# Course Design Document (Version 20)

Module Title: Traffic Signal Systems Operation and Design

Prepared For Tasks 2 and 3

Development, Deployment, and Assessment of a New Educational Paradigm for Transportation Professionals and University Students: A Collaboration of the Region X Transportation Consortium

Federal Highway Administration
Transportation Education Development Pilot Program

Document Authors:
Howard Cooley
Michael Dixon
Ahmed Abdel-Rahim
Michael Kyte
Steve Beyerlein
Dan Cordon
JJ Petersen
Kevin Lewis

December 19, 2012

## TABLE OF CONTENTS



In each section, there is an overview of what type of content should be created for that section, and some tips for the creation and formatting of the content. *An example of materials created for the Arterial Traffic Signal Operation Module is provided in italics at the end of each section.*

## 1. INTRODUCTION

This report represents the results of work completed as part of Tasks 2 and 3 of the project "Development, Deployment, and Assessment of a New Educational Paradigm for Transportation Professionals and University Students: A Collaboration of the Region X Transportation Consortium." The tasks focus on (1) the development of a guidance document for the development of course modules and (2) the development of the educational materials based on this guidance document.

The project is being undertaken as part of the Federal Highway Administration's Transportation Education Development Pilot Program. This project has established several ambitious goals, including:

1. The development of a distance learning environment
2. A student focus in an active learning environment
3. A hands on approach to learning

This report serves as the course design document for the module "Traffic Signal Systems Operations and Design", a semester long course that was presented in both live and distance learning formats to undergraduate and graduate students who wanted to learn how to design a traffic operations plan for an arterial that serves a variety of users, including vehicles and pedestrians. Following the development of this document, a set of course activities and an instructor's guide were developed. This document also served as the design guide for the development of the other three modules developed as part of this project.

This document is based on the curriculum design process developed by Apple, Beyerlein, and others [Pacific Crest Handbooks: Course design, Activity design]. The process, adopted for use in this project and summarized in Figure 1, consists of several steps beginning with an analysis of the potential audience and the context for the class.

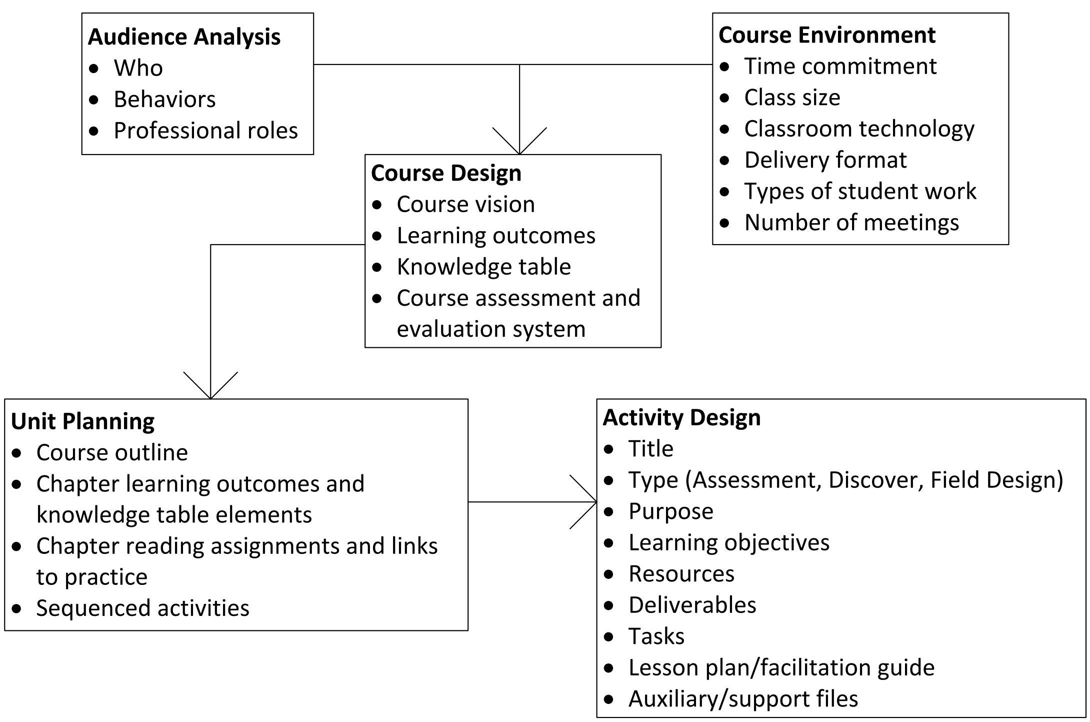



Figure 1. Course Design Process

## 2. AUDIENCE ANALYSIS

An audience analysis ensures that a course is designed to serve the intended population of students. This analysis also includes visualization of long-term behaviors that a course is intended to promote, beyond the end of the course and into professional practice. The audience analysis should capture who they are, and what they know. This includes likely distribution in age, education, experience, physical location, and technical background of the students. It is helpful to identify several professional roles that students can identify with and in which they can grow throughout the course.

