CHAPTER 3: WHOSE TURN IS IT? PHASING, RINGS, AND BARRIERS

This chapter includes information that you will need to prepare for, conduct, and assess each of the seven activities included in Chapter 3 of the student activity book. Figure 1 shows the various files that are available to support your works as you use these activities, including mini-lecture slides, solution files, and student resource files.

Chapter 3 Whose Turn Is It?	Mini-lecture slides	Solution files	Student resource files
A#13 Reading			
A#14 Assessment			
A#15 Field			
A#16 In Practice			

Figure 1. Support files

Figure 2 shows the kind of work required for each activity, how the activities might be grouped, and the approximate amount of class time required to complete the activity. The figure also identifies whether there is homework involved, a mini-lecture could be presented, student discussion could take place, and group work to do.

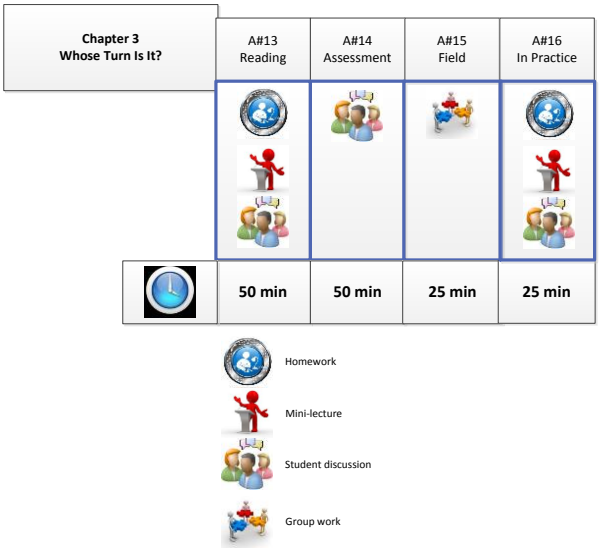


Figure 2. Activity work

Using Activity #13: Phasing, Rings, and Barriers (Reading)

Overview
This activity requires the student to read the "Information" section, define the terms listed in the Glossary, and answer the "Critical Thinking Questions." Students will learn about the fundamental elements of the ring barrier diagram, including the conflict matrix, concurrency groups, and ways of handling various sets of compatible and conflicting movements.

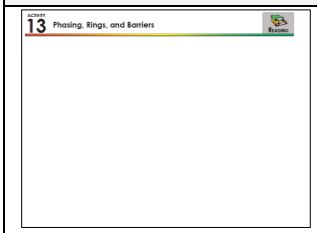
Options for Use
The reading, defining the terms in the glossary, and answering the critical thinking questions are usually done as homework. After the students complete this work, the instructor has several options for assessing and clarifying student understanding of the reading during class:

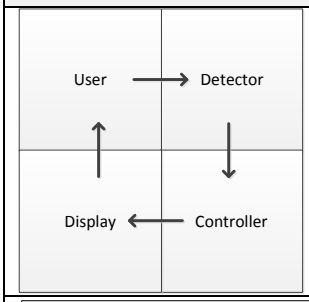
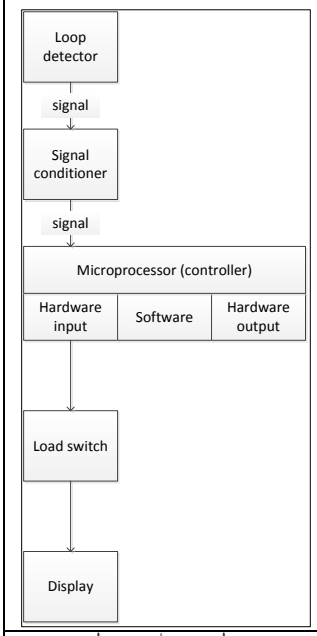
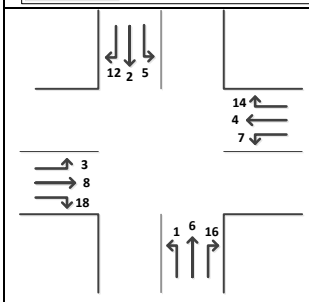
- Quiz to assess their understanding and to hold them accountable for the reading. (15 minutes)
- Discussion and synthesis of the answers to the quiz, the glossary definitions, and answers to the critical thinking questions. (30 minutes)
- Doing a mini-lecture on the key points of the reading
- Moving directly to Activity #14 in which students can assess their understanding of the reading and share what they know with other students in the class.

