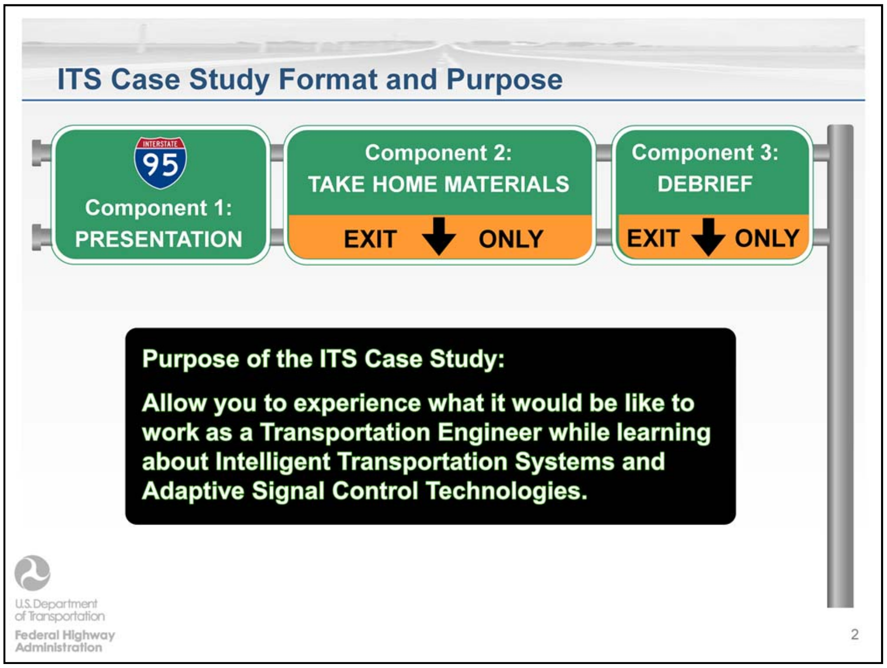
RITA Research and Innovative Technology Administration

Highway Transportation Engineering

ITS Case Study

Component 1 – Student Guide



The purpose of this case study is to allow you to experience what it would be like to work as a Transportation Engineer, working on an Adaptive Signal Control Technology project.

The case study is divided into three different components.

- Component 1: An introduction to Intelligent Transportation Systems and Adaptive Signal Control Technologies.
- Component 2: The take home packet that contains the case you will be reviewing and answering critical thinking questions.
- Component 3: An in-class debrief, where we will discuss the scenario, review the questions that you answered, and your experiences "on the job."

Component 1 Terminal Learning Objective:

- Describe the role of ITS in addressing transportation issues in the 21st Century.

Component 1 Enabling Learning Objectives:

- ELO 1: Describe the importance of ITS to the future of transportation.
- ELO 2: Demonstrate awareness of Adaptive Signal Control Technology.
- ELO 3: Differentiate between goals, objectives, strategies, and tactics in the context of a transportation problem.

Notes:

ITS is a term that refers to many different types of technologies being used to improve transportation safety and mobility. These systems integrate advanced communications technologies into the transportation infrastructure and in vehicles themselves. ITS technologies are designed to relieve congestion, improve safety, and enhance American productivity as well as reduce environmental impact.

Additional Resources: Federal Highway Administration RITA Website – FAQs:

http://www.its.dot.gov/faqs.htm

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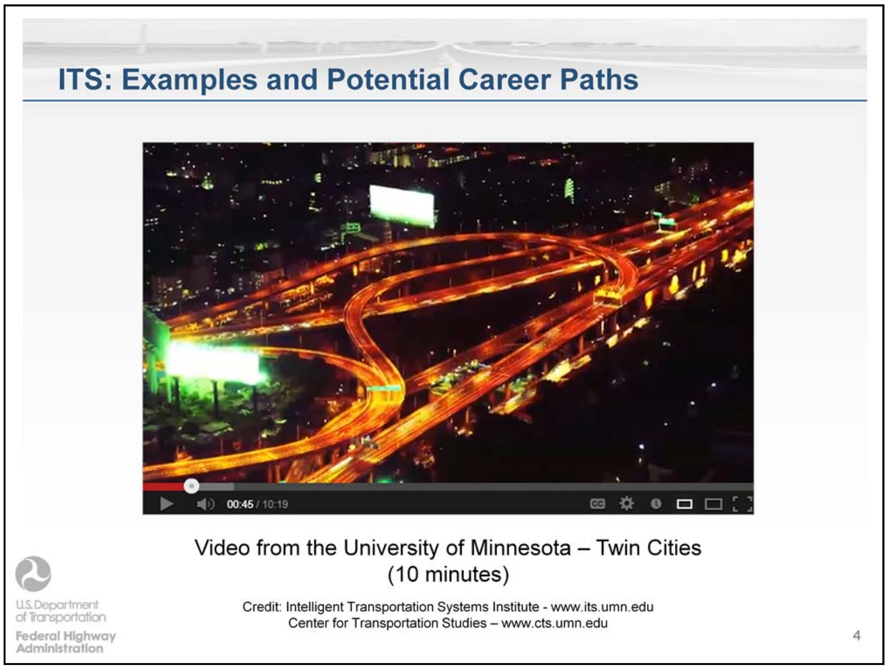

This video provides an overview and examples of ITS, and explains the specific technologies used in ITS.