*The project team identified potential audiences for the arterial traffic design course using data collected from the participants of the MOST project, a recently completed project designed to improve traffic signal timing skills based on an active and hands on learning environment[1]. It was clear that the level of education and engineering experience varies across potential participants and this will impact the quantity of new knowledge that can be mastered by different audiences. The primary audiences for this new course are junior engineers in practice, undergraduate civil engineering students, and graduate transportation students.*

*It was decided that this would be an advanced course that required the completion of an introductory undergraduate transportation engineering course.*

*The long term behaviors that we expect to mold through this course were also discussed. The discussion was based on the profile outlined in The Vision for Civil Engineering in 2025 [American Society of Civil Engineers]. The ASCE document highlights major attributes of the future civil engineer, including knowledge, skills, and attitudes. These attributes were discussed in detail and long-term behaviors associated with five professional roles were envisioned to be supported by the course.*

- *Designer (isolated intersection, coordinated system)*
- *Technologist (modeler, equipment specialist, diagnostician)*
- *Communicator (informal as team member, formal report writing and presentation)*
- *Collaborator (team member)*

[1] MOST: A Hands-On Approach to Traffic Signal Timing Education, prepared by University of Idaho, Purdue University, University of Tennessee, Pline Engineering, Federal Highway Administration, PTV America, and Econolite Control Products, 2009. [project web site: http://www.webs1.uidaho.edu/most/index.htm]

## 3. COURSE ENVIRONMENT

Physical and temporal constraints surrounding delivery of the course need to be established before significant progress can be made in course design. This includes the location of faculty and students, the number and type of contact hours, expectations of work outside of class, and the level of interaction between participants outside of formal class meeting times.

*The student time commitment, types of student work, and classroom technology for the arterial traffic operations course are summarized in* Table 1*.*

Table 1. Course environment

| ***Student Time Commitment*** | ***Types of Student Work*** | ***Classroom Technology*** |
|---|---|---|
| • *Approximately 75 contact hours (2 hours of lecture and 3 hours of lab or field work weekly) with an average of eight hours weekly outside class*<br>• *This corresponds to 5 credits for quarter system students and 3 credits for semester system students* | • *Individual reading assignments, problem sets and writing assignments*<br>• *Team based activities and projects*<br>• *Individual examinations* | • *Distance education delivery technology (if this delivery mode is used)*<br>• *Traffic simulation software (VISSIM), movie videos and animation, and software for data analysis (Excel)* |

## 4. COURSE VISION

It is important to articulate an overall theme for the course that briefly describes the course in a way that can promote brainstorming about course content, course activities, faculty preparation, and marketing to potential students. Ideally the vision should connect cognitive, social, and affective dimensions of the course. The vision is not static, it can be strengthened as learning outcomes are articulated, course knowledge is classified, and learning activities are scoped and sequenced. The vision serves to align and validate course components and delivery strategies. To create an effective course vision it is helpful to isolate a phrase that will resonate with important course stakeholders and offers insight about what is expected to be unique and exciting about the course. The course vision is the source of various themes that can unify week-by-week course design.

The following vision was crafted for the arterial traffic design module:

| |
|---|
| ***Building a Community of Traffic Operations Professionals** -- engaging academic, industry, and government stakeholders in case-based use of state-of-the-art simulations, traffic control equipment, and decision support tools to create efficient traffic signal timing plans and designs.* |

## 5. LEARNING OUTCOMES

Learner performance is more likely to improve if one is able to precisely define what is to be achieved along with how this performance can be documented at the end of a learning experience. The number of learning outcomes for a course should be small enough so individual outcomes can be revisited several times throughout the course and the set of learning outcomes for a course should be varied enough to make learning activities realistic. For a typical 3-credit college course a good target is 10-12 course outcomes. For a typical engineering course, the number of competency outcomes is often equal to the total number of movement, experience, and integrated performance outcomes.

Learning outcomes should be phrased such that they describe student behaviors that are developed by the end of the course. Learning outcomes provide a vector for development in relevant learning activities. In contrast, learning objectives for each learning activity are intermediate milestones that can be achieved at the end of the learning activity.

It is helpful to separate different types of learning outcomes with respect to who is performing the outcome and the nature of the outcome (see Figure 2). The common outcomes in higher education include competencies, movement, experiences, accomplishments, and integrated performance. Each type of outcome is best suited to different educational methods and requires collecting different evidence to demonstrate that the outcome has been achieved.

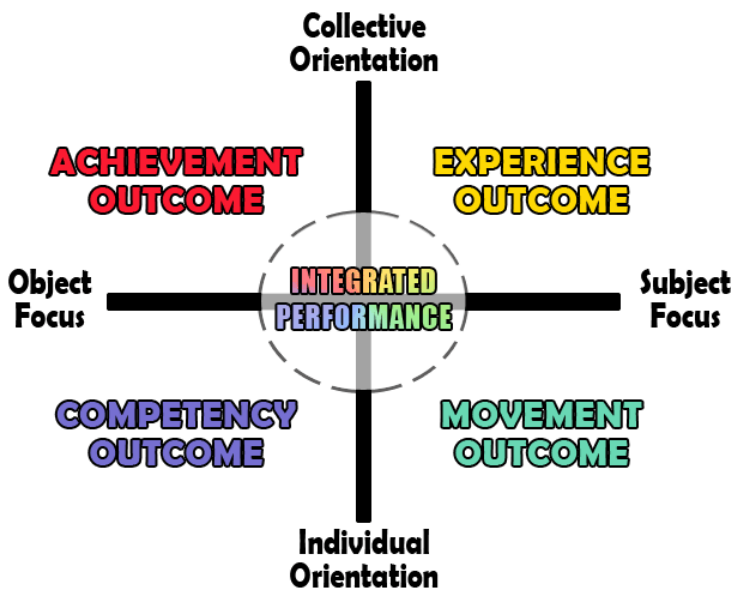



Figure 2. Learning outcomes (citation)

**Competency outcomes** are tasks that learners must perform at a prescribed level in a specific context. Competency outcomes typically probe lower to mid-levels in Bloom's taxonomy (i.e. remember, understand, apply, or analyze). Competency outcomes are snapshots of what learners can do at a specific point in time, and they are relatively easy to measure. Common learning activities that support competency outcomes are guided discovery, and active learning. To promote long-term retention of competency outcomes, it is advisable to target at Bloom's level of "apply" or above. ***Examples:***

1. Find all positive real roots of a second-order polynomial using the quadratic formula.
2. Use a decision matrix to defend a solution from among multiple alternatives, customer requirements, and resource limitations.