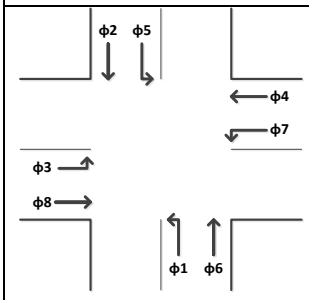
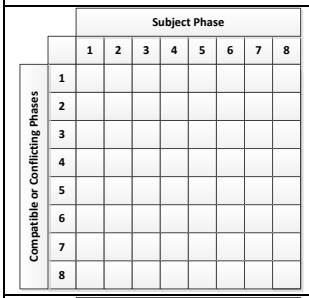
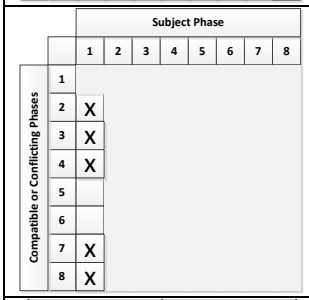
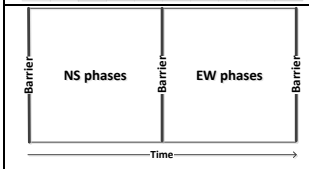
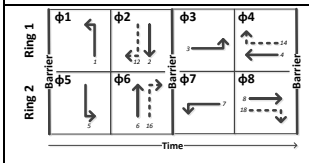
Preparing for the Activity

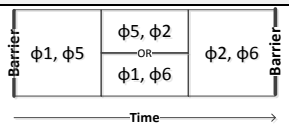
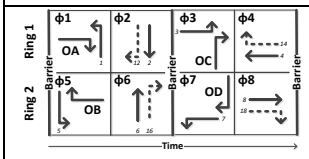
- Decide which of the options you want to use during class.
- Prepare for the class by reviewing Activity #13, including the "Information", the Glossary, and the Critical Thinking Questions.
- Review the example script included below.

Doing the Activity
[Slides: slides13.pptx]
You can use all or part of the following script for your mini-lecture that reviews the concepts included in the reading. While slides are included below and in the slides file, it is sometimes more effective to draw the figures or sketches on the board. This allows you to proceed at a slower pace, more easily followed by students.

Slide	Text
	Let's start with a short quiz on the reading: 1. Define "movement" and "phase". 2. What is a ring? 3. What is a concurrency group? 4. What is the purpose of a ring barrier diagram? [Answers are provided later in this section.]

Slide	Text
	Let's start with the four-component model that I introduced at the beginning of the course. This shows the relationship between the four components of the traffic control system. In this chapter, we will focus on the sequence in which various users are served.
 	Now let's take a closer look at the cabinet, and how it relates to this diagram. And here is more of the engineering than you will most likely need. • Length and diameter of wire in the loop detector determine the inductance. • The detector amplifier (1) amplifies the signal, (2) compares the signal to a threshold, and (3) generates output signal that is compatible with the microprocessor. We set the sensitivity (threshold) which sets how much metal is needed to change the inductance. The output signal can be 0 or 5 volts, or on or off, or contact open or closed. • The controller interprets the bit (0 or 1) as no call or a call. The call is registered when the computer has processed the inputs and determined that a call is registered. This is one of the algorithms in the traffic controller. • The load switch receives output from the controller and transfers (converts) it to a power signal; that is, it takes v and ma and amplifies it to 120v and amps.
	We are going to discuss today two links concepts, and try to be clear about what each is. These concepts are a movement and a phase. We'll start with movement. We typically use the term movement in conjunction with the direction of a vehicle: for example, LT movement or TH movement. Our definition for a movement will be: "activity by a user in response to a go indication or display. We add several modifiers: the turn direction (LT, TH, and RT) and the compass direction (EB, WB, NB, SB). The go indication can be: green display, walk display, LRT vertical bar. We can also say whether the movement is opposed or not by any other movement (permitted, protected, unopposed]

Slide	Text
	While the movement is an activity by the user, a phase controls a movement. Specifically, a phase is a timing unit that controls one or more movements. Chart showing numbering scheme of movements.
	The other key term is the phase: a phase is a controller timing unit that controls one or more movements. The timing unit generally includes three timing intervals, one each for the green, yellow, and red displays. Chart showing typical numbering of phases. [Most often, an even numbered phase controls both the associated TH and RT movements]
	One of the most important tasks of the traffic controller is to separate movements in time so that conflicts between traffic streams are either avoided or minimized. The concept of the conflict matrix will now be introduced, and we will consider this in terms of the phases that we described above (that control one or more movements). [show chart]
	Here is an example of the conflicting movements/phases (as well as the compatible movements/phases) for phase/movement 1.
	So how do we separate out these phases that can occur simultaneously, and those that must occur sequentially (not simultaneously). We start by separating the phases into two "concurrency" groups, most often into two such groups, EW and NS. We separate both groups by a barrier.
	Now we will fully populate the ring barrier diagram. Each ring is a sequence of phases that must time sequentially. A phase can time concurrently with another phase in a different ring but in the same concurrency group.