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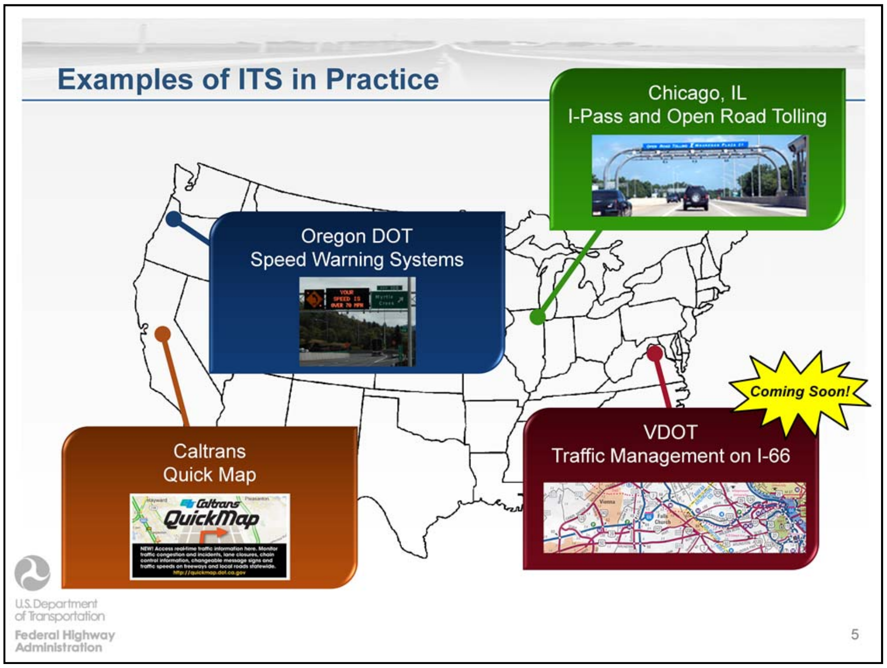

Some examples of different systems that fall under the ITS umbrella.

- Chicago, IL – I-Pass is a prepaid toll collection system that saves motorists time and money. An I-Pass transponder eliminates the need for customers to stop at a gate by allowing them to drive in the open road tolling lanes, saving drivers an estimated two hours of travel time per week.

- Oregon DOT – Speed Warning Systems use radar to determine an approaching vehicle's speed, especially in the area near sharp highway curves. If the speed exceeds a safe speed, then a warning message is displayed on a VMS sign.

- Caltrans – QuickMap. Access real-time traffic information. Monitor traffic congestion and incidents, land closures, chain control information, changeable message signs, and traffic speeds on freeways and local roads statewide.

- VDOT – Traffic Management on I-66 (coming soon). VA Governor McDonnell announced on 2/26/13 that the Virginia Department of Transportation (VDOT) will design and install an active traffic management (ATM) system on a 34-mile stretch of Interstate 66 in northern Virginia from Washington, D.C. to Gainesville, VA. Construction of the $34 million system will be completed in early 2015. Drivers will see new dynamic message and lane control signs, which will advise them of incidents and delays, travel times and provide directions on merging traffic and usable lanes to help transition traffic smoothly and safely. Ultimately, the improved road monitoring and information collected by the system should enable first responders to clear incidents more quickly.

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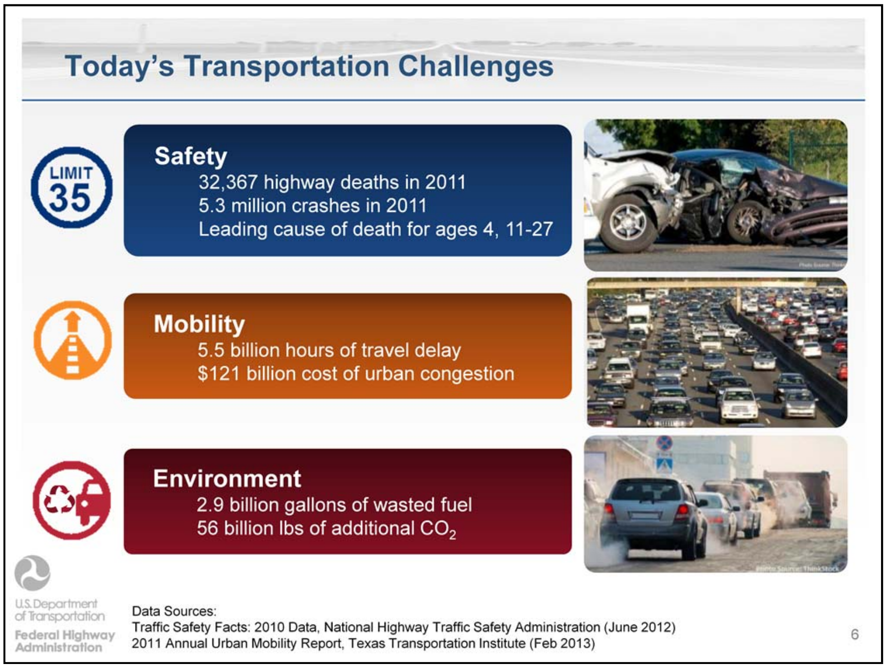

The safety of the traveling public on the roadway is always of utmost concern. In 2011, there were 32,367 highway deaths and 5.3 million crashes. Automobile accidents are the leading cause of death for ages 4 and 11-27.