**Movement outcomes** focus on personal and professional development. They prescribe a desired direction and magnitude of growth that extend well beyond the present capabilities of all learners. Movement outcomes require samplings over time to establish whether real growth as occurred. Common learning activities that support movement outcomes are peer and self-assessments, logbooks, and self-growth papers. ***Examples:***

1. Translate word problems in to symbolic equations with greater speed and accuracy.
2. Manage project knowledge, resources, and the work environment to produce a more effective design product in a timely manner, and within budget.

**Experience outcomes** capture changes in attitudes, values and behaviors that result from life-changing experience. They should reveal awareness and critical analysis of the causes and impacts of personal changes in the learner. Common learning activities that support experience outcomes are team projects, seminars led by guest facilitators, and field trips. Common measurement tools for experience outcomes are personal interviews, focus groups, and reflective writing. ***Examples:***

1. Serve as a tutor once a week throughout a semester in a math laboratory at a local high school, advancing your confidence in learning mathematics.
2. Gain appreciation of professional practice through interactions with clients, mentors, team members, and support staff in a year-long product development project, documenting issues and discoveries in a journal that illustrates formation of a personal design philosophy.

**Accomplishment outcomes** are recognized through outside affirmation from other faculty, alumni, or practitioners in the field. They are worthy of mention on a resume. Common learning activities that support accomplishment outcomes are project work, service learning, and formal presentations. Common measurement tools for accomplishment outcomes are testimonials, awards, and recommendations. ***Examples:***

1. Place in the top 10% at a student math league competition.
2. Produce a design product that impresses a client, your peers, and the general public at a year-end design show and wins an award while at the same time meeting key functional performance specifications so that the product is used by the client.

**Integrated performance outcomes** require extension and transfer of knowledge, skills, and perspectives in response to challenging situations which are new and meaningful to the learner. Integrated performance outcomes typically probe upper-levels of Bloom's taxonomy (i.e. analyze, evaluate, or create). Common learning activities that support integrated performance outcomes are role playing, creative performances, and capstone projects. Common measurement tools for integrated performance outcomes are formal performance appraisals and feedback from an external review. ***Examples:***

1. Use mathematical skills developed in this course to formulate, analyze, and report quantitative results related to a scientific experiment in your lab course.
2. Display professionalism in forming client relationships, assuming team responsibilities, achieving consensus, fulfilling commitments, applying prior knowledge, and conducting self-directed learning in a Capstone Project Course.

Establishing a strong set of learning outcomes for a course is an iterative process. Time should be spent early on to create a fairly complete initial draft that encompasses all types of relevant outcomes for the course. Another way to develop the set of course outcomes is to inventory a large list of learning objectives, find a logical groupings of objectives, determine the highest level of performance desired within each grouping, and write an outcome statement that defines this level of performance.

Table 2 lists the learning outcomes developed for the arterial traffic signal operations course.

Table 2. Learning Outcomes – Traffic Signal Systems Operations and Design Course

| ***1. Competencies*** | ***2. Movement*** | ***3. Experience*** | ***4. Integrated performance*** |
|---|---|---|---|
| *1.1 Synthesize visual observations of traffic flow, performance data, and traffic control system processes to identify changes needed in the traffic control system.*<br>*1.2 Apply traffic analysis tools such as the queue accumulation polygon, critical movement analysis, and traffic simulation to produce system performance measures.*<br>*1.3 Appropriately use the following information to characterize the quality of traffic flow at an intersection: delay, volume/capacity ratio, queue length, and cycle failure rate.*<br>*1.4 Program traffic signal controller emulators with phasing plans, timing data, and detector maps.*<br>*1.5 Produce an arterial signal timing plan.* | *2.1 Document insights and discoveries from activities (field observations, simulation modeling, and data analysis) that can be understood and shared with others.*<br>*2.2 Use multiple forms of data, multiple vantage points, and state-of-the-art analysis tools to identify traffic operations problems and create a signal timing plan.*<br>*2.3 Propose and defend timing parameter selections and implementation.*<br>*2.4 Organize and coordinate analysis and design activities leading to meaningful synthesis in a final group report* | *3.1 Developing and debugging a traffic simulation network.*<br>*3.2 Demonstrate understanding of traffic flow and signal timing processes using a simulation too*<br>*3.3 Gaining confidence in using the Signal Timing Manual and other professional guides as a primary reference for answering questions about signal timing processes and nominal values* | *4.1 Create and communicate a corridor signal timing plan design (in written and oral formats)* |

## 6. KNOWLEDGE TABLE

A knowledge table identifies the content you want students to know and how students can most effectively explore this knowledge. The knowledge table surfaces key concepts, identifies important processes and tools, suggests important contexts for learning, and reinforces important long term behaviors.

**Concepts** are ideas that connect a set of relationships. Concepts are representational and abstract. Concepts are best introduced with definitions, pictorial representations, and interactive learning objects.

**Processes** are a sequence of steps, events, or activities that result in a change or that produce something over a period of time. Processes are active and continuous. Processes are best introduced through methodologies that guide users through a sequence of steps with quality standards. Processes focus on actual performance, not just understanding what to do.

**Tools** are any device, implement, instrument, or utensil that serves as a resource to accomplish a task. Tools can be in paper form (templates), electronic form (software/simulation), or physical form (laboratory hardware). Tool knowledge includes selection and use of the tool, not just understanding its features or its typical use.

**Contexts** are the whole situation, background, or relevant conditions surrounding learning. Contextual knowledge is needed for experience outcomes. Contextual knowledge focuses on adaptation to varied conditions, not changes in basic processes.