Slide	Text
	And the duration of the phases depend on the traffic demand and the timing parameters that we've specified. So, if the demand for movement 1 is greater than the demand for movement 5, we will observe a RBD like this. But both phases 2 and 6 must terminate and "cross the barrier" at the same time. So, for the first concurrency group (phases controlling NS movements), we can have either of the following sequence of movements.
	Note some points: (1) We've assumed LTs are leading and protected, (2) other LT options will be discussed later in chapter 8, (3) need to address overlap: what is it. Example: RT movement that is controlled by a conflicting phase.

Solutions

The solutions presented here include:

- Quiz questions and answers
- Glossary definitions
- Critical thinking questions and answers

Quiz questions and answers

1. Define "movement" and "phase".

- A movement is (1) a response of the user to a "go" indication, (2) a compass direction and a turn direction, and (3) protected, permitted, or not opposed.

2. What is a ring?

- A ring is a sequence of phases that are not compatible and that must be served sequentially.

3. What is a concurrency group?

- A concurrency group is a group of phases controlling the east-west movements or the north-south movements.

4. What is the purpose of a ring barrier diagram?

- The purpose of the RBD is to define the safe sequencing of phases (and thus the movements that they control) at a signalized intersection.

Glossary Definitions

Term	Definition
Concurrency group	Group of phases controlling EW movements or NS movements.
Movement	Response to a "go" indication. Compass direction, turn designation. Protected, permitted, not opposed.
NEMA phase numbering	The through movements on the major street are numbered 2 and 6 with their corresponding left turns numbered 5 and 1. On the major street, through and left turn movements should add to 7. For example, if the major street is oriented east west, the eastbound through and eastbound left movements should be numbered 2 and 5 respectively. On the minor street, the through movements should be numbered 4 and 8 with their corresponding left turns numbered 7 and 3. Just as the through and left turn movements should add to 7 for the major street, the through and left turn movements should add to 11 on the minor street.
Overlap	
Phase	A controller timing unit that controls one or more movements.. The timing unit for vehicles includes three intervals: green, yellow, and red.
Ring	A sequence of phases that are not compatible and must be served sequentially.
Ring barrier diagram	The purpose of the ring barrier diagram is to separate movements which are able to safely time simultaneously (ensures that movements do not conflict).

Critical Thinking Questions and Answers

1. What is the purpose of the ring barrier diagram?

- The purpose of the ring barrier diagram is to separate movements which are able to safely time simultaneously (ensures that movements do not conflict).

2. How is timing represented in the ring barrier diagram?

- Timing can be represented in the RBD by the duration of the phases along the x-axis of the diagram.

3. Why use a ring barrier diagram instead of a conflict matrix to describe the sequencing of phases?

- The conflict matrix shows compatible and conflicting movements or phases, but not sequencing of the movements or phases. This is the role of the ring barrier diagram.

4. What is the difference between a movement and a phase?

- A phase is the timing unit which controls one or more movements. A movement is a collection of users with a common direction.

Using Activity #14: What Do You Know About Phasing and Ring Barrier Diagrams (Assessment)

Overview

The purpose of this activity is to assess what students to ring-barrier diagrams and to allow them to gain understanding into how phases are numbered. The key concepts for a student to master are how to arrange movements into a ring-barrier diagram so that traffic is regulated in a safe and efficient manner and for students to rings one and two must cross the barrier at the same time, although the each movement can be a different duration.

Options for Use

- Completion of activity questions by individual students during class.
- Discussion of responses to questions.

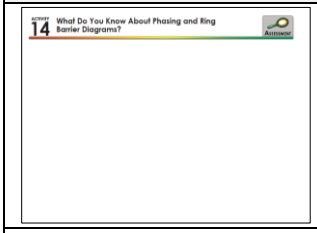
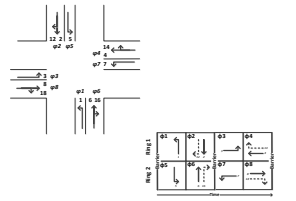
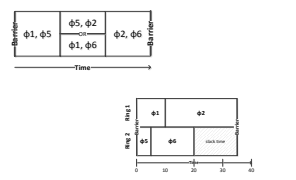
Preparing for the Activity

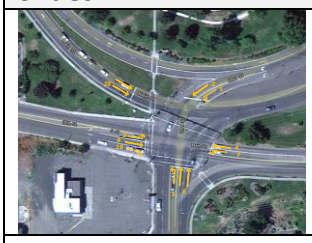
- Confirm options for class period.
- Review questions and answers.
- Consider how you might engage students after they have completed the activity, reinforcing and clarifying what they have learned.