Infrastructure - roads, bridges, tunnels - provides the foundation that makes mobility possible. Being a user of the roadway, you have an opinion about mobility on the roads on which you drive. There are many areas where mobility could be improved (in some places drastically).

Surface transportation has a significant impact on the environment. There were approximately 2.9 billion gallons of fuel wasted and an additional 56 billion pounds of additional CO2 added to the air in 2011.

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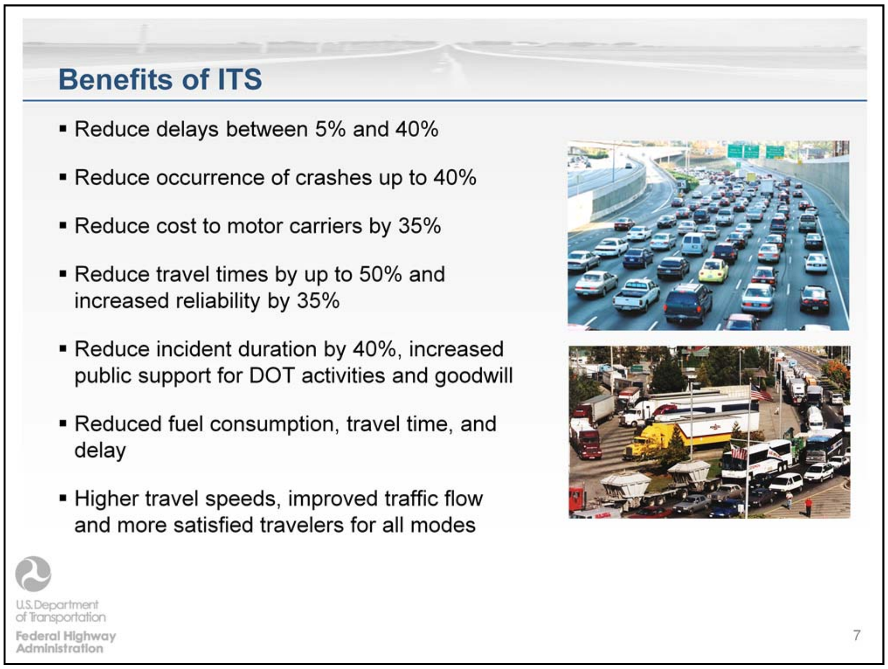

ITS improves effectiveness, efficiency, and safety of the transportation system. ITS deployments have the potential to offer the following benefits:

- Arterial management systems can potentially reduce delays between 5% and 40% with the implementation of advanced control systems and traveler information dissemination.
- Freeway management systems can reduce the occurrence of crashes by up to 40%, increase capacity, and decrease overall travel times by up to 60%.
- Freight management systems reduce costs to motor carriers by 35% with the implementation of the commercial vehicle information systems and networks.
- Transit management systems may reduce travel times by up to 50% and increased reliability by 35% with automatic vehicle location and transit signal priority implementation.
- Incident management systems potentially reduce incident duration by 40% and offer numerous other benefits, such as increased public support for DOT activities and goodwill.
- There is a wide range of benefits that can be obtained from ITS deployments. For example, fuel consumption, travel time, and delay can be reduced. ITS deployments can also result in higher travel speeds, improved traffic flow, and more satisfied travelers for all modes.

Additional Resources: http://www.benefitcost.its.dot.gov/

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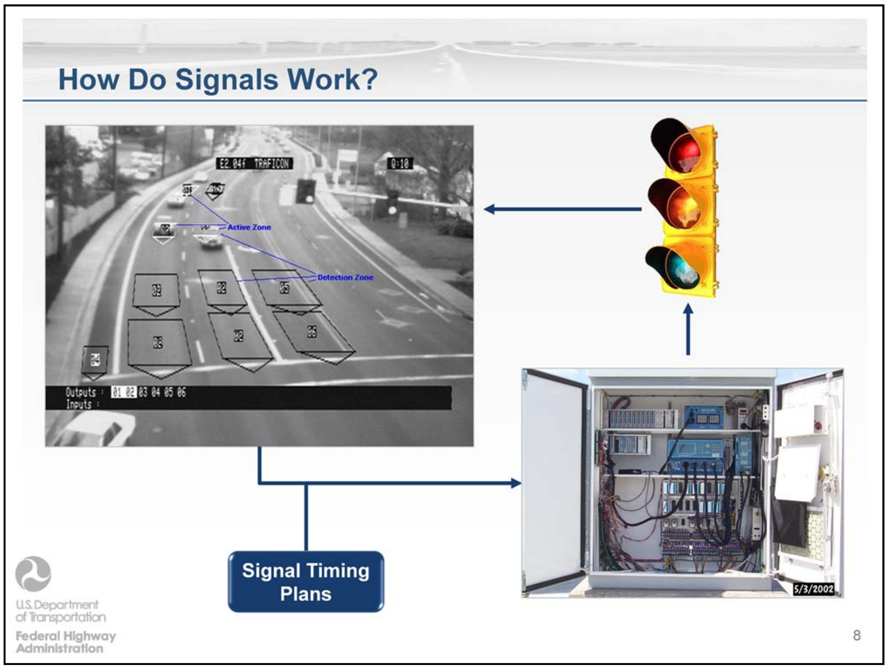

