Lesson 3
Module 3-2: Time-Space Diagrams

Objectives:
- Identify causes for variations in Time-Space diagrams for single and multiple intersections.
- Visually identify the concept of Offset and Delay

Introduction and Motivation

The basic principle to give students is that there are methods used to “predict” signal conditions prior to putting them in the field where trial and error is more costly. The Time-Space diagram is the progression of vehicles in space along the y-axis and time along the x-axis. Using this method in addition to the volume split methods learned in previous lessons can give students more information about delay.

Delay is a key measure of effectiveness for traffic operations. Describing this concept visually is a major benefit of time space diagrams at this level. Some basic calculations show the student geometry applications in the “real-world”.

Multiple signals illustrate how traffic engineers must account for interdependencies of a network and how this impacts the options available for implementation. Signal coordination is a fundamental aspect of the traffic engineer’s job.

“In situations where signals are close enough together so that vehicles arrive at the downstream intersection in platoons, it is necessary to coordinate their green times so that vehicles may move efficiently through the set of signals.”

Key Terminology

*Delay*  Difference between ideal travel time and actual travel time due to signal
*Offset*  Time between start of green of upstream signal and start of green of downstream signal

Task

Note: The following was done with two instructors but it can be executed with a single instructor with a student substituting for the other instructor.

The following will present a series of activities that were used to introduce the concepts involve in creating a Time-Space diagram while understanding the concepts of *delay* and *offsets.*

*On board:*

Draw Blank time space diagram on the board. (Figure 1 w/o vehicle trajectories)
With the Students

1. Measure distance of board, have distance marks on ground already
2. Set metronome to walkable speed (~2ft/s or 64bpm)
3. Instructor walks parallel to board while another instructor (or student) makes dots as he/she past distance marks (Figure 1 - Line #1)
4. Instructor walks parallel to board while another instructor (or student) makes dots as he/she past distance marks this time with signal delay (Figure 1, Line #2)
5. Ask for student volunteer for bi-directional data collection they make dots for one direction while
6. Present the following website (http://www.cetl.gatech.edu/Transport/Transport.html) as a demonstration of an automated form of the above process.
7. Give handout (Figures 3 and 4 should given out as a handout to the students)

Narrative that goes along with task:

Previously we talked about what goes into selecting timing plans for a signal and had a demonstration of network operations.

Today we’re going to talk about timing multiple signals along a corridor and how we measure and predict delay.

Remember that delay is the difference between how much time it would take to travel a certain distance if there were no obstacles (traffic signals, slow moving vehicles, bad weather etc.) and the ACTUAL time it takes. Therefore, delay is the difference between a perfect world and the real world.

On the board we have a diagram of a single intersection alongside a graph of time and distance.

Instructors will demonstrate how to collect data on this graph then give student a chance to conduct their own data collection effort.

Executing Step 3 from above, instructor #1 creates a dotted line on the board as instructor #2 walks, non-stops to the beat of the metronome.

So you see this graphic shows progression in time and space so it’s called a … (wait for it … Time-space diagram!)

Ok this time we have a signalized intersection. How do you think that will affect the graph? Let’s see.

Executing Step 4 from above, instructor #1 creates a dotted line on the board as instructor #2 walks, non-stops to the beat of the metronome. But this time instructor #2 will stop, but because continues to progress, instructor number 2 continues to create a dotted line. While instructor #2 is stopped the dotted line will run parallel (flat) to the horizontal / time axis).
Now we have some really cool data to do diagnostics.

- What does the slope of this line tell you?  
  - Speed
- What about the horizontal distance?  
  - Delay
- What about the vertical distance?  
  - Queue Length

*On board:* Work out equations (see below)

Ok so what happens if we add another direction? Who wants to be the data collector?

Thanks, now the handouts show a number of different scenarios let’s see if we can tell intuitively what’s different in each scenario. (Figure 3 and 4 are handouts)

- Different speeds
- Later start
- Multiple intersection

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**Figure 1:** Sample representation of the Time Space Diagram Created from Steps 3 & 4
Figure 2: Sample representation of the Time Space Diagram with Equations

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\text{Speed of veh} = \frac{\text{distance}}{\text{time}} = \frac{x_2 - x_1}{t_2 - t_1}
\]
Exercise for Students to Reinforce Concepts

Figure 3: Time-Space Diagram with Multiple Intersections and Signal Timing Plan
Figure 4: Time-Space Diagram with Vehicles Traveling in Opposite Directions