Doing the Activity (Script)

[Slides: slides14.pptx]

You can use all or part of the following slides and script to introduce and conduct this activity.

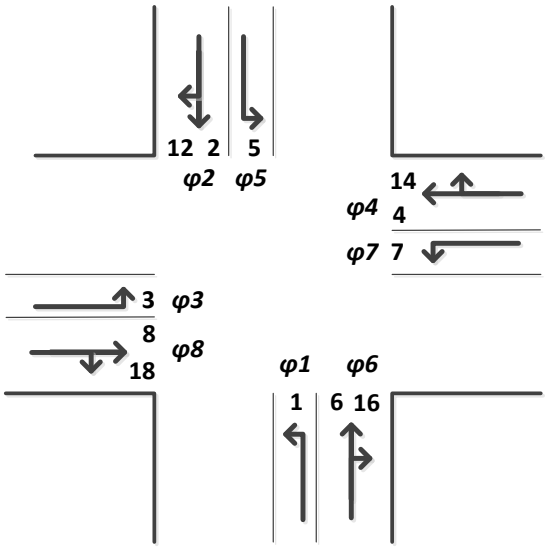
Slides	Text
	• Invite the students to read through the activity. Ask if they have any questions on the activity. • **Tell**: The purpose of the activity is to test your understanding of the basic concepts of phases, rings, and barriers. • Ask them to complete tasks 1 through 5.
	This slide shows the results from tasks 1 and 2.
	This slide shows the results from task 4.

Slides	Text
	This slide shows the figure from task 5.
	Discuss their responses to the CTQ.

Solutions

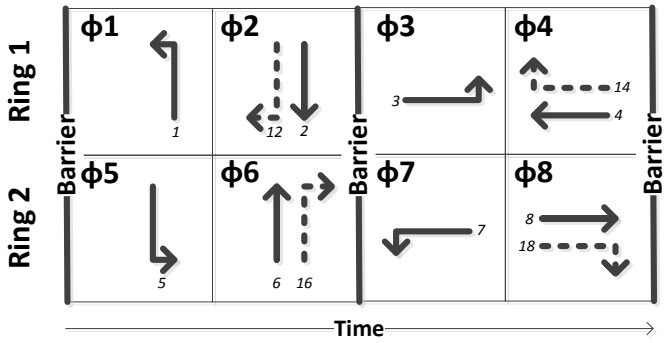
Task 1. Sketch a four leg intersection, showing an exclusive left turn lane and one through lane on each approach. Number each movement and list the phase number corresponding to the standard NEMA numbering scheme that would control each movement.

- This figure shows the movement numbers and the phase numbers for a standard intersection.



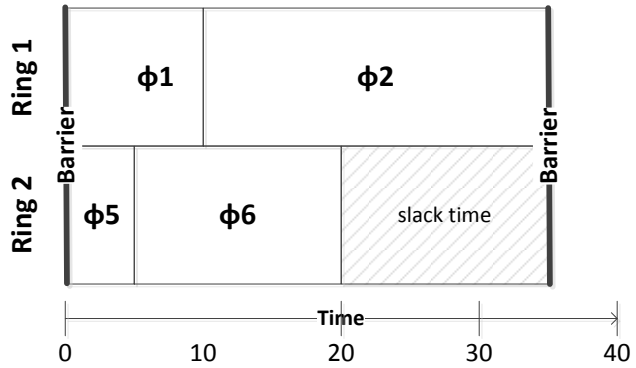
Task 2: Prepare a sketch of a ring barrier diagram that represents that conditions described in task 1.

- This figure shows a ring barrier diagram for the conditions from task 1.

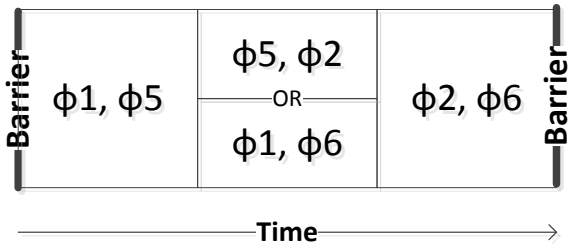


Task 3. Prepare a brief description of the timing process for this eight phase operation by describing the order and manner in which each phase is served. Consider (identify) the various sequences that may occur depending on the traffic flow volumes.

