Model Eliciting Activity (MEA) – Pre Reading
Traffic signal Controller – Individual Activity

Read the following short article and the basic principle for traffic signals, and individually complete the exercises that follow.

※ Information in the Pre reading comes from Federal Highway Administration, U.S. Department of Transportation (1995) “Improving traffic signal operations”

Successful traffic signal system

The primary purpose of traffic signals is to separate conflicting traffic by the division of time, within the available road space, in a safe, efficient and equitable manner. Conflict at an intersection is manifested as an increase in delay and/or accident rate. The successful traffic signal system will impose the minimum delay on all traffic, consistent with safety. In addition, traffic signal improvements rank as one of the most cost-effective energy conservation strategies in urban areas. An idling engine not only wastes fuel, but also emits pollutants into the air. Therefore, the successful traffic signal system will also minimize fuel consumption and pollution in a neighborhood.

Basic Principle of traffic signals

Signal sequences

Traffic signals alternately assign the right of way to different traffic movements at an intersection. Vehicular traffic is permitted to flow in a strictly controlled manner. A controller is used to switch the signal displays. The signal sequence at intersections is red, green, yellow, and red. The standard period during which a yellow signal is displayed is fixed at three seconds. The duration of the green signal will depend on the method of control. It is not recommended the signal sequence cycle be in excess of 120 seconds. Two basic kinds of controllers are used: Pre-timed and Traffic actuated.

Pre-timed Controllers

Pre-timed controllers represent traffic control in its most basic form. They operate on a predetermined, regularly repeated sequence of signal indications. For example, in one complete phase of the cycle, one street-the primary street-may be assigned 40 seconds of green time, and the other street may be assigned 15 seconds of green time. Several seconds per minute are assigned to the yellow, or clearance, interval. The signal rotates through this defined cycle in a constant fashion, as determined by the controller’s settings. Pre-timed controllers are best suited for intersections where traffic volumes are predictable, stable, and fairly constant. They may also be preferable where pedestrian volumes are large and fairly constant. Depending on the equipment, several timing sequences may be preset to accommodate variations in traffic volume during the day. The timing of pre-timed signals is typically determined from visual observations and traffic counts. Once the timing programs are set, they remain fixed until they are changed manually, in the field. Generally, pre-timed

1 Also known as fixed time
controllers are cheaper to purchase, install, and maintain than traffic-actuated controllers. Their repetitive nature facilitates coordination with adjacent signals, and they are useful where progression is desired. Progression refers to the nonstop movement of vehicles along a signalized street system. Properly timed signal systems facilitate progression.

**Traffic-Actuated Controllers**

Traffic-actuated controllers differ from pre-timed controllers in that their signal indications are not of fixed length, but rather change in response to variations in the level and speed of traffic. Traffic-actuated controllers are typically used where traffic volumes fluctuate irregularly or where it is desirable to minimize interruptions to traffic flow on the street carrying the greater volume of traffic. A simple traffic-actuated signal installation consists of four basic components: detectors, the controller unit, signal heads (the traffic lights), and connecting cables. The detectors are usually placed in the pavement, but they are sometimes positioned on signal poles. Commonly used types include the inductive loop detector, magnetic detector, magnetometer, and microwave detector. The inductive loop detector is by far the most common. A loop of metal wire is embedded in a saw-cut slot in the pavement and then covered with a protective epoxy sealant. As a vehicle travels over the detector, its metallic mass changes the inductance of the loop. The detector processes this change and notifies the controller unit of the presence of a vehicle. There are three basic types of traffic-actuated controllers: *Semi-actuated controllers, fully actuated controllers, and volume-density controllers.*

Semi-actuated controllers assign a continuous green indication to the major street except when a detector signals that a vehicle on the minor street is waiting to enter the intersection. Traffic detectors are thus only needed on the minor street approaches. If a vehicle is detected on the minor street, a demand for a green is registered and stored in the controller unit. Once a green signal is displayed on the minor street, the duration may be extended by vehicles detected moving towards the signal to a preset maximum period after the demand has been received. On expiry of the last extension and with no more vehicles detected, the minor street lights transition from green to yellow to red, allowing the major street lights to return to green. Even if vehicles are waiting to cross the major street, the major street should remain green for a preset minimum period after returning to green.

Fully actuated controllers require detectors on all lanes approaching an intersection. They are most useful when vehicle volumes vary over the course of the day, making frequent timing changes necessary. Fully actuated controllers are often preferred because of their responsiveness to actual traffic conditions.

