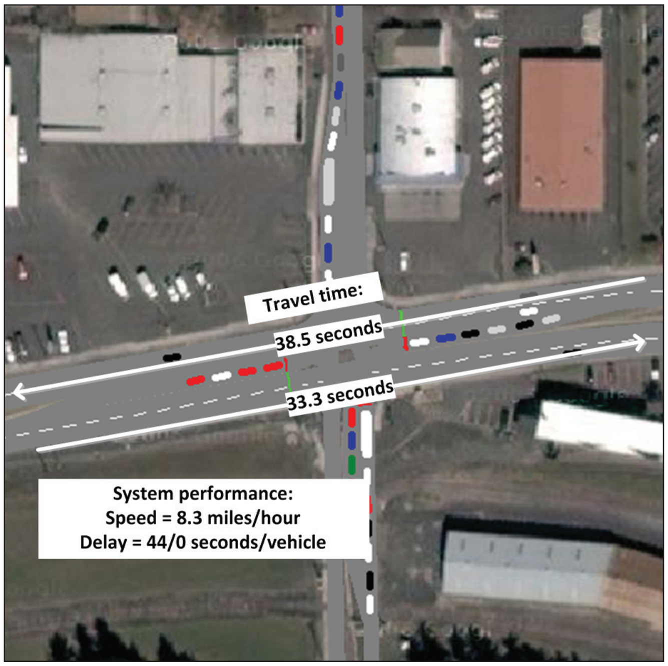

Figure 178. System performance data

Presenting Data

Tables and charts are potentially a good way to show your data and the story that your data can tell. We say "potentially" because tables and charts can also obscure your results and get in the way of the story you want to tell about your data. In this section we will look at both good and bad examples of tables and charts. We will also consider examples of "before and after" comparisons, precision and accuracy, and differences, both statistically and operationally significant. Read through the examples and see how each one might be of value as you prepare your final report. Each one is from a report previously completed by a university student. A quote from Edward Tufte (from *The Visual Display of Quantitative Information*) says it clearly:

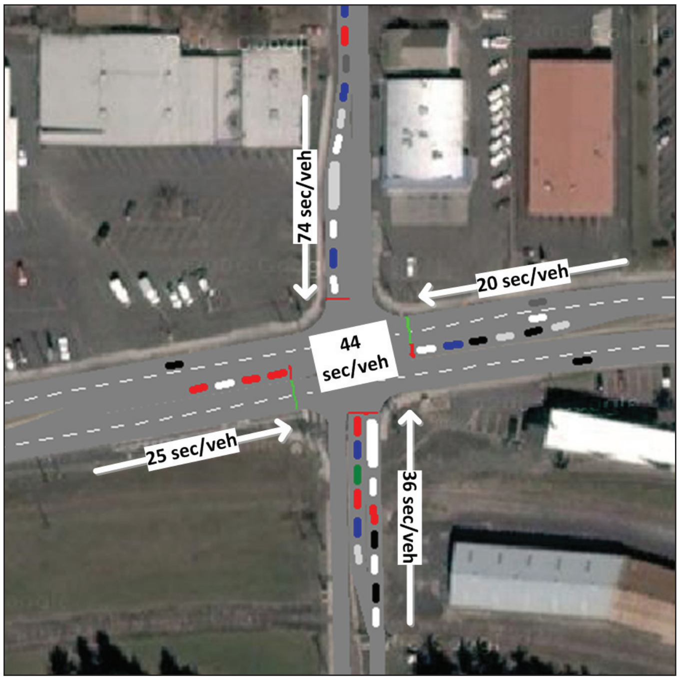

Figure 179. Intersection and approach performance data (average delay)