- The ring barrier diagram describes the order or sequencing of phases that are served. For ring 1, the order is phase 1, phase 2, phase 3, and phase 4. For ring 2, the order is phase 5, phase 6, phase 7, and phase 8. However, the duration of each phase (how long each phase times), depends on the demand. For example, if the demand for phase 1 is less than the demand for phase 5, phase 1 will terminate before phase 5 and phase 2 will begin to time as phase 5 continues to time. An example is shown below:



In general, the following two sequences are possible for phases 1, 2, 5 and 6:

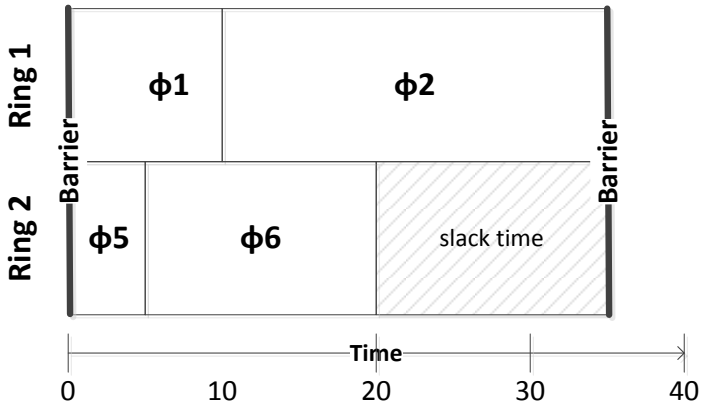


Task 4: Suppose the east-west movements at a signalized intersection require the following times to be served. Draw a partial ring-barrier diagram showing the sequence and the timing of the phases controlling these movements.

Movement	Phase controlling movement	Required time (sec)
EBLT	5	5
EBTH	2	25
WBLT	1	10
WBTH	6	15

- The figure below shows the partial RBD that results from the timing shown in the table above. Note that phase 5 terminates after 5 seconds, but phase 1 continues to time. When phase 5 terminates, phase 6 begins even while phase 1 continues. And, though the demand

for phase 6 requires less time than phase 2 (and phase 6 began timing before phase 2), phase 6 will continue timing during what is shown as "slack time". The term often used for this is phase 6 is "resting in green", while phase 2 continues to time.



Note: When initially constructing ring-barrier diagrams, students typically believe that movements one and five must have the same duration and that movements two and six must have the same duration. The goal of task 4 was to address this misconception. To assist students in overcoming this misconception, it is important to emphasize that the sum of movements' durations in ring one must be equal to the sum of the movements' durations in ring two, but that no individual movements must be identical to any other movement (although they potentially can be).

Task 5: The book shows an intersection with five approaches. The movements are shown and numbered. Prepare a conflict matrix and a ring barrier diagram that would provide safe operation for this intersection.

Note the following clarifications for restrictions on the movements:

- Movement 4 is TH only, no RT
- Movement 28 is TH only, no RT
- Movement 2 is TH only, no RT

- The conflict matrix is shown below.

Step 1. Conflict Matrix

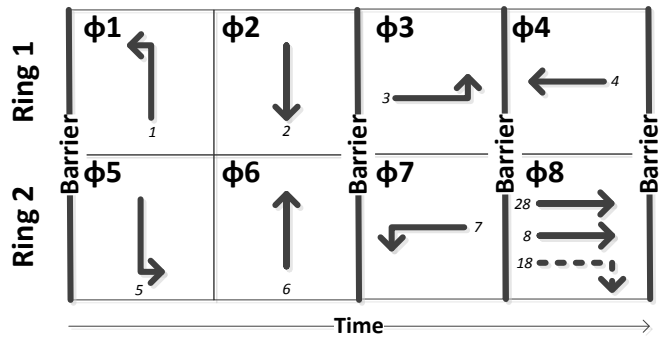
		Subject Phase (Movement?)									
		1	2	3	4	5	6	7	8	18	28
Conflicting (X) or Compatible (C)	1		X	X	X	C	C	X	X	C	C
	2	X		X	X	C	C	X	X	X	X
	3	X	X		X	X	X	C	C	C	X
	4	X	X	X		X	X	C	C	C	C
	5	C	C	X	X		X	X	X	C	X
	6	C	C	X	X	X		X	X	C	X
	7	X	X	C	C	X	X		X	X	C
	8	X	X	C	C	X	X	X		C	C
	18	C	X	C	C	C	C	X	C		C
	28	C	X	X	C	X	X	C	C	C	

Step 2. Concurrency groups

North-South	East-West	Other
1, 6	3, 8, 18	28
2, 5	4, 7	

Step 3. NEMA ring barrier diagram

The standard movements (1, 2, 3, 4, 5, 6, 7, 8, and 18) can be controlled by the eight phases of a standard NEMA ring barrier diagram. The big question here is how is movement 28 controlled? Partly because of the turn restrictions listed above, movement 28 can be served at the same time as movements 4, 8, and 18. But this would also mean that another barrier would have to exist so that the left turn movements 3 and 7 both terminate before movements 4, 8, 18, and 28 can be served. One possible ring barrier diagram would be as follows.