Most controllers can handle about 200 timing plans, however, timing plans are expensive to develop (approximately $3000 for each plan) and most intersections have between 3-5 different timing plans that cover different time periods during the day: peak a.m., off peak, mid-day, p.m. peak, and off peak, for example.

The way a traffic signal works depends on if it is a fixed-time signal or an actuated signal. Fixed-time signals follow a predetermined sequence of signal operation, always providing the same amount of time to each traffic movement, whether traffic is present or not.

Actuated signals change the lights according to the amount of traffic in each direction. They use various types of sensors to detect vehicles, and adjust the length of the green time to allow as many vehicles as possible through the intersection before responding to the presence of vehicles on another approach. The full range of actuated control capabilities depends on the type of equipment employed and the operational requirements.

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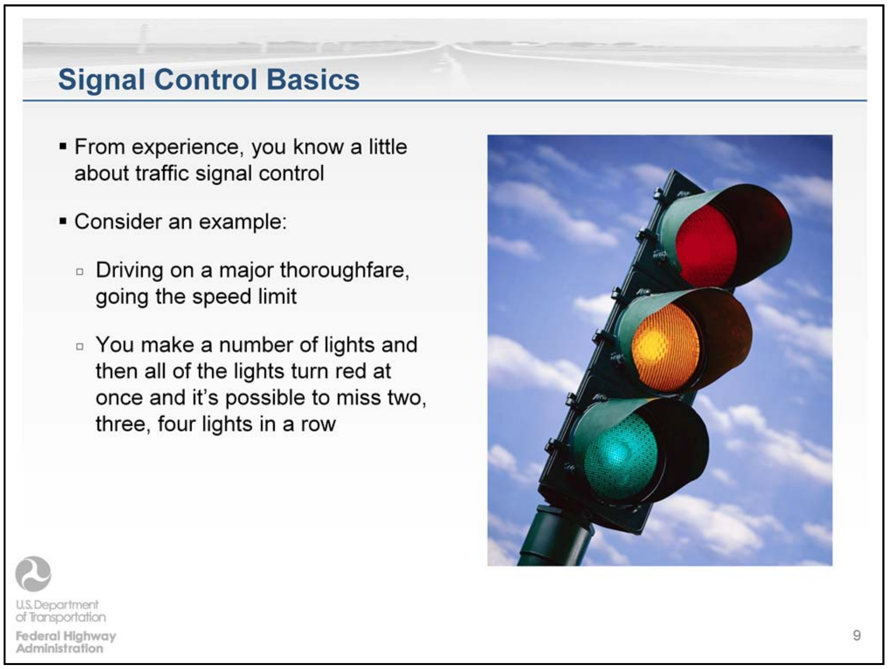

Additional Resources: Traffic Signal Timing Manual (TSTM): http://ops.fhwa.dot.gov/publications/fhwahop08024/index.htm

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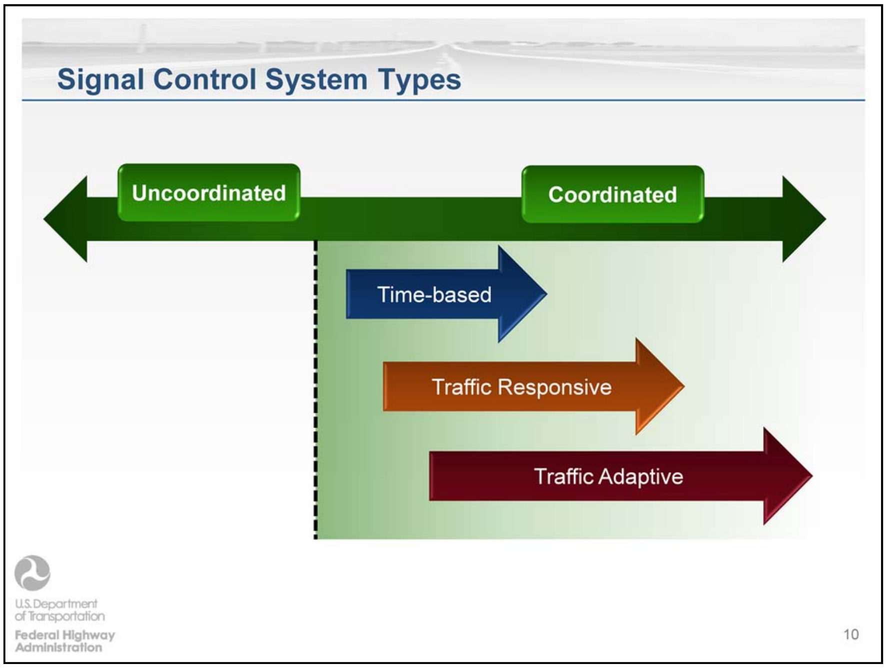

There are two forms of traffic control: Uncoordinated and Coordinated. Uncoordinated is a singular mode of operation in which there is no interaction between traffic demand and traffic signal operation. You see uncoordinated traffic signals when the signal is located more than 1 mile from other traffic signals.