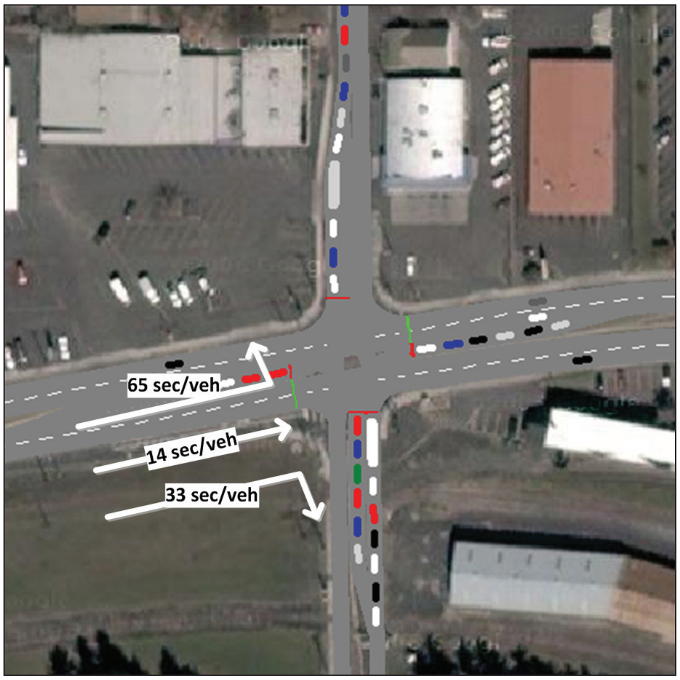

Figure 180. Movement performance data (average delay)

> "What is to be sought in designs for the display of information is the clear portrayal of complexity. Not the complication of the simple; rather the task of the designer is to give visual access to the subtle and the difficult – that is, the revelation of the complex."

Figure 181 shows the duration of the mean green times for each of the eight phases at a signalized intersection. Much of the chart is good: the bar charts clearly show the green time values and it is easy to see the differences: phases 2 and 6 (generally the phases that control major street through movements) have the longest mean green durations, and the phases controlling the left turn movements (phases 1, 3, 5, and 7) have the lowest mean green time durations. However, the title is incorrect since this isn't really a histogram or frequency diagram.

Table 29 compares four attributes for a set of simulation runs where the maximum green time setting has been varied from 100 seconds down to 20 seconds. The number of gap outs and max outs vary as expected, as the maximum green time varies: for lower maximum green times, the phase is more likely to max out while for higher maximum green times the phase is more likely to gap out. Both are clearly shown in the table. The delay varies, and decreases as the maximum green time is decreased, which is what we would expect from theory (higher cycle lengths generally results in higher delay). This table is a good example of presenting and comparing results for the analysis of one timing parameter. But the table could be improved by giving the units for the average queue (feet) or delay (sec/veh).