Using Activity #15: Verifying Ring Barrier Operation in the Field (Field)

0verview

The purpose of this activity is for students to apply their knowledge of ring barrier operations by going out into the field and observing an intersection. In this activity, students will be observing an intersection in the field to test their knowledge of ring barrier diagrams, phases and movements. Students will then write a one page report which includes their field observations and a ring barrier diagram the represents how the intersection operates.

Options for Use

This is a field activity.

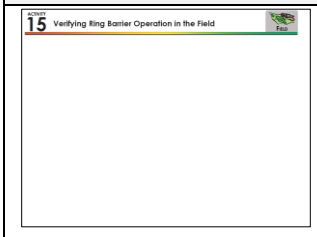
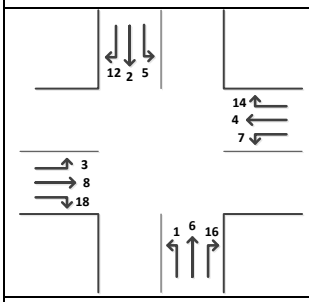
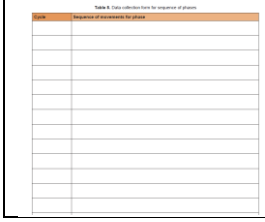
Preparing for the Activity

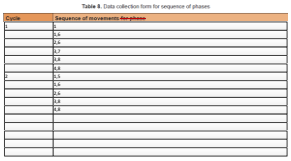
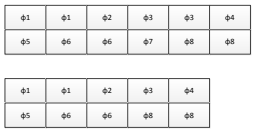
You need to know what the students are expected to do in the field, which intersections you will assign to each team, and how you intend to review the work that they have done once they have completed their field work.

Doing the Activity (Script)

[Slides: slides15.pptx]

The following script can be used along with the slides for this activity. The script and slides can be modified based on your needs and what you decide to emphasize for the activity.

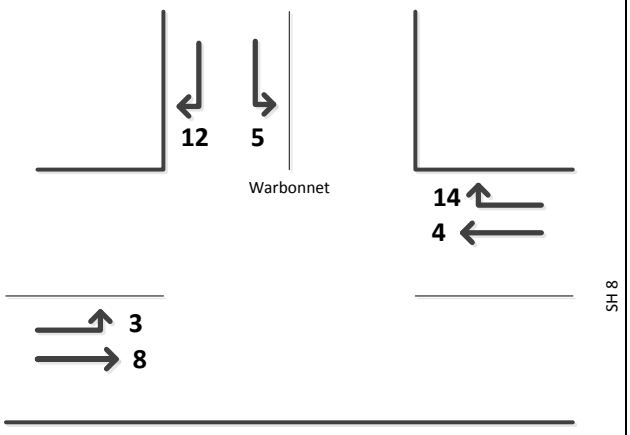
Slide	Text
	**Tell**: The purpose of this activity is to observe the movements that exist at a signalized intersection, determine the sequence in which these movements occur, and synthesize a RBD that represents what you observe. [Assign intersections]
	**Tell:** Suppose your intersection looks like this, with all 12 movements possible.
	This form can be used for you to record the sequence of movements that you observe.

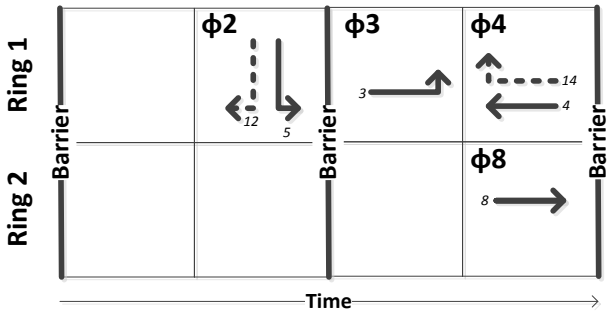
Slide	Text
	For example, suppose that you observe the following sequence over a period of two cycles. This takes some concentration to note which movements are being served at any given time and when service to one or more of the movements terminates. This example shows 11 distinct periods in which unique movements or pairs of movements are served.
	This chart shows the sequence of phases that can be synthesized from the data in the previous slide. So what can we learn from this? • For the first cycle, the left turns are served first (movements 1 and 5). Service to movement 5 ends, and movements 1 and 6 are served. • Next, movements 2 and 6 are served. • Examination of each of these pairs point us to the conclusion that this is a standard NEMA 8 phase operation. • And, we can conclude here that the standard eight phase RBD can represent what we've observed, as shown in this slide.
	After they have finished the activity: what challenges did they have in doing this activity?