Coordinated is a plural mode of operation where traffic demands are consistent and failure to consider adjacent intersection operations would result in congestion and delays.

Time Based coordination is a form of coordinated operation where there is no physical connection between the controllers but they share a common time base allow a low level of coordination that is subject to the limitations of clock drift.

Traffic Responsive coordination is a form of coordinated operation where the internal "clocks" in each controller are synched and data is exchanged. There is a central algorithm making decisions, but it is not making a lot of change outside the plan. It is changing the overall strategy.

Adaptive control is a high level form of coordination. There are physical connections between the intersections and algorithms to process traffic demand and to develop signal operations tactics. Recall that the traffic controller orchestrates what happens at the intersection. An adaptive system helps conduct the orchestra more effectively. It is an additional system with advanced capabilities that tells the controller what to do.

Additional Resources: Traffic Control Systems Handbook

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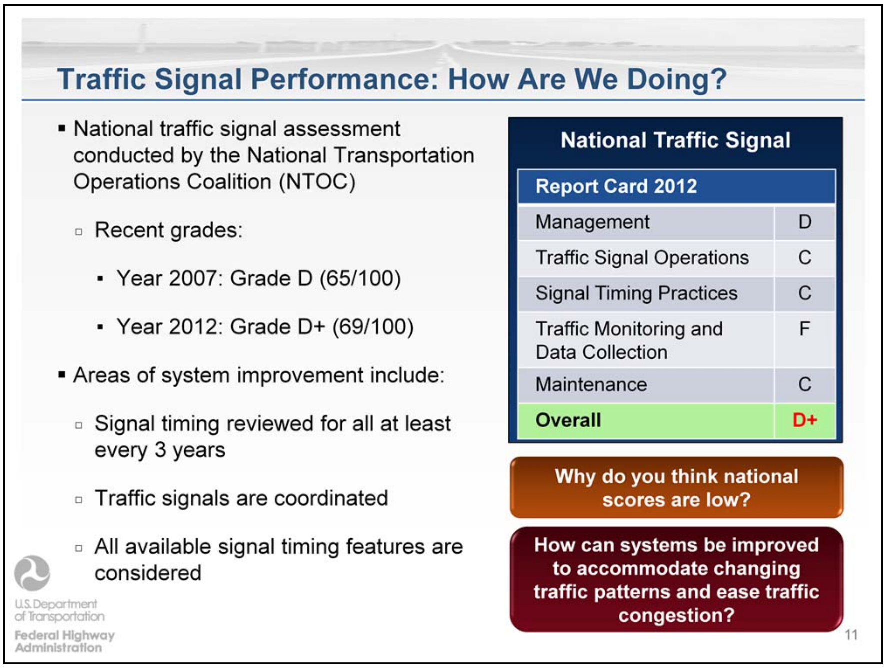

Agencies are beginning to reorganize, working smarter to focus resources on operations and maintenance, and collaborating regionally to take advantage of distributed expertise and to compete for resources more effectively to improve their capabilities. Management, operations, and maintenance practices that consider agency objectives, capabilities, and resource constraints have great potential to improve the performance of the transportation system.

Additional Resources: http://www.ite.org/reportcard/

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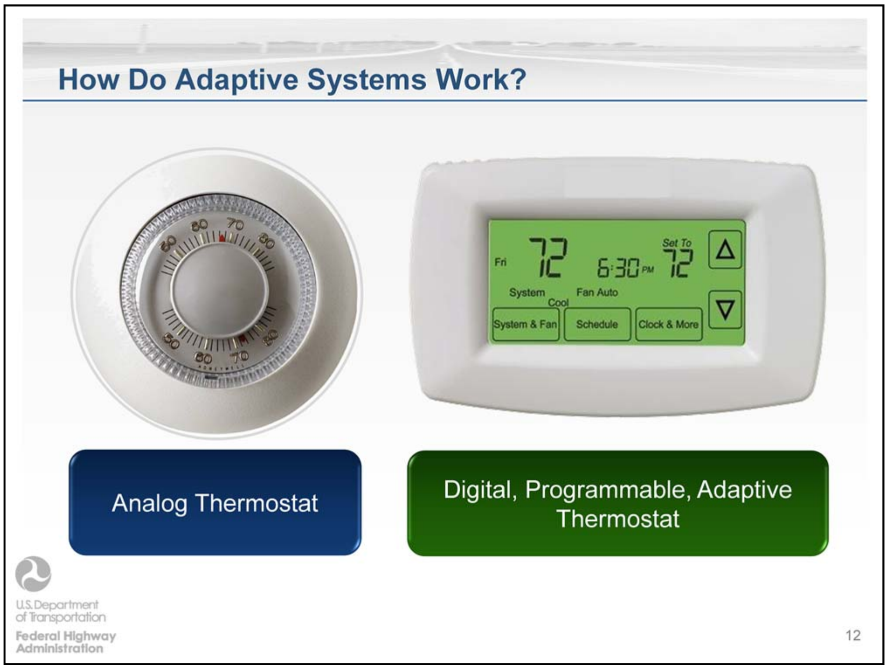

