Improving Highway Safety

Study Guide

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NOTE: This study guide is NOT intended to replace the online course, but instead, to supplement the materials presented in-depth in the online course.

There may be slight differences in content. In these cases, the online content should be considered to be the most current.
Lesson 1
Introduction

In 2006, highway vehicle crashes accounted for 3.7 persons killed and 253 injured every hour in the US. This translates into over 32,367 fatalities and 2.22 million injured persons per year, respectively. To comprehend the severity of these highway statistics consider that there were approximately 58,000 US soldiers killed in battle over 8 years of war in Vietnam.

Highway safety must be improved. ITS has the potential to help.

Course Topics

This course is focused on the safety challenges currently facing transportation engineers, with particular emphasis on:

- Areas in which these challenges can be mitigated using a variety of ITS applications.
- USDOT ITS Programs and their impact on safety.
- Safety challenges associated with a work zone.
- Countermeasures fusing the traditional and ITS approaches to address safety challenges.
- Key aspects of the safety strategic planning process, ITS project implementation and system engineering approach for deploying ITS.
Course Learning Outcomes

• Outcome 1. Discuss participants’ highway safety challenges and triumphs; identify general uses of ITS to improve highway safety; outline USDOT ITS Programs.

• Outcome 2. Describe and discuss four highway safety priority areas specific to state or local highway/street agencies.

• Outcome 3. Demonstrate how ITS can contribute to improved highway safety and traffic operations through a work zone.

• Outcome 4. Discuss the status of highway safety and the need to continuously improve highway safety. Describe ITS-supported countermeasures that can be employed to address highway safety priority areas identified in your jurisdiction.

• Outcome 5. Outline organizational and individual-level actions for future ITS and Safety collaboration at the planning level, and activities to enable these actions.
Lesson 2

Highway Safety Challenges

This lesson introduces several types of safety challenges faced by transportation engineers and a variety of ITS applications that can mitigate them. In our discussion, we will attempt to answer a few basic questions about safety, such as:

• What do we mean by “safety problems”?
• How can ITS help improve highway safety?

Learning Outcomes

After completing this lesson, you will be able to:

• Describe four formal means of identifying safety problems
• Discuss and list examples of several ITS applications that help improve safety
• Identify USDOT ITS Technologies
How Critical is Highway Safety?

2011 Highway Deaths Reach 32,367; Highway Fatalities called a “National Epidemic”
- 3.7 persons killed every hour
- 32,367 fatalities in 2011
- 253 persons injured every hour
- 2.2 million injuries in 2011
- In three hours from now, approximately 12 people will have died on our highways

Sample Safety Goals

Some of the more common safety goals of State DOTs are listed below:
- Reduce bicycle and pedestrian fatalities and serious injuries.
- Improve the safety of highway-railroad crossings
- Improve the safety of commercial vehicle operations
- Minimize incident response times
- Improve data and decision support systems
- Improve Intersection and Interchange Safety
- Reduce Lane Departure crashes

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How To Identify Safety Problems

We all have intuitive ways to identify safety problems. However, they can be identified in more formal ways.

• Highway Safety Manual
• Road safety audits (RSA)
• Crash data analysis
• Statewide safety planning processes

Statewide Safety Planning

• FHWA Safety - http://safety.fhwa.dot.gov/
What is ITS?

Some of you may not have been exposed to ITS before. So before proceeding further into the lesson, let’s look at the definition below:

- Electronics
- Communications
- Information Processing

Intelligent Transportation Systems (ITS) means electronics, communications, or information processing, used singly or in combination to improve the efficiency and/or safety of a surface transportation system.

Applying ITS To Improve Safety

Bringing the Safety and ITS departments together provides for greater opportunities to achieve greater safety benefits. We will now discuss a variety of ITS applications that can be brought to bear to address safety concerns. These ITS applications could significantly improve highway safety.
Where Does ITS Improve Safety?

- Intersections & Interchanges
  - Collision Avoidance
- Pedestrians & Bicycles
- Road Weather
- Other Adverse Roadway Conditions
  - Advanced Warning Systems
  - Animal Crossings
- Speed Management
- Lane Departure
- Work Zones
- Incident Response & Mitigation
- Connected Vehicle
  - V2I
  - V2V

Intersections and Interchanges

A number of ITS applications are available to address safety challenges that occur at intersections and interchanges, including:

- Improved Traffic Signal Control
- Variable Lane Signs
- Ramp metering
- Intersection Warning Systems
- Automated Enforcement
Pedestrians and Bicycles

The FHWA has identified several safety concerns involving pedestrians along with ITS technologies capable of addressing them:

- Increasing motorist awareness
- Providing feedback to waiting pedestrians
- Providing feedback to crossing pedestrians
- Detecting pedestrians at crossing areas
- Enhancing the safety of visually impaired pedestrians

A variety of countermeasures are available to address pedestrian and bicycle related safety challenges, including the following:

- Pedestrian Detectors
- In-Pavement Lighting
- Animated Eyes Display
- Bicycle Actuated Signals

Bicycles

New technologies on signal and detection systems:

- Bicycle Signal Heads
- Bicycle Detection
- Pedestrian/Bicycle Crosswalk Signals

A bicycle signal is an electrically powered traffic control device that may only be used in combination with an existing traffic signal. Bicycle signals shall direct bicyclists to take specific actions and may be used to address an identified safety or operational problem involving bicycles.
Road Weather

Adverse weather conditions have a major impact on both traffic flow and road safety, as well as the productivity of road operating agencies. Several ITS technologies are available to help transportation managers mitigate weather impacts by providing driver warning, information, or traffic control:

- Environmental Sensor Stations
- Mobile Sensors
- Information Dissemination
- Treatment Strategies
- Traffic Signal Control
- Variable Speed Limits

Each of these technologies and strategies can be applied to improve safety under adverse weather conditions.