Solutions

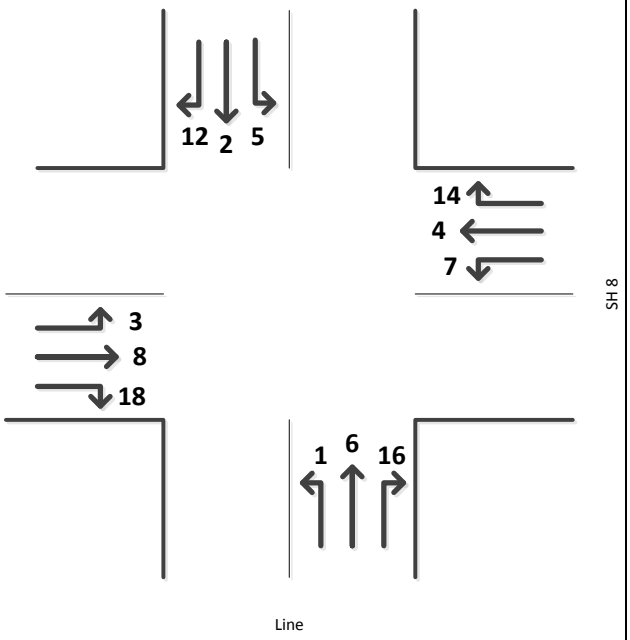
Following are examples from Moscow, Idaho that show the observed movements and the resulting RBD.