Here is a thermostat analogy to describe adaptive signal control technology. An analog thermostat, like the one on the left, is not making any decisions, it is purely and simply reacting to the temperature is senses and the temperature you set. If it is hotter than the temperature set, it turns off. If it is colder than the temperature set, it turns on. This is much like a time-based system, it is purely reacting to it's programming and is not using any cues from any outside data.

On the other hand, you have digital, programmable, adaptive thermostats. These thermostats can handle multiple different programs to run during the day or night, or different days depending on the programs set. They also have adaptive qualities, and measure the time it takes to reach a certain temperature. If the temperature is not achieved, and adaptive system can learn from this and know to begin heating or cooling earlier or later to reach its temperature goal.

Poor traffic signal timing contributes to traffic congestion and delay. Conventional signal systems use pre–programmed, daily signal timing schedules (analog thermostat). ASCT adjusts the timing of red, yellow and green lights to accommodate changing traffic patterns and ease traffic congestion (digital, programmable, adaptive thermostat).

The main functions of ASCT over conventional signal systems are that it can:

- Continuously distribute green light time equitably for all traffic movements.
- Improve travel time reliability by progressively moving vehicles through green lights.
- Reduce congestion by creating smoother flow.
- Prolong the effectiveness of traffic signal timing.

First, traffic sensors collect data. Next, traffic data is evaluated and signal timing improvements are developed. Finally, ASCT implements signal timing updates. The process is repeated every few minutes to keep traffic flowing smoothly.

Notes:

This video provides an example of what an advanced adaptive signal control technology system looks like and how it functions.

Notes:

ASCT is effective where variability and unpredictability in traffic demand results in excessive delay and stops that cannot be reasonably accommodated by updating coordinated signal timing parameters on a frequency consistent with agency traffic signal operations objectives.

The traditional signal timing process is time consuming and requires substantial amounts of manually collected traffic data. Traditional Time-of-Day signal timing plans do not accommodate variable and unpredictable traffic demands. With ASCT, the data collection and analysis are done automatically. More important for travelers, signal timing updates are made as situations occur—stopping many complaints from ever happening. Adaptive signal control technologies are also kinder to the environment. Using ASCT can reduce emissions of hydrocarbons and carbon monoxide due to improved traffic flow.

With ASCT, information is collected and signal timing is updated continually. Special events, construction, or traffic incidents typically wreak havoc on traffic conditions. While large-scale construction projects and regular events can be anticipated, determining their impact on traffic conditions can be extremely difficult. Other disruptions, such as crashes, are impossible for time-of-day signal timing to accommodate.

The cost of ASCT typically ranges between $6,000-$50,000 depending on the current infrastructure, communications and detection requirements of the selected system.

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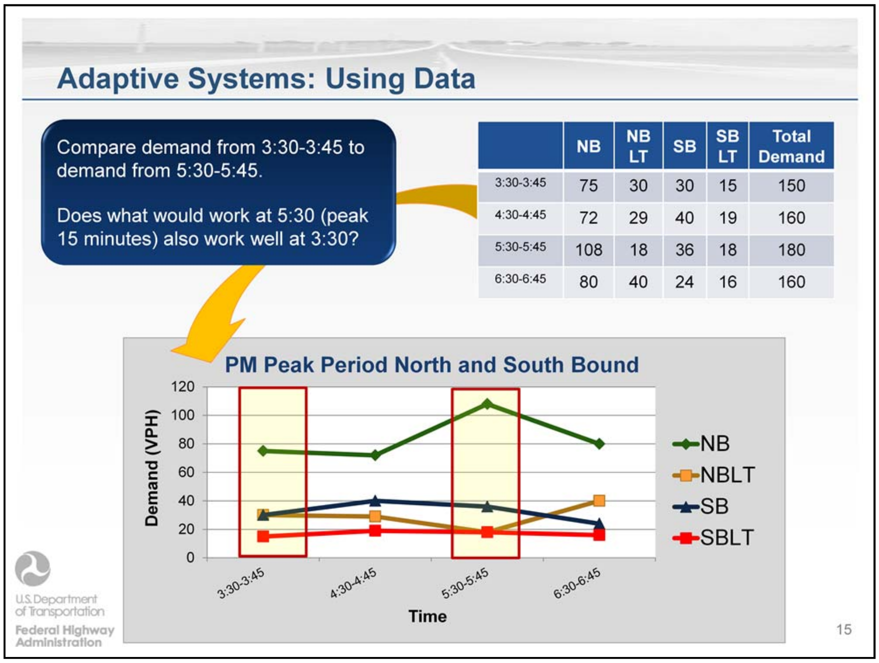

	NB	NB LT	SB	SB LT	Total Demand
3:30-3:45	75	30	30	15	150
4:30-4:45	72	29	40	19	160
5:30-5:45	108	18	36	18	180
6:30-6:45	80	40	24	16	160

There is no research or methods to define what level of variability might suggest the need for ASCT. However, this data may suggest that the traditional method of developing signal timing based on the peak 15 minutes of the peak hour may not be a good practice if demands change dramatically over the peak period (3-5 hours).

