Utah Department of Transportation
Traffic Operation Center
Operator Training

Peter T. Martin , Ph.D., PE (UK)
Professor

Jeremy Gilbert
Graduate Research Assistant

Benjamin Shepherd
Graduate Research Assistant

University of Utah Traffic Lab

November 2010

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

This paper is a summary of work performed by the Utah Traffic Lab (UTL) to develop training programs for the Utah Department of Transportation (UDOT) Traffic Operations Center (TOC) operators at both the basic and advanced levels. The basic training is designed to train operators in the basic knowledge, skills, and ability to work as traffic operators. The training is performed at the UTL and the TOC in a concise two-week training course instead of the traditional on-the-job training method. In order to conduct the training, the UTL began with the UDOT TOC mission statement and applied a military approach to develop individual training tasks required of operators. Although training operators off site is not a new technique, the UTL used the unique approach of focusing training on the regional transportation network and branching off into other relevant topics when appropriate. The UTL found that understanding the local and regional transportation network was the single most important factor in efficient incident management. The advanced training program is designed to develop the knowledge, skills, and ability of traffic operators to identify and solve advanced traffic management and operation problems encountered at the TOC. It supports incident management instruction at the highest level and utilizes the advantages of traffic operators who work 24/7 and continually monitor the traffic network through closed circuit television. The report explains who is qualified to receive the advanced training program. The specific curriculum containing courses on advanced traffic operation techniques, geometric design, and traffic flow is presented. The method to measure performance through assessment and evaluation for the advanced training program is also presented. The advanced training program is an effective method to train operators to identify and solve advanced transportation management and operation problems. We present a critical overview of our training methods.

INTRODUCTION

The management of roadways in the United States has been discussed since the development of the interstate highway system in the 1940s. However, it is only in the past 20-30 years that dedicated traffic operation centers (TOC) have been built for the purpose of monitoring freeways and implementing intelligent transportation systems (ITS) to help freeways operate more efficiently. As these centers are built, staffing them with competent operators is essential. Since TOCs are often focused on the development and implementation of new technologies, the importance of training and evaluating operators can sometimes be overlooked (1).

This report focuses on the training and evaluation of new operators and training advanced techniques to good operators. The report is divided into two separate parts: Part One details the basic training program and Part Two details the advanced training program. Each part provides a detailed background of training practices at each level, a problem statement, and basic/advanced training modules for UDOT TOC traffic operators. The report also provides results and conclusions for the two parts and recommendations for continuation of training.

PART 1: BASIC TRAINING

Section 1 explains what is currently being done to train new employees, then shows what is missing in this training and presents a problem statement to solve the deficiencies. The section also contains the method that was approached in this specific training module, military and network focused.

2.1 Background

The Federal Highway Administration (FHWA) stresses the importance of traffic operator skills. According to their *Freeway Management Handbook* (1), “The degree to which a traffic control center meets the objectives of the freeway management system depends on how well the human operators are able to interface with the system devices.” This handbook was one of the first manuals to formalize aspects of TOC development. Since its publication, both the FHWA and the Research and Innovative Technology Administration (RITA) of the U.S. Department of Transportation have published several reports documenting the emergence of TOCs nationwide, as well as the training practices for operators.

The first FHWA publication to cover TOCs was the *Comparable Systems Analysis: Design and Operation of Advanced Control Centers* (2). It summarized lessons learned from visits to 18 traffic management centers nationwide. One focus of the report was the human resource management of traffic management centers, particularly from a training standpoint. One section of the report covers staffing, selection, and training of operators. The FHWA notes that, as was the case with UDOT, initial operator training is usually an “on-the-job” activity. The FHWA also defines the required operator skill set as “good verbal skills, a degree of computer literacy, and good reasoning skills according to the practices of several centers here and abroad.” As vague as this description is, none of the reviewed literature provides a more detailed required skill set. It is interesting to note that even in an age of unprecedented technological developments; the focus must remain on these basic functions.

This role of the individual traffic operator was further discussed by the FHWA (3), focusing on user-centered design. Traditionally, TOCs have not utilized a user-centered design concept because they have been more focused on the ITS devices the operators control. This trend of neglecting the human side of the TOC appears to be a weak point in current TOC operator training research.

Traffic operators must be trained to complete many tasks. The list of tasks they must perform is exhaustive and has been thoroughly researched, but the qualifications for the traffic operator job are weakly defined. *Design of an ITS-Level Advanced Traffic Management System: A Human Factors Perspective* (4) provides great detail in describing the operator job, specifically investigating the task list with which operators should be familiar. The report divided the job into six task types: communicating, coordinating, decision making, information processing, observation, and outcomes. For each of these task types, the FHWA developed required and related tasks that an operator should be able to perform. In total, the report listed 363 required tasks and 463 related tasks. A more recent source of operator tasks is available through the Traffic Management Center Pooled-Fund Study (TMCPFS)(5). This report created a task list by beginning with 16 essential functions, dividing the functions into composite tasks, and then dividing the composite tasks into discrete tasks. To support the 16 functions, operators must execute 1,050 total discrete tasks (TMCPFS Appendix B)(5).

Recent research has focused on simulation evaluation of operators. Simulation exercises are essential in quantifying operators’ abilities because they assess the operator under simulated real-world conditions. Gerfen (6) documents how the California Department of Transportation (Caltrans), the University of California-Irvine, and the California Polytechnic State University collaborated to create a training simulator for Caltrans’ traffic operator trainees using micro-simulation techniques.