**Ways of being** are sets of behaviors, actions, and language associated with a particular discipline, knowledge area, or culture. Ways of being reflect preferences and tacit assumptions, not understanding of concepts or processes.

Construction of the knowledge table is also an iterative process. Even after the initial knowledge table is completed, it should be revisited as more details at the weekly and activity level are completed to capture important decisions about course content. Issues exposed in the generation of a knowledge table include the following:

1. If there is excessive ambiguity in the distinctions among the five forms of knowledge within a map, e.g., by overlapping concepts with processes, learning activities may also lack appropriate focus.
2. If the descriptions and details used to represent the five forms of knowledge within a knowledge map are disjointed, e.g., lacking in integration or parallelism, multiple problems in learning and assessing performance are likely.
3. If there is not enough detailing or complexity in how the forms in the map are represented, learners may not fully recognize relevant exemplars or models, and educators may find it difficult to provide clear assessments.

Table 3 lists the knowledge table elements for the arterial traffic signal operations course.

Table 3. Knowledge table- Traffic Signal Systems Operations and Design Course

| ***1. Concepts*** | ***2. Processes*** | ***3. Tools*** | ***4. Contexts*** | ***5. Ways of being*** |
|---|---|---|---|---|
| *1.1 Traffic flow Characteristics*<br>• *Uniform flow*<br>• *Saturation flow*<br>• *Headway*<br>*1.2 Models and graphs*<br>• *Queuing model*<br>• *Queue accumulation polygon*<br>• *Flow profile diagram*<br>• *Cumulative vehicle diagram*<br>• *Time space diagram*<br>*1.3 Traffic control system*<br>• *User*<br>• *Detection*<br>• *Control*<br>• *Display*<br>1.4 *Performance measures*<br>• *Delay*<br>• *travel time*<br>• *Volume capacity ratio*<br>• *Queue length*<br>1.5 Safety<br>• Phasing<br>• Dilemma zone<br>• Pedestrian timing<br>• Minimum green | *2.1 Signal timing design process*<br>• *Isolated intersection*<br>• *System*<br>*2.2 Critical movement analysis*<br>*2.3 Traffic analysis process*<br>*2.4 Network development*<br>• *Creation and debugging*<br>• *File management*<br>*2.5 Timing parameters*<br>• *Min green*<br>• *Max green*<br>• *Passage Time*<br>• *Yellow*<br>• *Red clearance*<br>• *Pedestrian timing intervals*<br>• *Offset*<br>• *Split*<br>• *Cycle length*<br>*2.6 Timing processes*<br>• *Phase timing*<br>• *Phase termination*<br>• *Vehicle speed*<br>• *Detector length*<br>• *Dilemma zone*<br>• *Phase and movement*<br>• *Ring and barrier*<br>• *Left turn treatments* | *3.1 VISSIM*<br>• *Visualization*<br>• *Data collection*<br>• *Building traffic network*<br>• *Adding detectors and signal controllers*<br>*3.2 Excel*<br>• *Data analysis*<br>• *Time space diagram*<br>• *Platoon dispersion diagram*<br>• *Queue accumulation polygon*<br>• *Critical movement analysis*<br>• *Signal controller emulator*<br>*3.3 Timing process sheet*<br>3.4 *Technical resources*<br>• Signal timing manual | *4.1 Isolated intersection and coordinated system*<br>*4.2 Field observation of various traffic flow and signal operations conditions*<br>*4.3 Integrating traffic observations (field and simulation) with traffic operations concepts and models*<br>*4.4 Working within a team (partner)*<br>*4.5 Intersection configurations (left turn phasing, exclusive lanes, close-spacing)*<br>*4.6 Identification of boundaries for design problem, leading to advanced topics to be covered in future courses or experiences*<br>• *Controller types*<br>• *Detector design*<br>• *Common practices and applications*<br>• *Common field problems*<br>• *Pedestrians*<br>• *Mid-block volumes* | *5.1 Designer*<br>*5.2 Tool user*<br>*5.3 Communicator* |

## 7. COURSE ASSESSMENT AND EVALUATION SYSTEM

There are many ways to provide assessment and collect evaluation. Care should be taken to match the tool with the type of outcome being measured. For each outcome it is beneficial to use multiple tools to improve accuracy of the measurement. It is also more efficient to select tools cut across multiple outcomes in order to minimize the number of measurements being accounted. Table 4 provides some guidelines mapping learning outcomes with typical tools.

Table 4: Matrix for matching tool with outcome type (Elements used in the Traffic Signal Systems Operations and Design course are noted with an asterisk)

| | Competency | Movement | Experience | Accomplishment | Integrated Performance |
|---|---|---|---|---|---|
| Homework* (Problem set) | X | X | | | |
| Quizzes* (Short answer) | X | | | | |
| Exams* | X | X | | | |
| Assessments* (peer, self) | | X | X | | |
| Logbooks | | X | X | | |
| Self-growth papers | | | X | | X |
| Recorder reports (Team discussions) | | X | X | | |
| Team citizenship assessment | | X | | | |
| Progress reports | | X | | | |
| Final report* | | | | | X |
| Video presentation | | | X | | X |
| Oral exam | | | | | X |
| Survey (pre-course)* | X | | X | | |
| Conference presentation | | | | X | X |
| Design review (with external stakeholders) | | | X | | X |

It is useful for students to have a guideline for expectations on assignments. For most evaluation tools a lot can be learned and communicated through use of a rubric. The rubric should divide the task in to several categories or components. Then descriptions of what performance in those categories looks like at various levels should be added so the students have an idea of what is expected of them.

The Traffic Signal Systems Operations and Design course was offered six times during this project. The delivery dates and number of enrolled students is shown in Table 4.