Adverse Roadway Conditions

A wide array of ITS applications can be applied to warn drivers of dangerous conditions on the roadway that may arise regardless of weather conditions. Examples include congestion, traffic incidents, tight curves, or long downhill grades.

ITS applications available to mitigate these conditions include:

- Advanced Warning Systems
- Animal Crossings
- Pre-Trip/En-Route Information
- Reversible Lanes
Speed Management

A number of ITS applications are available to assist motorists with maintaining speeds appropriate to the conditions.

- Variable Speed Limits
- Speed Display Systems
- Variable Advisory Speed Display

Work Zones

The safety of highway workers and travelers is of critical importance during roadway maintenance and improvement projects.

Various ITS applications have the ability to assist in efforts to enhance the safety of work zones:

- Portable Traffic Management Systems
- Traveler Information Systems
- Speed Enforcement and Display Systems
- VMS Merge Point Notification
Incident Response and Mitigation

Many ITS applications can help reduce the adverse impact of an incident and improve safety of the transportation system. These applications increase the efficiency and effectiveness of responders and aid the quick clearance of incidents:

- Incident Management
- Emergency Vehicle/Signal Preemption
- Telemedicine
- HAZMAT Management
- Emergency Vehicle CAD/AVL
- Motorist Assistance Patrols/Call Box Systems

Benefits include better medical services to reduce injury impacts, fast removal of the incident hazard to help minimize the potential of secondary incidents, and improved safety of the responder.

The Connected Vehicle Concept

The Connected vehicle concept addresses a suite of technologies and applications that use wireless communications to provide connectivity:

- Among vehicles of all types
- Among vehicles and a variety of roadway infrastructures
- Among vehicles, infrastructure, and wireless consumer devices

The development and deployment of a fully connected transportation system that makes the most of multi-modal, transformational applications requires a robust, underlying technological platform. The platform is a combination of well-defined technologies, interfaces, and processes that, combined, ensure safe, stable, interoperable, reliable system operations that minimize risk and maximize opportunities.
Archived Information Management

The National ITS Program Plan describes ITS data archiving as follows:
“the collection, storage and distribution of ITS data for transportation planning, administration, policy, operation, safety analyses, and research.”

ADUS Service for Safety

Fully Connected Vehicle

Vehicle Data
latitude, longitude, time, heading angle, speed, lateral acceleration, longitudinal acceleration, yaw rate, throttle position, brake status, steering angle, headlight status, wiper status, external temperature, turn signal status, vehicle length, vehicle width, vehicle mass, bumper height

Infrastructure Messages
Signal Phase and Timing, Fog Ahead, Train Coming, Drive 35 mph, 50 Parking Spaces Available
Connected Vehicle Technology

- **What it is**
  - Wi-Fi radio adapted for vehicle environment
  - Inexpensive to produce in quantity
  - Original FCC spectrum allocation in 1999
  - FCC revised allocation in 2004 and 2006

- **How the technology works**
  - Messages transmitted 10 times/sec (300m range – line of sight)
  - Basic Safety Message: vehicle position, speed, heading, acceleration, size, brake system status, etc.
  - Privacy is protected (vehicle location is NOT recorded or tracked)

- **Benefits of DSRC technology compared to radar/laser technology**
  - Reduced price
  - Improved reliability \(\Rightarrow\) fewer false alarms
  - Increased performance \(\Rightarrow\) addresses more crash scenarios

- **Drawbacks of the technology**
  - Both vehicles need to be equipped to gain benefit
  - Requires security infrastructure

Safety Applications

**Connected vehicle safety applications** are designed to increase situational awareness and reduce or eliminate crashes through vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) data transmission that supports: driver advisories, driver warnings, and vehicle and/or infrastructure controls. These technologies may potentially address up to 82 percent of crash scenarios with unimpaired drivers, preventing tens of thousands of automobile crashes every year (further research will incorporate heavy vehicle crashes including buses, motor carriers, and rail).

- Forward Collision Warning (FCW)
- Emergency Electronic Brake Light (EEBL)
- Blind Spot/Lane Change Warning (BSW/LCW)
- Do Not Pass Warning (DNPW)
- Intersection Movement Assist (IMA)
- Left Turn Assist (LTA)
- Curve Speed Warning (CSW)
- Red Light Violation Warning (RLVW)
- Stop Sign Gap Assist (SSGA)
- Transit Pedestrian Warning
Additional Resources

The ITS JPO website contains links to information on Benefits, Costs, Deployment Levels, and Lessons Learned.

http://www.its.dot.gov

Additional examples of ITS experience can be found in the ITS Benefits database, a valuable resource for providing comparable examples of the impacts of ITS and the costs to deploy ITS.

http://www.itsbenefits.its.dot.gov

Review Learning Outcomes

Now that you have completed this lesson, you should be able to:

• Describe four formal means of identifying safety problems
• Discuss and exemplify several ITS applications that help improve safety
• Identify USDOT ITS Initiatives
Lesson 3
Work Zone Case Study

Safety and ITS have collaborated to improve safety and performance in many instances. In this lesson, we will go through a case study conducted by USDOT to see how ITS can be applied in an interstate work zone.

This report on the reconstruction on the Big-I Interchange in the city of Albuquerque provides a concise overview of the work zone safety challenges faced; the functions needed to mitigate these challenges; the ITS deployed; the performance of the work zone and systems; and the benefits realized.

Lesson 3
Learning Outcomes

After completing this lesson, you will be able to:

• Identify and demonstrate how ITS can contribute to improved highway safety and traffic operations through a work zone
• Identify and discuss critical institutional, developmental and operational characteristics that must be in place to successfully apply ITS to improve highway safety
Background
Why use a work zone as an example?