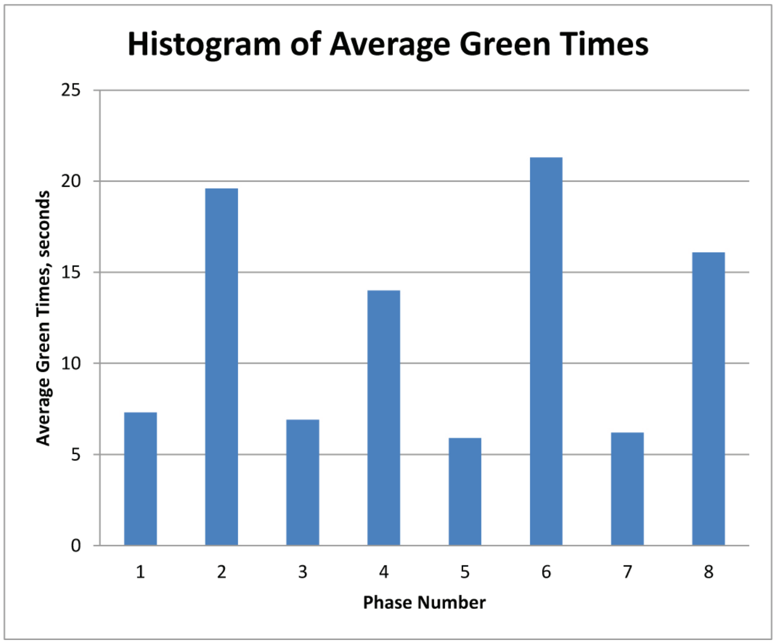

Figure 181. Example chart with incorrect title

Measure	**Maximum Green Time (sec)**									
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
Gap outs	0	129	138	154	175	180	178	190	198	205
Max outs	209	80	71	55	33	30	22	11	4	4
Average queue	37.9	34.6	41.2	43.6	53.2	49.3	57.4	50.9	52.2	48.4
Delay	24.0	29.0	32.0	35.2	41.1	39.0	43.2	41.6	43.1	41.9

Table 29. Effective comparison of the variation in the number of gap outs and max outs by maximum green time

Figure 182 shows a cumulative frequency chart for two sets of data, NQ and Q. We most likely know that Q is for "queued vehicles" and NQ is for "non-queued vehicles." However the reader should never have to guess what these abbreviations are. Another element in the chart that could be improved is the labeling of the y-axis range: the maximum should be 1.0 (the actual maximum value for a cumulative frequency chart) and not 1.20. In addition, only one decimal place is needed and not the 2 that are included in the figure. Similar comments can be made about the labeling of the x-axis: a spacing of 1 is sufficient; 0.25 results in too many numbers displayed on the x-axis.

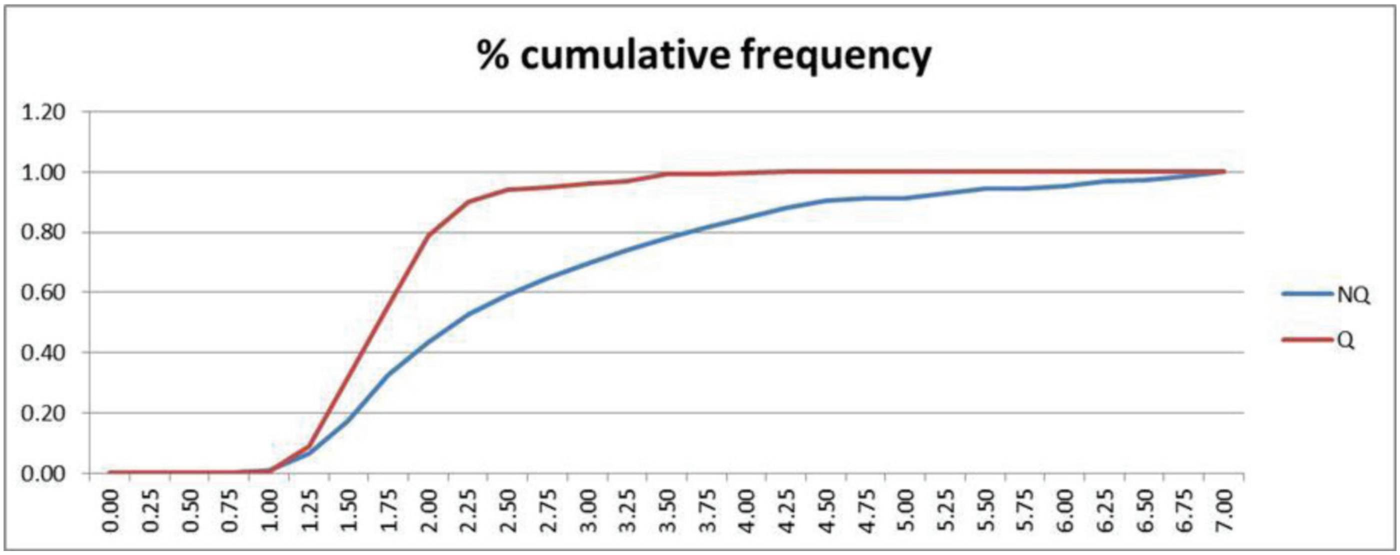

Figure 182. Poor example of graph labeling

Figure 183 is a screen capture from a VISSIM simulation that shows the traffic flow on one approach at a signalized intersection. This figure clearly captures the problem of traffic spilling out of the left turn pocket, impeding the flow of traffic on the two through lanes, and is a good way to illustrate a "traffic problem."