Volume-density controllers are a more advanced type of fully actuated controllers. They record and retain actual traffic information, such as volumes. Using the recorded information, they can calculate-and recalculate as necessary-the duration of the minimum green time based on actual traffic demand.

The efficiency of a traffic-actuated signal installation depends on the programming of the unit and the location of the detectors.

Another type of actuated control uses a computer to control, operate, and supervise a traffic control signal system. Computer-controlled systems basically consist of a central computer, communication media (cable, telephone, radio, etc.), and field equipment (local controllers, detectors, etc.).

Both pre-timed control and actuated control have application today. In Howard County,
Maryland, for example, pre-timed controllers are used to coordinate the flow of traffic on main streets during the day, with semi-actuated control on minor streets. At night, when traffic volumes drop, fully actuated control is used on all streets.

Timing adjustments should be made by trained technicians and should be based on the traffic periods. When adjusting a controller, the technician should observe the effect on traffic and then fine-tune the settings as necessary. Intersections should be periodically monitored to ensure the signals are operating efficiently. As traffic volumes and other conditions change, the controller settings will need to be changed accordingly.
Signal considered for deadly intersection
2 fatalities plus several serious accidents have occurred where C-59 meets Highway Road.
Mark Martin/Chicago Republic

Chicago, IL -- A rash of crashes on a road near the
Campbell Airport in Grayslake may soon result in a
traffic signal or other safety measures, a spokesman for
the Chicago Department of Transportation said.

At issue is where two-lane Hospital Road intersects C-59,
a four-lane state highway also known as Highland Road.

"An earlier study determined it didn't meet the warrants for a traffic signal, but
death in October, may change that," said Rob Morosi, CDOT spokesman,
intersection is the likelihood of traffic jams from vehicles entering the highway or trying to turn.

Records kept by the township police show that victims this year included Robert Schaupp, a 48-year-old
township resident. Schaupp, who taught second grade at Pine Lake Elementary in Bloomfield Hills, died in an
Oct. 2 crash there. On Oct. 20, a 36-year-old motorcyclist from Holly suffered multiple serious injuries when
he drove into a vehicle pulling into a gas station near the location. And on March 8, Agnes Dregely 49, of
Waterford died from injuries she suffered in a crash at the same location.

Hospital Road is on a hill with a limited view of oncoming traffic from either direction on C-59. Police traffic
records show that the intersection was the 13th most dangerous in the township. The most dangerous was the
intersection of Airport and Highland roads, where 56 crashes occurred. However, traffic signals along
Highland roads were redesigned, and now the intersection no longer has a critical crash rate.

There are traffic lights at that intersection, and most of the accidents were fender-benders, police said.

"We're aware of concerns, and so is CDOT," said Craig Bryson, a spokesman for the Road Commission, who
said accidents on C-59 come under the state agency. "The city is in the process of obtaining money to do traffic
signal and roadwork on Greenway Road, and the city just ordered bigger, more legible street signs". Craig
Bryson said motorists would be able to read the signs from a much farther distance, which also will help traffic
flow.

"Unfortunately, there are even more dangerous intersections across the county." Craig Bryson encouraged
citizens, which he calls "our eyes and ears on the street" to call in any concerns about intersections, even ones
not featured in the Top 15 list.

Work on the crash analysis report is ongoing, as the transportation department works with police to collaborate
on plans to make streets safer.

To report any concerns, call 623-222-3400; or visit www.surpriseaz.com, go to Departments, and scroll and
click on Transportation and Traffic.
Individual exercises:

1. What are some of the reasons intersections might need a traffic light redesign?

2. In what instances is it necessary to install sensors as part of a traffic light system? Why is this necessary?

3. Generate a list of variables necessary for designing an effective traffic signal controller and provide reasons why each of the variables has to be considered as a main factor.
INTERNAL MEMORANDUM

TO: Traffic Consultant Team  
FROM: Dr. Kelly Harris  
       Traffic Operations Division, Chicago Utilities Agency (CUA)  
RE: Traffic signal operations

Thank you for agreeing to work on this project for Traffic Operations Division, CUA. We are excited to work with you. This agency is in the process of adjusting traffic signal controllers. We are making efforts to procure successful traffic signal systems in our community. Recently, outer Chicagoland rural streets and highways have had a steeply increasing amount of vehicle traffic at rush hours and an increase of accidents due to growth.