- Work zones exist in all states
- Work zone safety is a typical highway safety focus area of states
- Work zone safety has been improved by ITS applications
- Work zone ITS benefits have been documented and evaluated by USDOT and states
- Work zones are an issue today and will be a growing travel experience as roads are rehabilitated and maintained.

The Big-I case study presents an opportunity to examine the process of understanding safety challenges, and to identify the critical institutional, developmental and operational characteristics that must be in place before ITS can be applied to improve highway safety.

Work Zone Safety Issues

Thus, work zones are becoming increasingly prevalent and hazardous and represent a prime opportunity for collaboration with ITS.

In fact, work zones are viewed as such a high priority by FHWA that they have issued a final rule that requires work zone traffic management plans (TMP).

FHWA believes that the new provisions in this work zone rule will help State Departments of Transportation (DOTs) meet current and future work zone safety and mobility challenges, and serve the needs of the American people.
Work Zone Safety Challenges

A few thoughts might come to mind when we approach a work zone: delay, frustration, tight lanes, congestion, danger, lane shifting, unknown lane availability, detours, getting lost, etc. Work zones have a major impact on both highway and construction worker safety.

Some of the most noted safety and mobility challenges are:

- Construction worker safety
- Roadway capacity and speed reductions
- Alternate routing and travel route availability
- Day and night time condition awareness
- Traffic pattern changes
- Incident management

These challenges can be addressed by a variety of countermeasures. However, it is important to identify performance measures that will help evaluate the impact of these countermeasures on the challenges they are meant to mitigate.

Performance Measures/Data Requirements

The performances measures listed below help define and monitor performance of the operating work zone and progress toward improving the mobility and safety challenges created by the work zone.

- Speeds
- Impact on Crash Frequency
- Traffic volumes
- Public Perception
- Incident response and clearance times
ITS and Work Zone Safety

ITS technologies are used increasingly to anticipate and mitigate congestion caused by highway work zones. These technologies provide ways to monitor and manage traffic flow through work zones more efficiently, thereby increasing safety for both workers and road users.

Use of ITS technologies in work zones reduces construction time and costs and improves incident detection, response, and clearance.

This is particularly important as traffic capacity often is reduced in work zones, and incidents in these areas cause even greater congestion and increase the potential for secondary crashes.

A wide range of technologies and operational approaches can be used to address the functions meant to increase safety and mobility through and around work zones. Some of these functions are listed below:

- Enhanced driver and worker safety
- Monitoring and management of traffic
- Provide traveler information
- Minimized decreased capacity
- Tracked work zone performance

The Big-I Project:
Background and Characteristics

Where is the Big-I?

- The Big-I is at the intersection of two interstates, the Coronado Interstate (I-40) and the Pan American Freeway (I-25) in Albuquerque.

Why was it rebuilt?

- The New Mexico State Highway and Transportation Department rebuilt the Big-I interchange in Albuquerque to make it safer, more efficient, and to provide better access.
- The original interchange was designed to support an average daily traffic of only 40,000 vehicles. However, it was severely over capacity, experiencing an average of 1.7 crashes per day that were estimated to cost about $12 million annually.

The two-year project began on June 30, 2000 and involved 111 lane-miles of construction and 45 new and 10 rehabilitated bridges. ITS was used in the form of a mobile traffic monitoring and management system to help move the large number of vehicles through the extensive construction area. Mobile traffic monitoring and management systems use electronics and communications equipment to monitor traffic flow and provide delay and routing information to drivers and agency personnel.
The Big-I Project: Safety Challenges

The Big-I project was designed to address a severe safety challenge and capacity need. The work zone was going to remain in place for two-year and traffic through the work zone was of course a major-concern.

The high volume of traffic moving through the Big-I created great potential for congestion. NMSHTD estimated that normal traffic volume had to be reduced by at least 20% to keep traffic moving through the Big-I area. Incidents would create further congestion and require rapid response to avoid additional delays.

How could the work zone impact be minimized?

• NMSHTD decided to use ITS for the project, notably because of the challenges created by the implementation of:
  • Changes in traffic patterns
  • Night-time closures
  • Pre-determined alternate routes
• A system was needed that could provide accurate information, support quick identification of incidents, and help manage traffic through the area.

The Big-I Project: Performance Measures

Earlier on we listed some of the performance measures commonly used to track work zone performance. It is vital to tie challenges to goals and performance measures in order to be able to assess whether the project goals are being met. Performance measures should be considered early in the project, so that metrics can track project performance along the way and enable readjustments when necessary.

As it began to implement the Big-I work zone, the NMSHTD selected these performance measures for the project:

• Public perception
• Reduction in significant incidents
• Incident response and clearance times
• Reduced traffic volumes
Big-I Project Planning

A project like the reconstruction of the Big-I demands substantial planning. Part of the planning effort involved three important steps: stakeholders identification, traffic flow analysis, and identification of the ITS required to support the traditional approaches.

Big-I Project Planning-Stakeholders Identification

NMSHTD coordinated with numerous key stakeholders during the implementation of the Big-I work zone, including the following:

- Incident Management Teams
- Public Relations Office
- Media
- Local Agencies
- Police/Fire/Rescue
- Public Safety Office

In the past, the media and public relations departments were sometimes considered as marginal stakeholders in the planning and design of work zones. However, agencies can highly leverage these stakeholders as information disseminators, and these partners are now often considered as critical stakeholders.

As we will see later in the lesson, the stakeholders involved in the Big-I work zone formalized their roles and responsibilities using a concept of operations for the work zones and the ITS they deployed.
Big-I Project Planning-Traffic Flow Analysis

Prior to beginning the Big-I reconstruction project, NMSHTD analyzed traffic flow through the interchange and the impact that the construction activities would have on traffic.