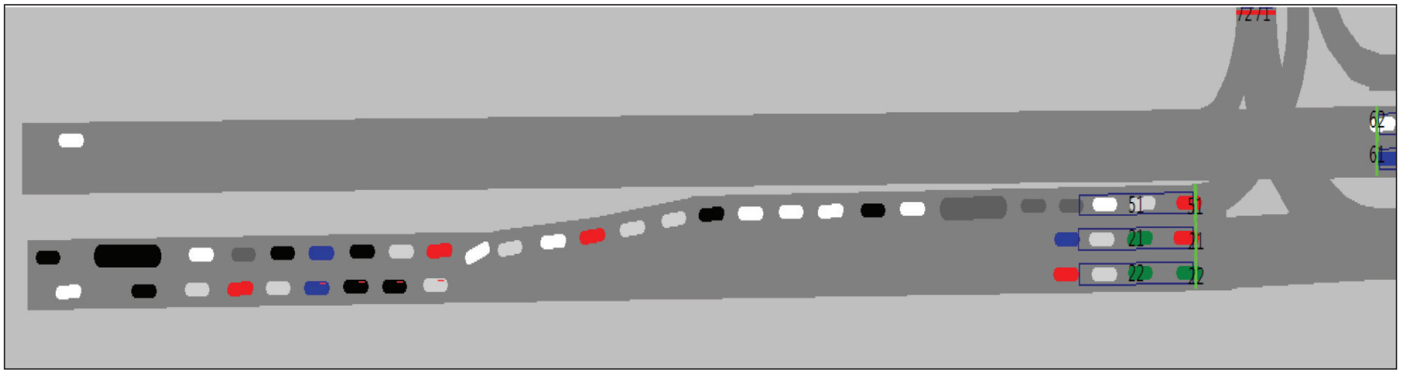

Figure 183. Good example of VISSIM screen capture showing left turn queue problem

Figure 184 shows a cumulative frequency plot for non-queued vehicles. While we might assume that it shows the distribution for headways, we don't know this for sure since the x-axis is not labeled. The numbers shown on the y-axis have two decimals places; whole numbers would be sufficient here since there is no decimal information conveyed. In addition, spacing intervals of 20 percent is sufficient for this range and not every 10 percent as shown in the chart. The x-axis also has too many numbers; spacing intervals of 1 or 2 would be sufficient as an interval.

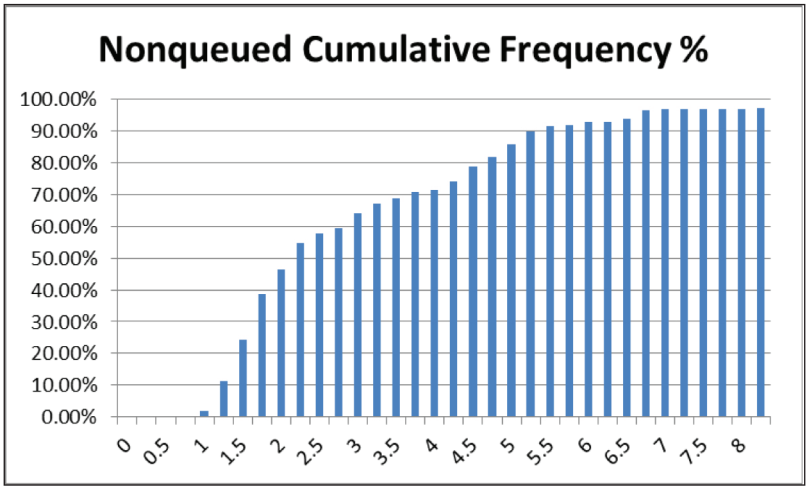

Figure 184. Poor example of cumulative frequency chart

Table 30 shows the before and after ("base case" compared to "final design") data for average queue length, total delay, and level of service. The table clearly makes the comparison between both cases, and we can see that the final design results in significant (observably significant) differences for both average queue length and total delay. The table also refers to level of service, a concept from the *Highway Capacity Manual*. The HCM provides a range of delay values for a set of grades from A to F. While these categories are useful for comparing two or more alternatives, it should be kept in mind that these category ranges are somewhat arbitrary, backed by little human factors research.