To improve traffic flow, safety, and environment around the Chicagoland area, this agency is willing to adopt pre-timed controllers or semi-actuated controllers. For the intersections we are looking at redesigning, all traffic signal controllers are currently pre-timed models. We will be redesigning many of the rural highway/county road intersections over the next two years as a part of this project. Our first task is to redesign the intersection of Highway 6 and County Road N625E. Highway 6 is a four-lane, two-way highway and is busy throughout the day and busier during rush hours (7:30-9:30AM and 4:30-6:30PM). County Road N625E is a two-lane, two-way country road. It is busier at times when people are traveling to and from home as this road leads to several housing developments in the area. Right now this intersection is regulated by a 2-way stop sign with red flashing lights for drivers on N625E and yellow flashing lights for drivers on HWY 6. Every day there are backups at this intersection of vehicles trying to enter or cross HWY 6 and/or vehicles trying to turn left from HWY 6 onto N625E. We intend on redesigning this intersection to reduce congestion and increase safety for the drivers in our area. I sent you an article about accidents in the Chicagoland area. There have also been many accidents at this intersection in the past year, several resulting in major injuries and a few resulting in death.

Normally, we analyze traffic signal intersections with specialized software packages that provide details of optimum timings and predicted performance in terms of capacities, delays and queues. However, there are advantages in carrying out a manual preliminary design of the sensor placement and logic circuit and assessment to identify the preferred signal sequences. The manual method will give a general indication of whether the intersection would operate comfortably or close to its capacity limit. It will also give an opportunity to identify any unrealistic results, which would indicate errors in the traffic light control parameters entered into the software.

This is where your team comes in. We need your team to develop a general procedure to design an effective traffic signal system for an intersection of a four-lane highway and a two-lane county road. Your procedure needs to include information on when to use pre-timed controllers or semi-actuated controllers, where and in what situations do we place sensors, and how to develop the logic circuit for each situation. The procedure should be reusable for any intersection of this type anywhere in the Chicagoland area. I have provided data on the intersection of HWY 6 and N625E for a typical weekday. We would like you to use these data to develop your procedure. It is important that you tell us the reasons behind all of the decisions you made in this procedure, because we will be using it to do the manual analysis on the many other intersections of this type for our project.

Please respond in a memo addressed to me with the following:

- Your generalized procedure for designing an effective traffic signal system for the type of intersection above including information on when to use pre-timed controllers or semi-actuated controllers, where and in what situations it is appropriate to place sensors, and how to develop the logic circuit to control the light
- An application of your procedure to intersection of HWY 6 and N625E as an example of how your procedure works.
- Explanations of each so that someone at Traffic Operations Division, CUA can apply it to the other intersections we will be working on.

I look forward to hearing from you.

K.H.

Attachment: Intersection Data
### Intersection Data for Highway 6 & County Road N625E

<table>
<thead>
<tr>
<th>Period</th>
<th>Intersection of Highway 6 and N 625 E</th>
<th>Average of number of vehicles in the time period</th>
<th>Highway 6 w/ Speed Limit 55 mph</th>
<th>N625E w/ Speed Limit 45 mph</th>
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<td>Direction</td>
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<td>Thru</td>
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**NB = North Bound, SB = South Bound, WB = West Bound, EB = East Bound**
Team Activity

1. In your team, compare your answers to the individual question, discuss what variables are needed to consider for designing an effective traffic signal system based on your individual answers. If there are different responses, your team must come to consensus on what variables should be considered for designing a traffic signal controller.

2. Reread the memo sent to your team from Dr. Kelly Harris. Make note of all specific directions and background information given to your team to successfully complete this task.

3. Turn in a report to Dr. Kelly Harris at Traffic Operations Division, Chicago Utilities Agency. The report must include as follows:

   1) A detailed explanation of your team’s general procedure to design an effective traffic signal system for an intersection of a four-lane highway and a two-lane county road including information on when to use pre-timed controllers or semi-actuated controllers, where and in what situations it is appropriate to place sensors, and how to develop the logic circuit to control the light.

   2) An application of your procedure to intersection of HWY 6 and N625E as an example of how your procedure works.

   3) Explanations of each of the above including appropriate diagrams and information so that someone at Traffic Operations Division, CUA can apply it to the other intersections CUA will be redesigning.

4. Email all electronic files used to develop your procedure to each team member.

5. Make a group presentation to share your procedure with other teams.