Frequent changes in traffic patterns and nighttime closures were expected to have a profound impact on traffic. The high-volume of traffic traveling through the Big-I (which drove the need for the reconstruction) also created a great potential for congestion during these activities.

Analysis indicated that traffic through the actual interchange would need to be reduced 20% during the project in order to keep traffic moving. The capacity that remained available to serve traffic would need to be jealously guarded, with traffic incidents within the work zone threatening to create further congestion.

Big-I Project Planning-ITS and Traditional Approaches

NMHSTD determined that ITS would be required in addition to traditional approaches in order to meet these requirements. Pre-determined alternate routes would be needed to help reduce traffic flow during particular time periods and traveler information technologies held great potential to smooth traffic during these periods. The need for aggressive incident detection and management strategies was also evident based upon the results of this analysis of traffic flow and construction plans.

Whether in work zones or in other application areas, ITS applications do not usually stand alone nor completely replace traditional strategies. It is therefore important to identify those traditional approaches that must be incorporated and implemented before (or in parallel with) any ITS that may be integrated.
Big-I Project Planning-Identifying ITS Functions

The ITS functions identified to address the safety challenges presented by the Big-I work zone were the following:

- Enhance traveler safety
- Provide traffic management capabilities
- Provide routing, detours & incident information
- Minimize capacity restrictions due to incidents
- Identify & determine appropriate incident response quickly

In essence, the overarching ITS functions focused on enhancing safety and mobility in and around the work zone.

Big-I Work Zone: Institutional Considerations

NMSHTD had to address a number of institutional and operations and maintenance considerations for the work zone ITS:

- Operation and maintenance of ITS
- Crisis communication plan
- Information dissemination to agencies
- Information dissemination to travelers
- Incident management and police vehicles on contractor staging site
Concept of Operations

What is a Concept of Operations?
The Concept of Operations is a high-level description of the system to be implemented, the environment in which the system will operate, and the relationship between the system and the agencies. The Concept of Operations outlines the who, what, when, where, and why, for the new or existing system, and supports the determination of how the system will be developed and implemented.

Concept of Operations

The concept of operations for the Big I work zone ITS, pieces together the agencies and technologies to present concisely who does what in the project. Note that it does not fully describe how the actions are to be performed, but rather who performs them and how they interact with what systems.

Developing a Concept of Operations yields numerous benefits and helps:
• Achieve stakeholder consensus
• Reduce risk for the system
• Ensure that operations meet requirements

This document was helpful to the participants in the Big I project in facilitating stakeholder collaboration, ensuring a successful ITS deployment.
Big-I ITS Functions

The ITS functions identified for the Big-I work zone were met through the implementation of a temporary Traffic Management Center (TMC). This TMC provided the capability required to implement the necessary ITS technologies for:

- The Traveler Information component
- The Incident Detection component
- The Incident Response component

Big-I: Traffic Management Center (TMC)

Purpose of the Traffic Management Center

- A temporary TMC was deployed at the Big-I work zone to provide the traffic management capability required for the implementation and operation of the needed ITS applications.
- These applications targeted the work zone safety challenges identified prior to the project.
- For instance, if a traffic incident caused congestion, the TMC combined with the ITS applications to provide incident management capabilities that helped minimize the extent and duration of the congestion, and provide notification of alternate routing and travel route availability information needed.
Big-I: ITS Applications

The ITS deployed at the Big-I in 2000 was used for the duration of the work zone (two years). The ITS components were deployed just prior to construction, with plans to incorporate portions of the system as part of a permanent ITS application for freeway management once construction was completed. The three major components are:

- Traveler Information
- Incident Detection
- Incident Response

Big-I Work Zone: ITS Benefits

The benefits of using ITS in work zones are becoming increasingly documented and widely known. These benefits are mostly related to safety and mobility, but they also factor into the overall cost of a project. Fewer accidents, injuries and fatalities mean not only improved safety, but also significant savings to the state, locality and country. The safety benefits obtained through the application of ITS in the Big I work zone are listed below:

- Reduced crashes and secondary crashes
- Reduced incident management times
- Saved effort through automation
- Reduced traffic through work zone by 15%
- Identified and responded to areas that were difficult to navigate
- NO FATALITIES!
Big-I Work Zone-Data Collection

The data collected during the project showed that system functioned properly approximately 95 percent of the time. Operational issues were typically resolved within 48 hours of detection. Collected data also served for system evaluation, including the following criteria:

*Incident responses during construction*

The temporary TMC participated in about 500 incident responses per month during construction. Incidents in the construction zone ranged from stalled vehicles to multi-vehicle injury crashes.

*Incident response and clearance times*

Visual coverage of the construction zone traffic resulted in average response times of less than seven minutes with average clearance times of less than 25 minutes.

*Traffic volumes and speeds*

*Surveys of public perception*

NMSHTD evaluated the ITS system through surveys of public perception, and through the measurement of impacts on crash frequency and incident response and clearance times. Results are noted in the report.

Review Learning Outcomes

Now that you have completed Lesson 3 you should be able to:

- Identify and demonstrate how ITS can contribute to improved highway safety and traffic operations through a work zone
- Identify and discuss critical institutional, development and operational characteristics necessary for the successful application of ITS to improve highway safety.
Lesson 4

Countermeasures for Safety Priority Areas

In this lesson, we will review both traditional and ITS approaches used in developing countermeasures meant to mitigate safety challenges and, specifically, the safety priority areas discussed earlier in this course. Along with the discussion, we will examine these questions:

- What are some of the traditional approaches to safety?
- How does nominal safety differ from substantive safety?
- What are some examples of ITS countermeasures?
- What is the logical process for developing an ITS countermeasure?