Measure	Before (base case)	After (final design)
Average queue (vehicles)	31.6	12.9
Total delay (seconds)	25.1	15.4
Level of service	C	B

Table 30. Before and after comparison

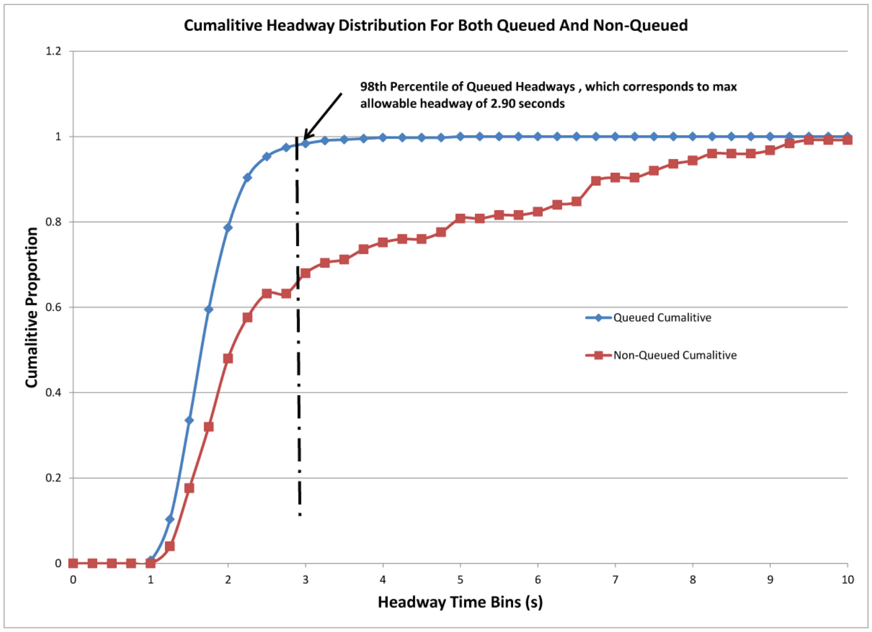

Figure 185. Example headway distribution for queued and non-queued vehicles (original)