Once a signal controller is programmed, it is set to whatever the timing is; it does not change even if traffic conditions aren't uniform throughout that period.

NB= Northbound, NB LT = Northbound Left Turn, SB=Southbound, SB LT= Northbound Left Turn

VPH= Vehicles Per Hour

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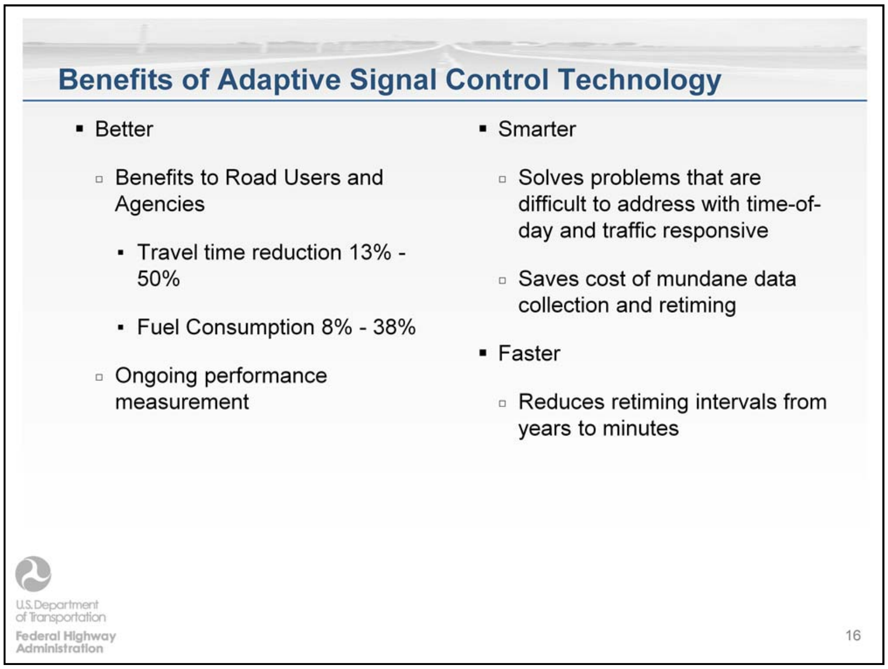

The benefits of ASCT are consistent with the theme “better, smarter, faster.” We have over 20 years of experience with this technology to gain and demonstrate these benefits. There are benefits to road users and agencies. Road users will see reductions in travel time, fuel consumption, emissions, etc.

Agencies are saving money because they aren’t doing a lot of the typical mundane tasks of collecting data and doing signal optimizations via software only to the go implement those plans.

Usually the signal retiming process takes from 3 to 5 years. This technology reduces that down to a matter of minutes.

Additional Resources: FHWA Every Day Counts – Adaptive Signal Control: http://www.fhwa.dot.gov/everydaycounts/technology/adsc/

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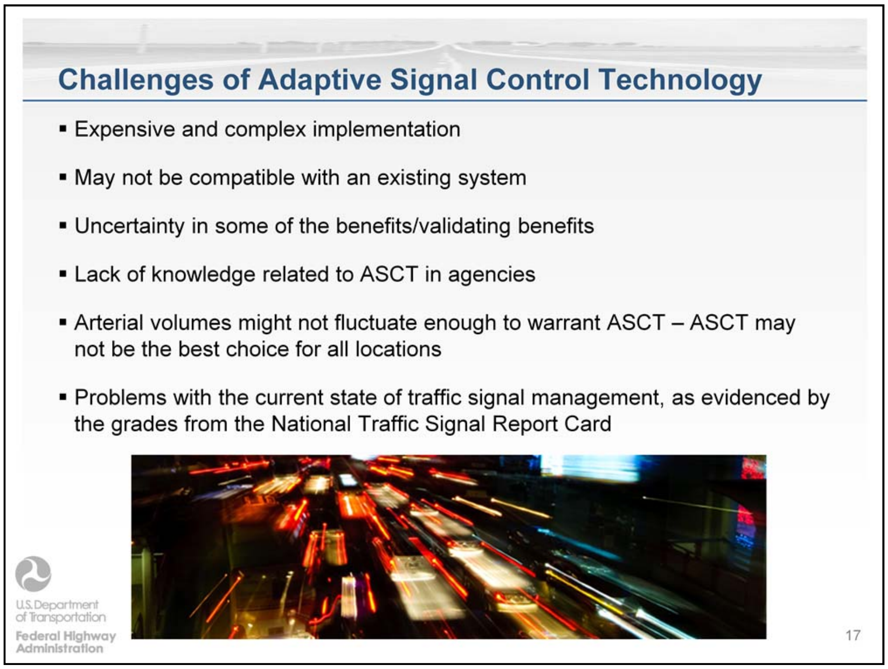

There are several general challenges that come with any adaptive signal control technology system implementation. ASCT implementation is expensive and complex, and is not a simple, straightforward process that will work the same way with each agency. ASCT may not be compatible with the existing system, creating additional costs and complexity. It can be difficult to quantify and/or validate the benefits that ASCT provides. ASCT is not the answer to every problem, and, depending on the data, it may or may not be the ideal solution.