Lesson 4 Learning Outcomes

After completing this lesson, you will be able to:

- Identify the status of highway safety and discuss the need to continuously improve highway safety
- Identify ITS supported countermeasures that can enhance traditional approaches to highway safety problems
- Design ITS supported countermeasures in response to a variety of highway safety challenges
Safety Performance Measurement

Safety performance measurement considerations are very important when deploying any type of safety mitigation strategy. They are especially vital when considering a hybrid approach because ITS can help contribute to enhancing as well as measuring performance.

The information collected by ITS is primarily meant to be disseminated quickly, but these data can also be put to many uses after they are archived, and can greatly assist safety professionals with understanding how the system has performed. Safety performance measures can be direct or indirect.

Direct Measures
- Crash Frequency
- Crash Severity
- Crash Rate
- Crash Type

Indirect Measures
- Incident Response Times
- Warning Information Effectiveness
- Traffic Conflicts
- Congestion
- Speed Management Effectiveness

Data Requirements

ITS can help collect many of the types of data required to measure performance toward alleviating problems caused by work zones. Some of these data requirements are listed below.

- Level of Service
- Crashes/mile and Hot Spots/mile
- Traffic volumes
- Speed over posted
- Speed variance
- Traffic headways
Traditional Approach to Safety

The traditional approaches listed in the graphic above may be working, but they are not sufficient to stern the swelling tide of vehicles on the roadway, driver distraction, and crashes, fatalities and injuries. Yet, tools and strategies exist to help us break the status quo and start working on the system-wide improvements.

Traditional approaches are an established process in which resolutions to traffic Level of Service and safety issues have been developed in the context of the state and region of interest. Many factors, such as pre-existing conditions, timing, sustained funding, local special interests, or what is politically feasible influence the project funding processes.

Applications in the Traditional Approach to Safety

Traditional approaches to improving safety focus on reducing the apparent challenges presented to the driver, such as tight curves, work zones, depressed highways, inadequate sight lines, degraded surface conditions, and spontaneous congestion.

Thus, traditional safety improvement applications tend to follow the general philosophy of “building better roads” and “increasing forgiveness of limited driving skills” mentioned earlier. The techniques listed below are commonly used by transportation professionals, following the lines of traditional safety:

- Straightening and widening
- Guarding and diverting
- Regulating
- Marking, signing and lighting
- Traffic controls

These traditional applications are proven approaches and transportations of professionals will keep on using them. Improvements on how they are developed and utilized are ongoing constantly, and use of technology can already increase their effectiveness.

Improvements in infrastructure do usually bring benefits. However, it can also be argued that improving infrastructure alone is, ultimately, a self-defeating approach; the more forgiving the driving conditions, the less is demanded of the driver’s attention and capabilities, with the risk of creating a negative feedback loop.
Highway Safety Status Quo

With nominal safety as the norm, 32,400 people are killed and two and a half million injured every year. Should we accept a constant number of fatalities, injuries and crashes on our roadways?

Of course not. To a certain degree, just realizing the crisis that these numbers represent contributes to changing them. We all have a role to play.

But to change the status quo, we have to advance past nominal safety. The point is not that things have been done wrong, but that they can be done better.

Status Quo: Nominal Highway Safety

In the past, traffic engineers operated on the principle that the more order and efficiency they brought to a transportation system, the safer that system became. Efficiency and safety were synonymous.

Over the years, this attitude has changed. Highway departments began and continue to set aside funds for specific safety projects and assign remaining funds to other categories - suggesting that safety is a goal by itself, but is not an integral part of everything they do.

Ezra Hauer, a noted researcher in highway safety, referred in 1999 to the use of standards in the context of delivering safety as nominal safety. Nominal safety can be defined as safety measured against compliance with standards, warrants, guidelines and sanctioned design procedures. In other words,

- Design must enable users to behave legally
- Design meets the minimum safety requirements

However, this is not always sufficient to guarantee safety. Nominal design can create situations that present difficulties to certain road users (e.g., senior citizens). For instances, speed limits may be set too high, or yellow intervals may be too short.
What Is Substantive Safety?

Hauer introduced a second dimension of safety described as *substantive safety*. Substantive safety represents a major transformation in the way of thinking about highway safety. In essence, substantive safety aims to go beyond nominal safety to achieve measurable improvement in safety performance.

**Substantive Safety**

- Measures roadway safety performance using crash data, including frequency and severity
- Employs available resources, including technology, design, maintenance, enforcement, and emergency services
- Provides meaningful quantitative safety measures to inform project decisions and thus improve understanding of tradeoffs involving other values such as environmental concerns, right-of-way, and stakeholder issues

Nominal vs Substantive Safety

- **Nominal Safety**: Examined in reference to compliance with standards, warrants, guidelines and sanctioned design procedures
- **Substantive Safety**: The expected or actual crash frequency and severity for a highway or roadway
How Did We Get To Substantive Safety?

The two-fold purpose of engineering standards must be understood in a contextual setting. Standards are used by engineers to design highways; but they are also used by others to judge the adequacy of highway design. The coexistence of these two goals gives rise to contrasting attitudes. On one hand, it is the obligation of the engineer to protect public safety within practical limits. On the other hand, that very same public complains and threatens litigation. These dualities of purpose and attitude are at the root of the problem.

Safety-conscious design requires that designers know the safety repercussions of their decisions. Engineering common sense recognizes that highways can be designed to be less or more safe. Policies and manuals might create an illusion when a highway is declared to be “safe” because it conforms to current standards, although crashes occur on it with statistical regularity.

Thus, the historical processes by which standards have evolved, and the persons who participated in the process, were subject to contradictory purposes and attitudes that are difficult to bridge. Hence nominative safety reflects a judgment made by many, on numerous occasions, that it is preferable and sufficient to speak about safety in qualitative terms.

How Does ITS Relate To Substantive Safety?