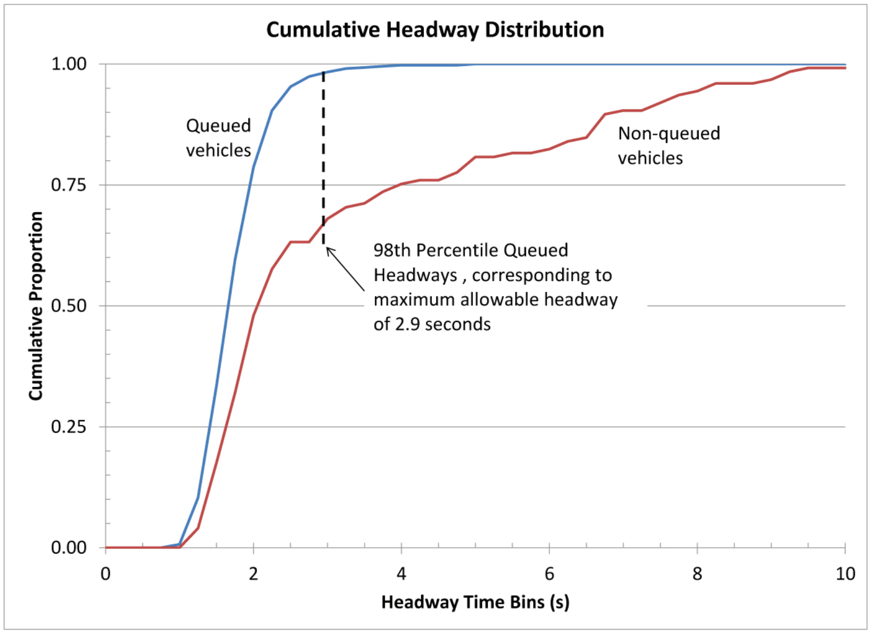

Figure 186. Example headway distribution for queued and non-queued vehicles (with changes)

Figure 185 shows a cumulative headway distribution for both queued and non-queued vehicles. The key parts of the chart are labeled so the reader can "see" the amount of difference in the headways between these two vehicle categories: the queued vehicles have lower headways (expected since they vary about the theoretical saturation headway), while the non-queued vehicles have a much wider range of values. However, there are improvements that can be made to the presentation of this information

Figure 186 shows the same information but with improvements. The type size is larger, making the chart easier to read. The maximum *y* value is 1.0, which is the actual maximum for a cumulative distribution. The legend has been eliminated and each of the lines is more directly labeled. Also, the graphs are shown as lines only and not a combination of lines and markers, which makes reading the chart much easier.

Movement	Before		After	
	Queue length (ft)	Delay (sec/veh)	Queue length (ft)	Delay (sec/veh)
EBTH	72.7	33.6	30.1	15.1
EBRT	72.7	38.8	30.1	18.6
EBLT	52.2	69.0	12.1	24.5
NBRT	51.3	43.0	22.2	15.4
NBTH	51.3	33.2	22.2	19.6
NBLT	25.1	59.6	7.1	21.7
WBTH	74.1	35.9	27.4	14.9
WBRT	75.8	28.9	28.6	10.8
WBLT	29.5	64.4	6.1	23.8
SBLT	76.7	46.8	28.1	19.0
SBTH	76.7	43.8	28.1	19.0
SBRT	45.7	74.0	9.3	23.2
Average	58.7	47.6	21.0	18.8

Table 31. Performance measures (before and after)

Three presentations of the same data are shown on this page. Table 31 compares queue length and delay for before and after conditions. The data are shown for each movement at the intersection. The average for all movements is also shown at the bottom of the table. Delay is improved both for the intersection, as well as for each movement. In fact, the difference is significant, showing that the signal timing changes in the after condition have resulted in a measurable change for the user.

Movement	Queue Length (ft)		Delay (sec/veh)	
	Before	After	Before	After
EBTH	73	30	34	15
EBRT	73	30	39	19
EBLT	52	12	69	25
NBRT	51	22	43	15
NBTH	51	22	33	20
NBLT	25	7	60	22
WBTH	74	27	36	15
WBRT	76	29	29	11
WBLT	30	6	64	24
SBLT	77	28	47	19
SBTH	77	28	44	19
SBRT	48	9	74	23
Average	59	21	48	19

Table 32. Performance measures (before and after)

Table 32 makes the comparison easier by showing queue length data side by side (before and after); delay data are shown the same way. Also, the data are shown only to the nearest whole number, eliminating the tenth of a second for delay and tenth of a foot for queue length. The precision shown in Table 31 is not warranted.