Table 4. Course delivery and enrollments

| Semester | Number of students |
|---|---|
| Fall 2012 | 21 |
| Fall 2011 | 20 |
| Spring 2011 | 15 (UI, WSU, PSU, UW) [via video] |
| Fall 2010 | 22 |
| Spring 2010 | 6 |
| Fall 2009 | 17 |

A series of assessment were conducted during the courses. Examples of the assessment forms are shown below.

**Mid-Semester Assessment Questions**

"Assessment is the process of measuring and analyzing performance to provide timely feedback to improve future performance. Assessment differs from evaluation in that it provides opportunities for feedback, improvement, and revision; identifies strengths, areas for improvement, and ways to improve; and is non-judgmental, frequent, and congruent with the learning goals."

1. What have you liked about the class thus far?
2. What aspects of the class have positively supported your learning about traffic systems design?
3. What aspects of the class have negatively impacted your learning about traffic systems design?
4. How well did the book support your learning during the class? What two suggestions would you make to improve the next version of the book?
5. What suggestions would you make to improve the effectiveness of your design team?
6. What suggestions would you make to me to improve the class for the remainder of the If
7. you could tell me two things about the class they would be (1) … and (2) …
8. List two topics that you feel that you understand well as a result of the first part of the class.
9. List two topics that you feel that you don't understand well that were covered during
10. What two things would you do differently in approaching the next design problem from how you approached the first design problem?

**Final Assessment Questions**

1. Considering your own learning style, comment on the value of an activity based learning approach compared to the more traditional lecture style.
2. Consider the range of activities in which you participated during the past three months and the various things that you learned about traffic signal systems during this time. List the two things that you liked most about the class. Briefly tell me why you liked these two things.
3. List two things that you think that I should change about this class the next time that I teach it. Why do you suggest these changes and why do you think that the changes would improve the class?
4. Following are several statements that might help to guide your reflections on your experience in this course. Consider each statement and complete the sentence as it applies to your experience in this class:
    - I really appreciated …
    - I would have learned more from this class if …
    - The course materials were …
    - In looking back to the beginning of the semester …
    - The two most important things about this course were …
    - One thing I would really like to tell the instructor (me) is …
    - I would have like to …
    - The one thing that the instructor can do next time is …
    - The course web site was …
    - The most important thing that I learned this semester was …
    - The hardest concept for me to understand during the semester was …

| Skills | SA | A | N | D | SD |
|---|---|---|---|---|---|
| 1. I understand the basic theory of traffic flow at signalized intersections. | | | | | |
| 2. I understand the operation of an actuated traffic signal controller. | | | | | |
| 3. I understand the basic relationships between detector parameters and signal timing parameters. | | | | | |
| 4. I am able to use experimental data to determine the optimal cycle length, green split, and offset for a signalized intersections with a given demand and geometry. | | | | | |
| 5. I am able to apply traffic flow models to simulate the flow of traffic at signalized intersections and optimize traffic signal timing parameters to test a signal timing design. | | | | | |
| 6. I am able to design a system to meet desired need as evidenced by the ability to complete a signal timing design that meets specified requirements and criteria. | | | | | |
| 7. I am able to communicate the results to other team members and to outside agency staff through both written reports and oral presentations | | | | | |
| 8. I am able to understand and successfully apply the factors that make for successful design teams that function effectively and productively in a team of peers | | | | | |

## 8. UNIT PLANNING

Before fleshing out individual activities it is important to identify the set of learning activities intended to support each unit within the course. Ultimately this should include the following elements for the entire course:

- Course outline/syllabus
- Sequenced reading assignments
- Sequenced activities
    - Targeted course outcomes
    - Knowledge table elements

*For the traffic signal timing course, the following topics are covered:*

*Isolated Intersection Design Problem*

1. *The Traffic Signal Control System: Its Pieces and How They Fit Together*
2. *Modeling What We've Observed: Queuing Systems*
3. *Whose Turn Is It: Phasing, Rings, and Barriers*
4. *Actuated Traffic Controller Timing Processes*
5. *The Simulation Environment: Learning to See a Traffic Signal Systems*
6. *Timing Processes on One Approach*
7. *Timing Processes for the Intersection*
8. *Left Turn Phasing – Permitted, Protected, or Both*
9. *Right of Way Change: Change and Clearance Intervals*
10. *Pedestrian Timing and Phasing*
11. *Design Process: Putting It All Together*

*Coordinated Signal Systems Design Problem*

1. *The Base System*
2. *Critical Movement Analysis*
3. *Split Analysis*
4. *Cycle Length Analysis*
5. *Time Space Diagrams and Platoon Dispersion Models*
6. *Offset Analysis*
7. *Final Design*