Transportation engineers design and create the roadways that provide mobility to the public. When crashes happen on those roadways, the driver is most often assigned the blame. One of the most significant threats to an effective safety management system, and to our profession’s successful involvement in the process, is the myth that driver error produces most accidents.
Moving Towards Substantive Safety

Progress towards substantive safety hinges on performing the actions listed below:

• Work to understand the context of hot spots.
• Develop proactive system-wide safety enhancements that help prevent crashes.
• Use data to help predict potential problems.
• Employ all available resources, including technology, design, maintenance, enforcement, and emergency services.

The question at hand is how to ensure these actions are performed. Many factors such as resources and budgets constraints make the move towards substantive safety challenging, but we can agree that it is a worthwhile goal.

ITS Approach to Safety

The DVH System

The development of ITS has led to the use of “systems engineering” processes in the design of ITS-enhanced transportation systems. Systems engineering focuses on the performance of the system and on how changes to one component can affect the performance of the whole. In highway safety, we consider the driver, vehicle, and highway as a system. It is that system we are concerned about.

ITS Approach to Safety

Part of the way in which ITS addresses a safety problem is by finding means of enhancing the driver, vehicle, highway, or the communication between them, resulting in safer performance of the DVH system. The ITS approach to safety is based on the following concepts:

• View Driver-Vehicle-Highway (DVH) as system
• Improve operations of DVH system
• Facilitate data collection and performance monitoring
• Use information collected to enhance understanding of safety approaches and the DVH system
ITS Safety Approaches

ITS can provide innovative infrastructure-based measures to enhance traditional safety approaches.

- Red Light Running Systems
- Automated Surveillance
- Curve Warning Systems
- Over-height Detection Systems
- Automated Traveler Information Systems

How ITS Supports Safety Countermeasures

Fusing ITS with traditional safety approaches yields increased functionality in several areas, as exemplified below:

- Enhanced safety – ITS assistance can focus on cooperation between vehicle and driver, highway and driver, highway and vehicle, and can be realized as a result of information flowing in either/both directions between the pairs; that is, information may start with the highway (congestion ahead) or with the vehicle (traveling too fast for the conditions).
- Facilitated data collection & performance measurement
- Enabled automated enforcement – ITS can help support enforcement by automating or assisting speed monitoring. Even in states where automated enforcement is not permitted on its own, ITS has been used by officers to help monitor and enforce traffic regulations (e.g., speed limits or lane restriction violations in work zones where traffic is monitored).
- Enabled real-time performance monitoring – For instance, in work zones where ITS is sometimes used to monitor traffic through the work zone.
Review Learning Outcomes

Now that you have completed Lesson 4 you should be able to:

• Discuss the current status of highway safety and its continued need for improvement
• Identify ITS supported countermeasures that can enhance traditional approaches to highway safety problems
• Design ITS supported countermeasures in response to a variety of highway safety challenges
**Lesson 5**

Safety Strategy Planning

This lesson describes the safety strategic planning process, outlines the basic requirements of the FHWA Rule/FTA Policy for ITS project implementation and identifies a system engineering approach for deploying ITS.

We will concentrate on key aspects of safety strategic planning and the ITS project deployment process. This will set the stage for you to identify how a collaborative planning effort could be enabled in your state or region.

In our discussion, we will attempt to answer the following questions:

- What is safety strategic planning?
- What is the ITS project deployment process?
- What can be done to advance the collaboration of safety and ITS?
- What role can you play in improving the status of safety?

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**Lesson 5 Introduction**

“In 2005, Congress passed legislation (Safe, Accountable, Flexible, Efficient Transportation Equity Act – A Legacy for Users [SAFETEA LU]) requiring States to develop SHSPs (Strategic Highway Safety Plans). By October 1, 2007, all States and the District of Columbia had complied with the requirement, and many have since updated the original SHSP at least once. All States are implementing SHSPs, and many are experiencing remarkable results in roadway safety.

The primary goal of an SHSP is to reduce fatalities and serious injuries on all public roads. The collaborative process of developing and implementing an SHSP brings together, and draws on, the strengths and resources of all safety partners. An SHSP should help safety partners better leverage limited resources and work together to achieve common safety goals.”


“Every SHSP update is an opportunity to revisit and strengthen the State’s safety priorities, performance measures, goals, objectives, and strategies.” [Anthony Furst, Associate Administrator for Safety, Federal Highway Administration, Foreword to “Strategic Highway Safety Plans: A Champion’s Guidebook to Saving Lives”, March 2013]
Lesson 5 Learning Outcomes

After completing this lesson, you will be able to:

• Describe the safety strategic planning process and its main elements
• Describe the three major phases of the ITS project deployment process
• Outline organization- and individual-level actions for future ITS and Safety collaboration at the planning level, and activities to enable these actions

Strategic Planning Overview-Definitions

What makes planning “strategic?” In transportation, we use the terms strategic and plan often. But, how often do we really consider what these terms imply? For our purposed, we defined strategic planning as follows:

A Strategic Plan (Strategic: important to an objective, Plan: method for achieving an end) clearly and concisely defines a framework for accomplishing goals and objectives resulting from a structured process (This relays a key concept throughout history: the planning process is the most useful aspect of planning).
Strategic Planning Overview-Key Aspects of Strategic Planning

The three statements below describe key aspects of safety strategic planning.

*Stakeholders responsible for meeting goals must be involved in the development process.*

- Those who work to the plan should be involved in its development. This greatly enhances the likelihood of meeting strategic goals and objectives.

*Accomplishing strategic goals and objectives will change the status quo.*

- “Changing the status quo” is the underlying reason for strategic planning. Strategic plans are not meant to express complete satisfaction with the way things are but, rather, to point to the changes that need to be carried out.

*This plan lays out actions and initiatives that enable the project goals.*

- While we acknowledge that everyone meets minimum design standards, the status quo can always be improved be it with new tools, advanced processes, or renewed visions and attitudes.