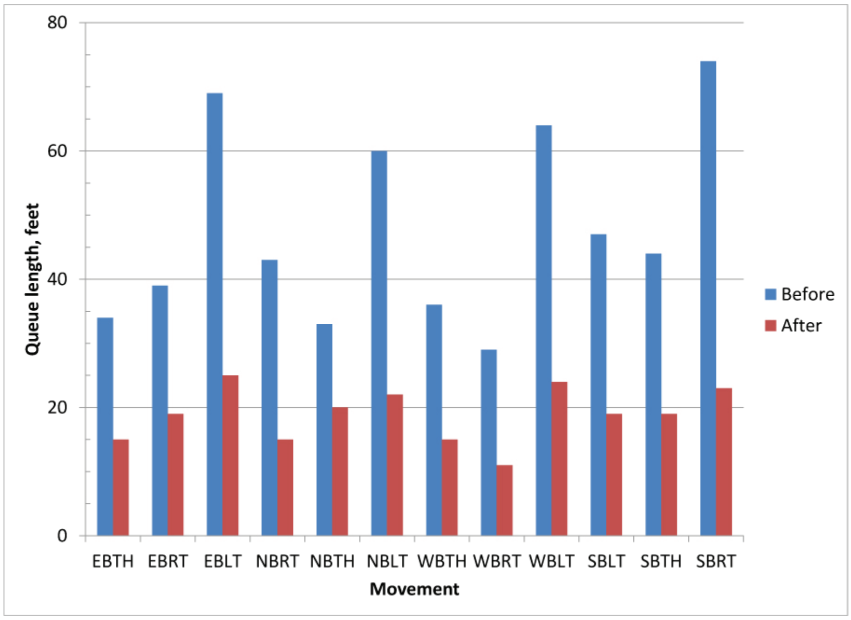

Figure 187. Queue length data (before and after)

An even easier comparison between the before and after conditions for queue length can be made if a chart is used to compare the data. The reduction in queue length that results from the "after" case is clearly represented in Figure 187.

Movement	Node	Permitted LT		Protected LT	
		aveQ	Delay	aveQ	Delay
W-E	1	46.9	7.6	15.5	5.4
W-N	1	496.4	178.4	76.9	39.3
E-W	1	24.9	6.9	101.4	19.1
E-N	1	0.1	1.4	0.8	4.0
N-E	1	49.0	34.2	47.4	35.7
N-W	1	49.0	36.1	47.4	35.0
All	1	100.8	24.3	47.2	17.7

Table 33. Performance data comparison

Table 33 compares the performance of the intersection for two cases, with permitted and protected left turns. However, it is difficult to identify the turning movements as they are shown in the default VISSIM notation (noted from one direction to another). Also, the "node" column is unnecessary as the data are all from node 1. Finally, the units are not given.

Movement	Permitted LT (sec)	Protected LT (sec)
EBTH	7.6	5.4
EBLT	178.4	39.3
WBTH	6.9	19.1
WBRT	1.4	4.0
SBLT	34.2	35.7
SBRT	36.1	35.0
All	24.3	17.7

Table 34. Delay data comparison

Table 34 provides for a more easily read comparison for delay between the permitted and protected left turn options. And, the movement label is the more traditional notation. But it is also worth looking at the differences. For example, the difference for the EBTH movement is negligible, only 2 seconds, a value too small to be perceived by the user. The differences are also small (and not operationally significant) for the WBRT, the SBLT, and the SBRT. However, differences are significant for the EBLT and the WBTH movements. The mean difference for all movements (24.3 vs. 17.7) is moderate and may not be perceivable by the users.

Experimental Results

We have tried to make the point regularly throughout this book that we want you to learn by observing and by learning to use a variety of data, synthesizing these observations and data into a decision about one element of your signal timing design. For example, in Chapter 6, you studied the effect of various passage time values on when a phase would terminate (given a specific detection zone length) and whether this termination would come just as the queue cleared, too early if the queue hadn't cleared, or too late if the phase continues on past when the queue has cleared. As we have said, this is a messy business. There is not one "right" answer that will apply to all conditions (short or long queues, low or high volumes). Our point is to get you to consider this messiness, as a regular part of the life of an engineer, and to learn to balance sometimes conflicting objectives.