**Activity List for Traffic Signal Systems Operations and Design Course**

| Chapter | Activity name (Type) | Learning objective |
|---|---|---|
| 1 | Reading #1: Exploring the system and providing a framework | |
| | Link to Practice #1: Introduction to the Signal Timing Manual | |
| | Activity #1: What do you know about traffic signal systems? (Assessment) | • Describe the content, scope, and organization of the Signal Timing Manual.<br>• Describe the basic components of and the operation of the traffic control system.<br>• Determine your current level of competency with traffic signal system concepts. |
| | Activity #2: Exploring the system: driving along an arterial and noting what you see (Discovery) | • Describe how drivers respond to signal displays.<br>• Identify and describe various physical components of a signalized arterial. |
| | Activity #3: Learning to see: the simulation environment in which we will work (Discovery) | • Assess the realism of a simulation environment by comparing it with a video of actual field operations.<br>• Develop your ability to "see" and "observe" video and animation of traffic flow at a signalized intersection and relate these observations to traffic flow theory and principles. |
| | Activity #4: Working together – team building for effective learning and effective design (Discovery) | • Identify essential team behaviors that lead to successful completion of activities and the design project.<br>• Explain how team behaviors support different team roles. |
| | Activity #5: Team agreement (Design) | • Develop group consensus on how the team will work, treat, and communicate with each other. |
| 2 | Reading #2: Modeling traffic flow at signalized intersections | |
| | Activity #6: What do you know about queuing systems? (Assessment) | • Connect your observation of traffic flow at a signalized intersection with a model framework.<br>• Represent and interpret queuing diagrams for a range of traffic flow and control conditions. |
| | Activity #7: Using high resolution field data to visualize traffic flow (Discovery) | • Connect your observation of traffic flow at a signalized intersection with a model framework. |
| | Activity #8: From model to real world: field observations (Field) | • Represent and interpret queue accumulation polygons for a range of traffic flow and control conditions. |
| 3 | Reading #3: Phasing, rings, and barriers | |
| | Link to Practice #3: Phasing, rings, and barriers | |
| | Activity #9: What do you know about phasing and ring barrier diagrams (Assessment) | • Describe NEMA phasing and the concept of rings and barriers.<br>• List of the phase numbers at a standard intersection with eight movements.<br>• Draw and describe a ring barrier diagram in which there are two rings and eight phases. |
| | Activity #10: Verifying ring barrier operation in the field (Field) | • Determine the phasing pattern and sequence for a signalized intersection in the field. |

| Chapter | Activity name (Type) | Learning objective |
|---|---|---|
| 4 | Reading #4: Controller timing processes | |
| | Link to Practice #4: Controller timing processes | |
| | Activity #11: What do you know about controller operations (Assessment) | • Describe the three basic actuated timing processes.<br>• Describe the response of the detectors, the timing processes, and the displays to a pattern of vehicle demand as shown in the time space diagram.<br>• Complete a Traffic Control Process Diagram. |
| | Activity #12: The ASC/3 traffic controller (Discovery) | • Describe the range of information provided in the ASC/3 controller. |
| | Activity #13: How a traffic phase times and terminates (Discovery) | • Describe the two primary methods for the termination of a traffic phase at an isolated intersection. |
| | Activity #14: Exploring a controller emulator (Discovery) | • Describe actuated traffic controller timing processes. |
| | Activity #15: Constructing a traffic control process diagram (Discovery) | • Describe actuated traffic controller timing processes. |
| | Activity #16: Inferring signal timing parameter values (Field) | • Infer signal timing parameter values through field observations. |
| 5 | Reading #5: Microsimulation models and the traffic control system | |
| | Link to Practice #5: Traffic analysis tools | |
| | Activity #17: What do you know about simulation models (Assessment) | • Describe the categories of traffic analysis tools that are commonly used by a transportation engineer.<br>• Describe the application of a simulation model.<br>• Synthesize visuals and data to describe system operation and performance. |
| | Activity #18: The VISSIM simulation model – learning your way around (Discovery) | • Describe the basic features of VISSIM. |
| | Activity #19: Building a simulation model network (Design) | • Build and use a simulation model network. |
| 6 | Reading #6: Jointly determining passage time and detection zone length using stop bar presence detection | |
| | Link to Practice #6: Actuated traffic control processes | |
| | Activity #20: What do you know about detection zone length and passage time? (Assessment) | • Describe the timing processes for actuated traffic control.<br>• Describe how the length of the detection zone affects the setting of the basic timing parameters. |
| | Activity #21: Relating the length of the detection zone to the duration of the green indication (Discovery) | • Relate the length of the detection zone to the duration of the green indication. |
| | Activity #22: Determining the length of the minimum green time (Discovery) | • Relate the length of the minimum green time to the efficient operation of a phase. |
| | Activity #23: Understanding the variation of vehicle headways in a departing queue (Discovery) | • Describe the variation of vehicle headways in a departing queue.<br>• Establish a desired maximum allowable headway. |

| Chapter | Activity name (Type) | Learning objective |
|---|---|---|
| | Activity #24: Relating headway to unoccupancy time and vehicle extension time (Discovery) | • Relate the maximum allowable headway to unoccupancy time.<br>• Determine the Vehicle Extension time based on the length of the detection zone and the desired maximum allowable headway. |
| | Activity #25: Determining the maximum allowable headway (Design) | • Select a maximum allowable headway. |
| | Activity #26: Determining passage time and minimum green time (Design) | • Be able to select timing and detector parameters. |
| 7 | Reading #7: Maximum green time, cycle length, and delay | |
| | Link to Practice #7: Maximum green time | |
| | Activity #27: What do you know about maximum green time, cycle length, and delay? (Assessment) | • Describe the maximum green time setting and timer process.<br>• Determine the optimal maximum green time (based on the optimal cycle length) at a signalized intersection. |
| | Activity #28: Determining the effect of the minor street vehicle extension time on intersection operations (Discovery) | • Determining the effect of the minor street Vehicle Extension setting on the efficiency of major street and intersection operations. |
| | Activity #29: Determining the effect of the maximum green time on intersection operations (Discovery) | • Understand the advantages and disadvantages of increasing Maximum Green time on intersection operations.<br>• Describe the advantages and disadvantages of increasing Maximum Green time on intersection operations. |
| | Activity #30: Setting the maximum green time for all approaches of an intersection (Design) | • Set the maximum green time for both approaches of an intersection, balancing the performance of both the minor street and the major street. |
| 8 | Reading #8: Left turn phasing | |
| | Link to Practice #8: Left turn phasing options | |
| | Activity #31: What do you know about left turn phasing? (Assessment) | • Describe and sketch the common left turn phasing options.<br>• Describe the basic concepts of left turn phasing. |
| | Activity #32: Permitted left turn operations (Discovery) | • Determine the efficiency of permitted left turn operations under various opposing through traffic volumes. |
| | Activity #33: Comparing permitted and protected left turn phasing (Discovery) | • Understand that protected LT phasing is more efficient than permitted LT phasing under some conditions. |
| | Activity #34: Comparing protected/permitted and protected left turn phasing (Discovery) | • Understand the trade-offs and relative efficiencies between protected/permitted and protected left turn phasing. |
| | Activity #35: Analysis and design of left turn treatment (Design | • Select optimal left turn phasing treatment based on an analysis of performance data and observation of simulation conditions. |
| 9 | Reading #9: The basis for the dilemma zone | |