Safety Strategic Planning - 1

*A Strategic Highway Safety Plan (SHSP)* is a major component and requirement of the Highway Safety Improvement Program (HSIP) (23 U.S.C. §148). It is a statewide-coordinated safety plan that provides a comprehensive framework for reducing highway fatalities and serious injuries on all public roads. An SHSP identifies a State’s key safety needs and guides investment decisions towards strategies and countermeasure with the most potential to save lives and prevent injuries. SHSPs were first required under SAFETEA-LU, which established the HSIP as a core federal program. The Moving Ahead for Progress in the 21st Century Act (MAP-21) continues the HSIP as a core Federal-aid program and the requirement for States to develop, implement, evaluate and update an SHSP that identifies and analyzes highway safety problems and opportunities on all public roads.

Safety Strategic Planning - 2

An SHSP is developed by the State Department of Transportation in a cooperative process with Local, State, Federal, Tribal and private sector safety stakeholders. It is a data-driven, multi-year comprehensive plan that establishes statewide goals, objectives, and key emphasis areas and integrates the four E’s of highway safety – engineering, education, enforcement and emergency medical services (EMS). The SHSP allows highway safety programs and partners in the State to work together in an effort to align goals, leverage resources and collectively address the State’s safety challenges.

Reference: http://safety.fhwa.dot.gov/hsip/shsp/

Are you familiar with your State’s SHSP? Take the time now to download the plan for your State and familiarize yourself with some of the key elements of the plan.

Safety Strategic Planning Process

Based on nation-wide research on best practices of highway safety planning, an effective safety strategic planning process should incorporate the actions listed below:

- Survey Customers
- Engage safety advocates and stakeholders
- Identify high level strategic focus areas
- Set safety goals
- Set safety-specific strategic objectives
- Establish mitigation approaches
- Deploy pilot improvements
- Evaluate initiatives
- Expand, change, eliminate strategies
- Measure the effectiveness in reaching goals

Think about the places where ITS could contribute formally within a process like this—or perhaps, where ITS already does contribute in your state or regional Safety strategic planning process.
Essential Elements of a Safety Strategic Plan

The actions presented on the previous pages result in the following outcomes, which are essential elements of a safety strategic plan:

- Stakeholder participation and organizational support
- Data driven problem identification
- Comprehensive action plan
- Specific and measurable crash reduction goals
- Vision for a sustainable program (funding, roles, responsibilities, etc.)

Note that even if we identify all the safety challenges and an action plan and determine how we will measure progress towards our goals, organizational support and a vision for sustaining the effort are critical.

Benefits of a Strategic Highway Safety Plan

Some of the key benefits of developing and maintaining a Safety strategic plan are listed below.

- Establishes common statewide goals and priorities
- Strengthens existing partnerships
- Builds new safety coalitions
- Promotes data, knowledge, and resource sharing
- Avoids redundant activities and leverages existing resources, such as funding, personnel, and leadership
- Incorporates both behavioral and infrastructure strategies and countermeasures to more effectively reduce highway fatalities and serious injuries on all public roads.
The ITS Project Deployment Process

Let us now turn to the ITS project deployment process. ITS provides a set of tools that can help improve highway safety. On important notion, however, is that the processes used to deploy these tools must comply with Federal standards.

The ITS project process provides a structure that reduces the risk associated with projects involving many stakeholders and technology.

Some of the activities of the process can sound intimidating; we will see shortly that this, and other, activities are similar and consistent with the sound project deployment principles employed on all projects.

If you are a Safety professional you may not feel a need to understand the ITS project deployment process.

Yet this understanding is essential to foster an awareness of the sequence of actions to be completed. This said, ITS professionals in your agency are there to help execute the ITS deployment process.

ITS Project Deployment Process

The ITS project deployment process involves three major phases or steps. We will examine them in some detail in the following pages, starting with the development of a Regional ITS Architecture.

Develop a Regional ITS Architecture
• A Regional ITS Architecture is a framework that identifies stakeholders, their systems, communications between the systems, and the information shared between systems. One easy way to think of a Regional ITS Architecture is as a blueprint for a region to follow with regard to ITS.

Develop an ITS Strategic Plan
• An ITS Strategic Plan can help to specify how to realize the Regional ITS Architecture. You could think of the Regional ITS Architecture as a “realistic wish list”, unconstrained by the fiscal, resource and scheduling realities a Region may face. The ITS Strategic Plan lays out a framework for building the ITS Architecture considering these realities.

Execute a Systems Engineering Analysis
• This refers to a structured process that helps ensure that systems being developed meet stakeholder expectations. Every ITS project that may result from the architecture and strategic plan must undergo a systems engineering analysis if the project is deployed with Federal funds.
Regional ITS Architecture

This diagram illustrates part of a regional ITS architecture. It represents the framework that identifies stakeholders, their systems, communications between the systems, and the information shared between systems.

In politics there is a famous expression that says “just follow the money.” Well, to an extent, ITS architecture is all about following the information. A regional ITS architecture should be developed for all projects, including small ones. For instance, an automated system for one rural intersection would benefit from it, although that architecture might actually be very simple.

What is a Regional ITS Architecture?

Just as a Safety strategic plan helps enable organizational support, a Regional ITS Architecture does the same by providing a common framework for the region or state. It is a “living” document that constantly reflects, at a minimum, the Region’s existing and planned ITS and the information flowing to and from stakeholders and systems. A Regional ITS Architecture will typically articulate what a region wants.

Safety stakeholders can be involved in Regional ITS Architecture development. Even when they are not formally brought to the table during architecture development, their projects and input can be identified and integrated during architecture maintenance iterations.