But we also pointed you to the *Traffic Signal Timing Manual*, the standard guidebook for signal timing in the U.S., where you have been able to read about "practice", or guidelines or rules that can be used or referred to by practicing traffic engineers. Why not just turn to the chapter in the *Traffic Signal Timing Manual* on timing and see what the table says for the value of the passage time? A good question! And, if you ask many engineers in practice, they may say that they do this regularly because they don't have time to explore an issue in greater detail, or they may not understand the issues behind setting the passage time, or other timing parameters. We hope that by dealing with the results from your observations (both the visual observations as well as the numeric data that you collect in the field or generate from your simulation runs) that you will develop a better understanding of why timing parameters are set with certain values, or why a given range might be just as acceptable. Learn to use guidebooks (like the *Traffic Signal Timing Manual*) but take the time to use data that you have available to help you select signal timing design values for the particular case or set of conditions that you face.

How to Communicate Your Results

So how do you tell others what you have learned and what are the important parts of the design that you are recommending? And, of all of the data that you have generated and sifted through, which data do you include to justify and support your work? You will be asked to use two forms of communication to do this, each of which is briefly described here.

A written report is the most common and widely used method of communicating technical results. We will not attempt here to address all of the considerations that go into good technical writing. As you prepare your report (Activity #62 specifies requirements for your design report that you will need to follow), consider several issues, maybe rules of thumb, that are listed below to help you in this process:

1. As your writing improves and matures, your reports should change from what we call laboratory reports to professional reports. A laboratory report is filled with statements like: "I plugged the data into the software" or "We ran VISSIM." By contrast, a professional report includes statements like: "The results of the simulation analysis showed that…"
2. No one writes well the first time through preparing a document. While you have time constraints and many demands on your time as a student, you need to schedule time to write, then read and critique, then write again.
3. Read your writing out loud. There is no better way to literally hear how your writing sounds. Reading slowly points out poorly written sentences, points that are not well organized, and obvious mistakes in grammar and punctuation.
4. Take care with the first sentence in each paragraph: each should be strong and lead the ideas that follow in the paragraph.
5. You are telling a story, using your observations and data, a story that builds into a justification for a design that you are presenting.

You will also orally present the results of your work. It is common (almost standard) to use slides as a set of visual aids in your oral presentation. However, it has become all-too-common for the slides to become a barrier between the presenter and the audience. And too often, the slides are filled with text that the presenter (and the audience as well) simply reads. Pretty boring, and not very effective communication! We will not attempt to address all aspects of a good oral presentation. But what follows are some ideas to consider as you prepare your oral presentation. Tufte notes (in *Beautiful Evidence*) that "making a presentation is a moral act as well as an intellectual activity."

1. Learn to talk about your work in a manner that engages the audience and that tells the story that you want to get across. When you really talk to the audience, they can take on the role that you really want them to play: active listeners who want to learn about your design, how you have designed it, and how you justify each component of the design.
2. Talk about your design; don't just read from the text in your slides. In fact, use slides for what they do best: as visualizations of some form of information that is best seen and then talked about. Show an excerpt from an animation of VISSIM to illustrate a traffic problem that you solved or better managed. Show a chart that illustrates how increasing the maximum green time increases delay. Show a time space diagram to illustrate the issues in setting the yellow time.
3. Use text only when you want to list key points that you want readers to grasp. And don't just read the key points. Talk about what they mean. Tell a story about them.
4. Tufte (2001) describes the concept of "data-ink." He notes that "a large share of ink on a graphic should present data-information, the ink changing as the data change. Data-ink is the non-erasable core of a graphic, the non-redundant ink arranged in response to variations in the numbers presented." Look at your visuals carefully and only keep those parts of each that are necessary to make the point that you intend.

Summary

So as you begin to prepare your report and presentation, keep in mind the issues raised in this Reading and that are summarized below:

1. Which elements of the traffic signal control system did you affect in your analysis and design?
2. How can you integrate the variety of information that you have generated?
3. What measures of effectiveness best show the performance of your system?
4. How can you most effectively present your information?
5. How have you used your experimental results to analyze the various design options that you considered and to select your final design?
6. How can you make your written and oral reports as effective as possible?