| Chapter | Activity name (Type) | Learning objective |
|---|---|---|
| | Link to Practice #9: Yellow and red clearance intervals | |
| | Activity #36: What do you know about yellow and red clearance intervals? (Assessment) | • Describe the components of the dilemma zone.<br>• Compute the change and clearance intervals.<br>• Describe the purpose and method of calculation of the vehicle change and clearance intervals. |
| | Activity #37: Drivers responding to yellow and red indications (Discovery) | • Quantitatively describe the response of a driver to the yellow indication. |
| | Activity #38: Vehicle response to displays at end of green (Field) | • Describe driver behavior at the end of the green interval. |
| | Activity #39: Determining the vehicle change and clearance intervals considering variability of vehicle approach speeds (Design) | • Determine the vehicle change and clearance intervals. |
| 10 | Reading #10: Pedestrian interval timing | |
| | Link to Practice #10: Pedestrian timing and phasing | |
| | Activity #40: What do you know about pedestrian timing and phasing? (Assessment) | • Understand basic concepts of pedestrian timing. |
| | Activity #41: Determining pedestrian timing parameters (Discovery) | • Determine the pedestrian clearance interval and understand its effect on intersection operations |
| | Activity #42: Determining pedestrian timing intervals (Field, Design) | • Design pedestrian timing parameters. |
| 11 | Reading #11: Design | |
| | Link to Practice #11: Signal timing design process: issues and themes | |
| | Activity #43: What do you know about the signal timing design process (Assessment) | • Describe the signal timing design process.<br>• Synthesize ideas from professional reports. |
| | Activity #44: Assembling information for your timing plan design (Discovery) | • Prepare a timing plan for an isolated actuated signalized intersection based on an analysis of traffic flow quality and intersection performance for a range of timing parameter values and phasing alternatives. |
| | Activity #45: Design report (Design) | • Integrate information into a professional style report and presentation.<br>• Clearly communicate the timing plan design for an isolated actuated signalized intersection based on an analysis of traffic flow quality and intersection performance for a range of timing parameter values and phasing alternatives. |
| | Activity #46: Design evaluations and assessments (Design) | • Provide effective feedback to others. |

## 9. ACTIVITY DESIGN TEMPLATE

The activity is the most fundamental unit of the course. The activity defines a set of actions that the student will undertake to accomplish a specific learning outcome and develop a given base of knowledge. The design of each activity is based on a template that is used to ensure that expectations and processes will be clearly defined for the students. The following elements are included in the activity design template used for this project.

- The *Purpose* lets the students know what the activity is about and why it is worth doing.
- The *Learning Outcomes* describe what students will know or be able to do when they have completed the activity.
- The *Resources* identify what they will need to complete the activity.
- The *Deliverables* describe what students are expected to produce.
- The *Critical Thinking Questions* provide students with a chance to deeply and thoughtfully consider what they learned.
- The *Information* provides additional ideas or notes that will help them complete the activity.
- The *Tasks* list the specific steps that they will need to follow.

To assist instructors not involved in the development process in using the curricula, a facilitation guide was prepared. This guide consists of a set of notes that an instructor "takes into the classroom" to guide and facilitate the work of the students. The template used to develop the guide includes an overview of how to use the activity, options for its use, how to prepare for the activity, what supplemental materials might be available, a script for conducting the activity, solutions to the questions and problems assigned, and a set of other useful notes. Following is an example activity created by for the Traffic Signal Systems Operations and Design class.

ACTIVITY

# 10 Using High Resolution Field Data to Visualize Traffic Flow

DISCOVERY

## Purpose

The purpose of this activity is to give you the opportunity to see how queuing system models relate to high resolution field data.

## Learning Objectives

- Connect your observation of traffic flow at a signalized intersection with a model framework
- Represent and interpret queuing diagrams for a range of traffic flow and control conditions

## Required Resource

- Spreadsheet file: A10.xlsx

## Deliverables

- Prepare an Excel worksheet that includes the following information:

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

  **Tab 2:** Original data

  **Tab 3:** Time-space diagram plot with answers to questions from Task 2

  **Tab 4:** Cumulative vehicle diagram plot

  **Tab 5:** Uniform delay calculation

  **Tab 6:** Summary and answers to Critical Thinking Questions

## Critical Thinking Questions

1. Consider the two estimates of delay from Tasks 4 and 5. Why are they different? How would you refine your calculation method from Task 4 to reduce this difference in the two delay estimates?

2. Compare the cumulative vehicle diagram that you prepared in Task 3 with the one that you sketched in Task 1 of Activity #9. Describe and explain any differences in these two diagrams.

## INFORMATION

While the models that we considered in the reading (Activity #8) provide an excellent framework for understanding traffic flow at a signalized intersection, they lack an important ingredient that we observe in the real world. The models are deterministic and the real world is stochastic. In this activity we consider a very high resolution data set that was collected in Los Angeles that will allow us to consider the messiness, or stochasticity, that is ever present in the real world.

In 2006, the Federal Highway Administration published the results of a study of traffic flow characteristics along a four-block section of Lankershim Blvd. in Los Angeles. The study was based on very high quality video that was taken from a 30-story building located adjacent to Lankershim Blvd. Video image processing software extracted data on position, velocity, and acceleration for vehicles traveling along the arterial for a 30 minute period at time intervals of 0.1 second. This is by far the most detailed study of vehicle trajectories ever compiled.