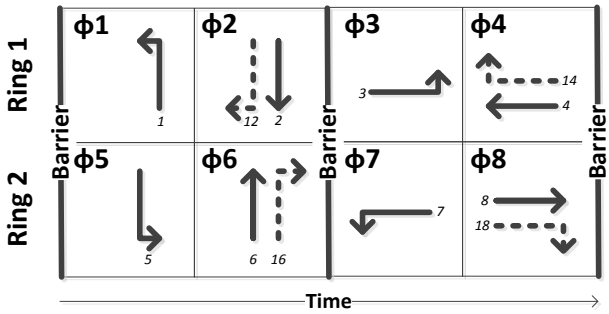
State Highway 8/Warbonnet



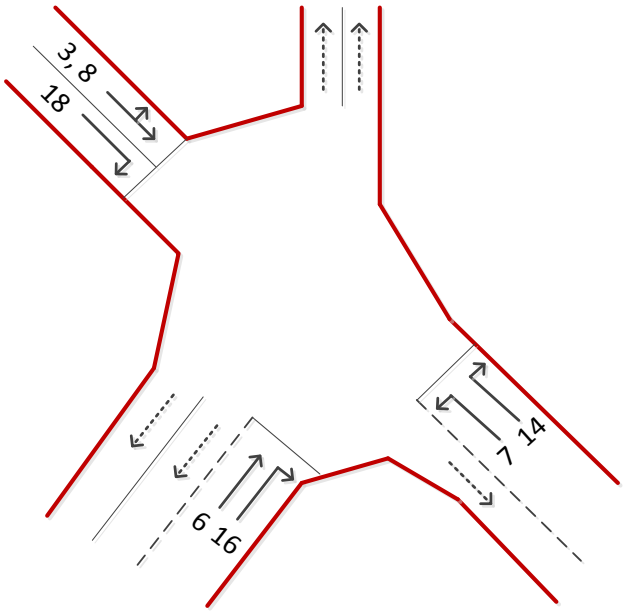


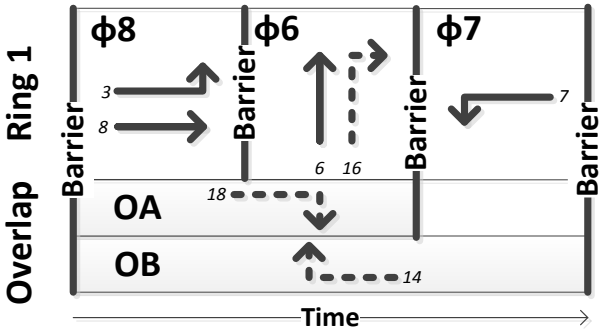
State Highway 8/Line



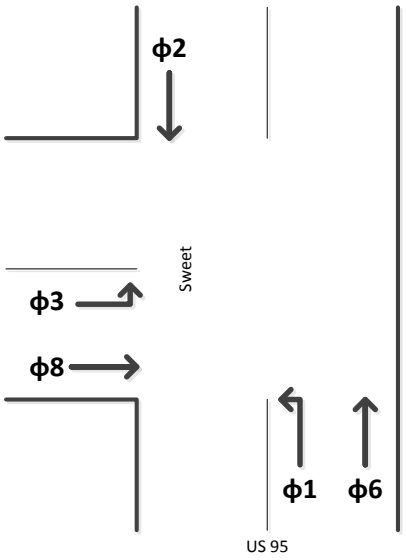


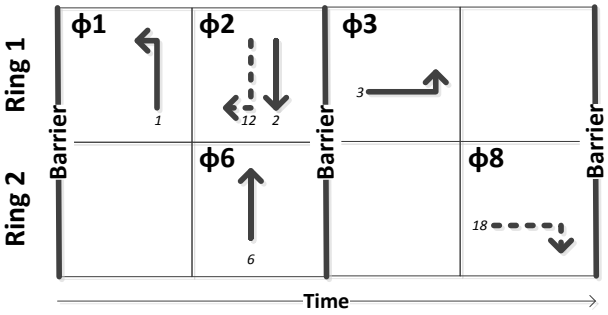
State Highway 8/US 95

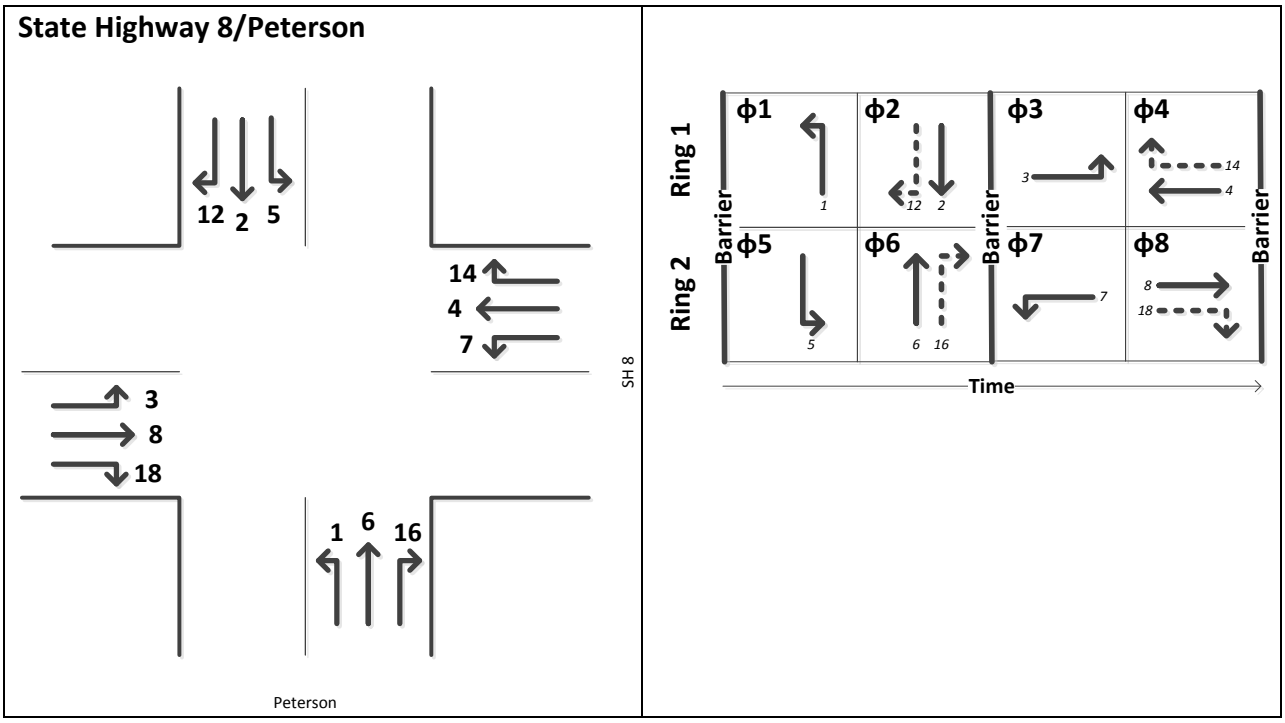




US 95/Sweet






State Highway 8/Peterson
12
2
5
14
4
7
3
8
18
1
6
16
SH 8
Peterson
Ring 1
Ring 2
Barrier
Barrier
Barrier
ϕ1
ϕ2
ϕ3
ϕ4
ϕ5
ϕ6
ϕ7
ϕ8
Time

Using Activity #16: Phasing, Rings, and Barriers (In Practice)

Overview
The purpose of this activity is to learn how the Traffic Signal Timing Manual explains phasing, rings, and barriers.

Options for Use
- The reading is usually done as homework.
- The synthesis and discussion of the questions can be done as part of a group either during class or as homework.

Preparing for the Activity
- Review the relevant sections of the Traffic Signal Timing Manual.

Doing the Activity (Script)
The following script provides ideas for how you would conduct the activity during class.

Slide	Notes
[no slides]	Describe the relevant sections of the TSTM Discuss and answer critical thinking questions.

Solutions
Critical Thinking Questions and Answers
1. What is the logic for the sequence of phases that are included in a ring?
- [p 4-5 TSTM]: "The ring identifies phases that may operate one after another and are typically conflicting phases organized in a particular order."

2. What impact did your field experience have on your understanding of phasing, rings, and barriers?