It is also a technology that a lot of agencies and departments aren't intimately familiar with so there is a lot to learn. You can be a valuable asset to a department if you have knowledge or experience with ASCT.

Several challenges associated with adaptive signal control technology can be found by reviewing the Signal Report Card we discussed earlier. In order for an adaptive signal control technology implementation to be successful, agencies must have the proper management practices, signal timing practices, traffic monitoring and data collection processes, and maintenance operations in place to support such a complex project.

Notes:

There are a few different ways that, as a traffic engineer, you will be notified of a problem. By performing routine maintenance of traffic signals and timing plans, you will review information about the effectiveness of the signal control and can make changes accordingly. If there is a problem, you will likely receive complaints from various stakeholders in the area (community members, business owners, etc.) explaining problems encountered.

Consider complaints. It is not ideal, or really in any way practical, to address each complaint or problem specifically. Rather, you will need to interpret each complaint/problem much like you'd interpret data collected from the system to determine what is really happening in the community you serve.

Notes:

To develop a good basic service model and Traffic Signal Management plan, it is important to define and understand the meaning of goal, objective, strategy, and tactics.

Example:

Goal: Keep vehicles moving on major routes, when stops are necessary the duration should be short and for obvious reasons.

Objective: Arterial routes will provide smooth flow in coordinated directions during peak hours and equitable green time outside of peak periods to all movements.

Strategy: Cycle lengths, Offsets, phase sequence and Splits designed to provide progression and promote safe and efficient movement of traffic along coordinated route.

Tactic: Resonant Cycle Length, Splits on side streets meet pedestrian minimums, offsets maximize bandwidth.

Notes:

Case Study: Adaptive Signal Control Technology

- Context:
  - You just started a new job as a Junior Traffic Engineer (Congratulations!)
  - Your job is in the City of Hamilton
  - Hamilton is a great place to live and work – as evidenced by the population growth in the past decade
- Current situation:
  - There are major traffic problems on the main arterial through Hamilton
  - Adaptive signal technology has been proposed at 15 signalized intersections along the main arterial and in the vicinity to help Hamilton meet operational objectives that are not currently being met with the existing system/technology

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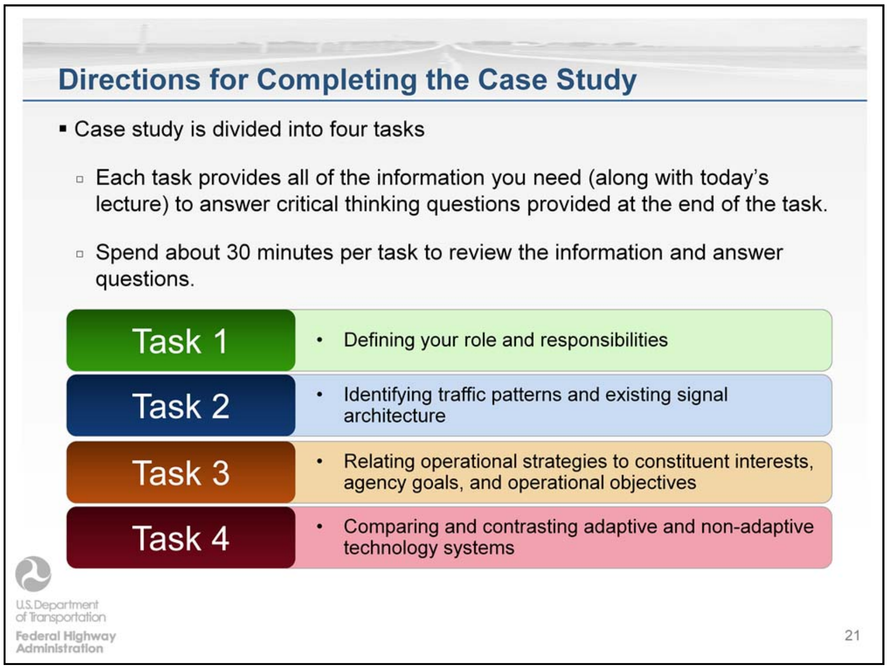
Directions for Completing the Case Study
▪ Case study is divided into four tasks
▫ Each task provides all of the information you need (along with today's lecture) to answer critical thinking questions provided at the end of the task.
▫ Spend about 30 minutes per task to review the information and answer questions.
Task 1
• Defining your role and responsibilities
Task 2
• Identifying traffic patterns and existing signal architecture
Task 3
• Relating operational strategies to constituent interests, agency goals, and operational objectives
Task 4
• Comparing and contrasting adaptive and non-adaptive technology systems
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