A plan or blueprint for a region’s systems
A resource that helps develop integrated systems
Benefits of Architecture Development

Here are some of the key benefits of developing and maintaining an ITS architecture:

- Address local needs
- Obtain buy in from stakeholders
- Provide for orderly and efficient deployments over time
- Lower risk in deploying ITS
- Identify coordination of ITS services in region
- Facilitate future ITS expansion and integration

It is critical that ITS are integrated with other existing or planned services and systems. Road users expect consistency in quality of information, system integrity, and overall operation of ITS. Developing and working towards a Regional ITS Architecture helps meet these expectations.

Develop an ITS Strategic Plan

Let's now examine the second element of the ITS deployment process - the ITS strategic plan. While an ITS Strategic Plan is not a Federal requirement when deploying ITS, it can help specify the manner in which the Regional ITS Architecture is realized.

One helpful analogy is to imagine the Regional ITS Architecture as a “realistic wish list” or a description of what the Region wants to when it grows up. It is unconstrained by the fiscal, resource and scheduling realities a region may face. The ITS Strategic Plan lays out a framework for building the ITS Architecture given these realities.
Characteristics of an ITS Strategic Plan

An ITS Strategic Plan:

• Focuses on ITS projects
• Considers project resources, phasing
  • and funding sources
• Examines project costs, benefits and performance measures
• Changes rapidly

These aspects build on the blueprint identified in the Regional ITS Architecture.

Benefits of the ITS Strategic Plan

While the ITS architecture is somewhat conceptual in nature, a strategic plan can begin to identify specific projects that fit within the architecture and are in sync with agency goals. The benefits of ITS strategic plans are listed below.
System Engineering Analysis

Execute a Systems Engineering Analysis
The main objectives of the discussion so far were the following:

– Introduce Safety professionals to the activities undertaken when using technology to enhance transportation.
– Providing a common understanding of the manner in which the deployment processes are followed.

You will notice that we went from the most unconstrained level of ITS planning (the architecture) to a more focused identification of how and when to build the architecture.

Where do you think system’s engineering fits in this scheme?

– That’s right-at the project level. Every ITS project that results from the architecture and strategic plan must undergo a systems engineering analysis. As we will see over the next few pages-this is a good thing.

What is Systems Engineering?

Systems engineering uses managerial and technical tools to analyze problems and provide structure to the overall process of planning, procuring, designing, implementing and testing a system. Thus, it is a structured process that helps ensure that systems being developed meet stakeholder expectations.

A system engineering analysis is required when deploying ITS with federal funds. This is in accordance with the Final Rule on Architecture and Standards Conformity (23 CFR 940), issued on January 8, 2001 to ensure that projects are developed according to pre-defined criteria and comply with the National ITS Architecture and applicable ITS standards.

The Final Rule emphasizes two aspects of ITS project deployment discussed in this lesson:

– The development of a regional ITS architecture for implementation of any new ITS project or program (this regional architecture should be “guided” by the National ITS Architecture)
– The obligation to use a systems engineering process for ITS project development
System Engineering Process for ITS Projects

ITS projects that are ready to be deployed must undergo a Systems Engineering Analysis.

The Systems Engineering analysis process that has been adopted by the FHWA is called the Systems Engineering “V” model or, simply, the “V” model. The diagram at your right presents the components of the “V” model.

Project Development Comparison

Now that we have looked at the systems engineering process, let’s see how it relates to the process that is used to “deploy” roadway projects.

The graphic on the next screen compares the components of the system’s engineering analysis with those of the more typical capital project development process.

This graphic is meant to give some perspective on the phasing required for implementation of an ITS project.
System Engineering Process for ITS Projects

ITS projects that are ready to be deployed must undergo a Systems Engineering Analysis.

The Systems Engineering analysis process that has been adopted by the FHWA is called the Systems Engineering “V” model or, simply, the “V” model. The diagram at your right presents the components of the “V” model.

Project Development Comparison

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Benefits of Systems Engineering Process

Listed below are some of the key benefits of following the systems engineering process. This process helps:

• **Control costs and schedule** - The project has a better chance of getting completed on time and within budget.
• **Satisfy stakeholder expectations and users’ needs** - The project does what it is supposed to do.
• **Improve system reliability and stability** - The products of the project are more reliable and stable.
• **Reduce risk** - All together, these benefits combine to reduce the risks associated with deploying a project with technology components.

Collaboration and Coordination

Collaboration and coordination with agency partners will help:

• **Improve decision making** effectively coordinating and communicating across ITS and Safety professions.
• **Foster proactive, rather than reactive attitude**
• **Create a broader safety networking resource**
  
  The results? Safer roads for everyone.

Collaboration is the most effective way to maximize resources and benefit from each other’s experiences. Throughout this course we have emphasized the need to understand how you can benefit from your professional partners from other agencies so that when you begin to plan you think of the resources that are available to you both inside and outside you on divisions, departments, and agencies. The key to improving highway safety is recognizing that there are numerous stakeholders and that each can play a significant role if given the opportunity.
How Does the Collaboration between Safety and ITS Help?

In Lesson 4 we examined some of logical and practical actions that can take us closer to enhancing safety using ITS approaches. Collaboration between the Safety and ITS areas can bring about substantive safety on the highway in several ways, such as:

- Identifying ITS for highway safety challenges & data collection needs
- Focusing the deployment of ITS to improve system-wide highway safety (beyond the hot spots)
- Developing new ITS applications for regional & statewide safety challenges

This course and the actions laid out in it are actually a first step towards substantive safety – i.e., recognizing ways to go beyond the status quo by applying ITS capabilities to traditional safety approaches to improve safety along our highways.

Review Learning Outcomes

Now that you have completed Lesson 5 you should be able to:

- Describe the safety strategic planning process and its main elements
- Describe the three major phases of the ITS project deployment process
- Outline organization-and individual-level actions for future ITS and Safety collaboration at the planning level, and activities to enable these actions.