Figure 46 shows an aerial view of one of the four signalized intersections included in this study. It is the intersection of Lankershim Blvd., Campo de Cahuenga Way and Universal Hollywood Drive, located near Universal Studios. Figure 47 shows the entire arterial. You took a video tour of this arterial using the file a03.wmv (See Activity #3 in Chapter 1).

**Figure 46.** Aerial view of Lankershim Blvd. intersection

**Figure 47.** Lankershim Blvd. study area

You are given field data for one lane of a signalized intersection in the Excel spreadsheet. The data in the "field data tab" give the location of eight vehicles over a period of three minutes at one foot resolution, and the time that each vehicle passes each one foot point. The data in the "arrival-departure data" tab includes the arrival time at a given point and the departure time from a given point.

ACTIVITY 10: USING HIGH RESOLUTION FIELD DATA TO VISUALIZE TRAFFIC FLOW

## TASK 1

Using the field data, prepare a time-space plot for the eight vehicles, placing distance on the y-axis and time on the x-axis. Note that the location of the stop bar for the subject intersection is at a distance of $y = 346$ feet. The stop bar should be shown on your plot.

## TASK 2

Change the chart settings to show the range $y = 200$ feet to 400 feet and $x = 20$ seconds to 120 seconds. Answer the following questions:

1. Is there movement in the queue while the vehicles are supposedly stopped?

2. Which vehicles are directly affected by the red display?

3. Which vehicles are affected only by the behavior of their leading vehicles?

4. Which vehicles are not affected by either the red display or their leading vehicles?

5. How far upstream does the queue extend?

## TASK 3

Review the data on the "arrival-departure tab." Using the maximum extent of the queue upstream from the stop bar as the system entry point to your queuing system, prepare a cumulative vehicle diagram showing the arrival time into the system and the departure time from the system.

## TASK 4

Using the cumulative vehicle diagram that you prepared in Task 3, show on the diagram the time that each vehicle is in the system (delay time). Compute the average delay (average time in system) per vehicle. Remember that this delay does not consider free flow travel time.

## TASK 5

Using the uniform delay equation from Activity #8, compute the average delay per vehicle for this system. For the uniform delay calculation, make the following assumptions: $C = 102$ seconds, $g = 35$ seconds, and $s = 1681$ vehicles per hour of green. Use your diagram to determine any other data needed for this calculation.

## 10. LESSON PLAN [INSTRUCTOR GUIDE]

This form is intended to help other instructors replicate learning experiences. This consists of a set of notes that an instructor "takes into the classroom" to guide and facilitate the work of the students. A convenient way to generate this is to have a colleague observe the class as a peer coach and record what he/she observes.



### Using Activity #1: Exploring the System and Providing a Framework (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." This activity is generally assigned as homework. Students will learn about the basic components and operation of the traffic control system. The components described in the reading include the user, the detector, the controller, and the display. The Traffic Control Process Diagram illustrates the interactions of these four components. Basic traffic flow characteristics are illustrated with descriptions and photographs.

**Options for Use**

The reading ("Information"), 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) As a way of encouraging students to complete a reading assignment in preparation for class, it is often useful to have a quiz or discussion to "test" their knowledge and to allow them to validate their understanding.
- Discussion and synthesis of the answers to the quiz, the glossary definitions, and answers to the critical thinking questions. (30 minutes) You can also facilitate discussion on the reading by allowing the students to discuss their responses to the quiz questions and the Critical Thinking Questions that were assigned as part of this activity. This discussion/synthesis is group work that allows students to review their quiz answers, as well as their answers to the Critical Thinking Questions and Glossary definitions with other students.

**Preparing for the Activity**

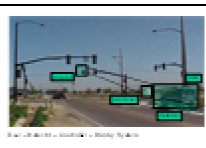
- Decide which of the options you want to do during class.
- Prepare for the class by reviewing Activity #1, including the "Information", the Glossary definitions, and Critical Thinking Questions and answers.
- Review the script to determine which parts of it that you want to use during class. And, review the slides that you want to include, based on your decision regarding the script.

**Supplementary Materials**

- Slides for use with the script (slides01.pptx)

**Doing the Activity (Script)**

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 | Notes |
|---|---|
|  | In transportation, we worry a lot about congestion. But congestion has been around as long as we have gathered in cities. Here is Cleveland, Ohio in 1915.<br><br>"Taylor also said he doesn't think Wire had a patent for his invention, which explains the competing claims about the world's first traffic signal.<br><br>"As early as 1868, a device with an arm that extended horizontally signaled stop and, when at a 45-degree angle, caution. And in 1914, a system in Cleveland, Ohio included four pairs of red and green lights, each mounted on a corner post and manually operated by a switch inside a control booth. That system was patented in 1918 by James Hoge, according to History.com the website for The History Channel." |
|  | Why do we consider traffic signals to be important as we talk about congestion?<br>[see list on slide] |
|  | Why traffic signals? [**Ask Them**]<br><br>Two answers<br>• To keep cars from running into each other [safety]<br>• To make sure cars don't stop, or don't stop for too long (performance] |
|  | But we are not doing a good job nationally in managing our signal systems and the congestion that results from too much traffic and/or poor signal timing practices. This slide shows the results of a report card from the National Transportation Operations Coalition (NTOC) that has been done at least twice since 2007, and is about to be done again. It is really a self-assessment done by traffic engineers from around the U.S. |
|  | So, what is a traffic signal system?<br>Let's first look at the system components and how they interact.<br>• Users respond to display<br>• Detection system responds to user<br>• Controller responds to detector<br>• Display responds to controller<br><br>The relationship of each of these components is a very important one, and we will come back to it a number of times this semester. |