2.2 Problem Statement

After reviewing relevant literature, the UTL identified two key areas that could be improved with the development of an operator training program. The first is the development of operator critical tasks. There is a discrepancy between job qualifications and expected abilities. Job qualifications, as defined by the FHWA, are simply to communicate well and understand relevant systems. However, having these qualifications does not necessarily ensure that the operator will be able to perform the many tasks expected of them as defined by the FHWA and the TMCPFS. The first area of improvement is to determine a finite list of operator tasks relevant to the UDOT TOC that could realistically be taught in a two-week operator course. The second area of improvement is the method of training. From communication skills to camera operation to the posting of CMS messages, traffic operator skills are wide-ranging, and a "best method" of capturing these skills in a confined period of time is required. This paper presents a new approach to operator training, developed with a military approach and an emphasis on understanding the transportation network.

2.2.1 Utah DOT Operator Training – a Historical Perspective

The UDOT TOC has not outsourced training of traffic operators. Instead, it relies on training operators "on the job." This entails shadowing a seasoned operator who is performing daily tasks. After an undetermined period of time, it was assumed that the new employee was proficient. Unfortunately, this on-the-job-training (OJT) method resulted in inconsistent competence of newly hired operators. It also degraded the TOC's ability to manage the transportation network as seasoned operators had to be removed from the control room to train the new hire.

The essential problems with UDOT TOC operator training were that it was neither structured nor evaluated. A structured training program is important to ensure all topics are covered. Items taught during OJT are often seen once and then forgotten. Many items are not covered because they do not occur during the days on which the training occurs. For example, there are many seasonal tasks and responsibilities utilized by operators. A trainee who is hired in the summer may work for six months or more before managing traffic in a severe winter storm. When this storm occurs, the operator, now with six months of experience, should be a seasoned veteran. However, if it is his or her first experience with winter weather, the operator may be confused and be ineffective. Under the current model of OJT, there is no checklist of items for new hires to be trained.

The second problem with OJT is that it has not been quantified by evaluation prior to beginning work. There was a gradual level of increased responsibility as the new operator was allowed to operate independently, but there was no evaluation of abilities at the conclusion of training. Such evaluations are critical to provide a "check on learning" that ensures all topics have been trained to an expected standard.

2.3 Basic Training Module

This basic training module is based on a new approach to operator training, developed with a military approach and an emphasis on understanding the transportation network. The training module is presented and supported in this section with figures and tables but the complete structured basic training module is located in the appendix.

2.3.1 Integrating a Military Approach to Training

Since the development of operator tasks are poorly defined in current transportation literature, we researched other organizations that may have more of a focus on training in their day-to-day operations. The US Army is a highly-structured and well-trained organization. All procedures and events in the Army are directed, evaluated, and documented by an Army Regulation (AR) or Field Manual (FM). Also, because one of the most important tasks of the Army is to recruit and train new individuals to fill positions within the ranks, training of new employees has been refined to a very high level. This paper shows how a similar approach can be applied to operator training at traffic management centers. The cornerstone of the Army's training program is FM 7-0 *Training the Force* (7). It defines how a given unit develops training tasks to meet organizational goals. It was decided to apply principles presented in FM 7-0 to the UDOT TOC, using the existing UDOT TOC mission statement to develop operator training tasks.

The Mission Essential Task List (METL)

An underlying premise of Army training is that every unit at every level has a mission statement. The mission statement captures what the unit must accomplish in order to be successful and is the starting point for all training. The difficult part is often determining from the unit's mission statement what training events should occur to keep the unit proficient. METL development is the vehicle that facilitates this training development. The METL is exactly what it sounds like – a list of tasks that are essential to the unit accomplishing its mission. Developing this METL is described in FM 7.0 as follows:

> "The METL development process reduces the number of tasks the organization must train and focuses the organization's training efforts on the most important collective training tasks required to accomplish the mission. (It) is the catalyst that keeps Army training focused on wartime operational missions" (FM 7.0 Section 3.3-3.4, p. 3-2).

This concept is well-suited to TOC operator training because state DOT's usually have a defined mission statement, but lack the structure or training program to support it. Although the DOTs do not have a "wartime operational mission" as described in FM 7-0, some of the 1,000+ operator tasks are more important than others. By using the METL development process outlined in FM 7-0, the authors were able to identify operator tasks that are necessary to allow the UDOT TOC to achieve its mission.

Developing the UDOT TOC Mission Essential Task List

The mission of the UDOT TOC is five-fold. It has been virtually unchanged since the inception of the TOC in 1995 with the Department of Public Safety (DPS). It is as follows:

1. *We support UDOT and DPS activities to improve highway safety.*
2. *We operate the highway system to provide reliable and efficient travel time.*
3. *We provide accurate, timely, and useful real-time traffic information.*
4. *We work together with other government agencies to serve the public*
5. *We provide excellent customer service.*

This mission statement is complete and directive in nature. This is important because it reinforces the most important aspects of the job on a daily basis. Missing is the derivation of training tasks from the mission statement. Implementing each of the statements above is only possible if individuals are proficient at tasks that enable the statement. Beginning with the mission statement, we developed key operator tasks for each tenant of the statement.

They are listed in Table 2.1 with the statement they support. This mission essential task list is more detailed than a generalized job description, but it is not overwhelmingly long. There are 22 tasks of various difficulties. While each task has to be taught using different techniques, simplifying the job into these tasks enabled building the two-week course from a list that is quantifiable but not unmanageable.

The objective of this project is to develop a logical training program that teaches all concepts in the most efficient manner possible. We determined from observation and initial pilot training courses, that the most critical component of an operator's knowledge is an understanding of the local transportation network. The entire training course was built around this concept.

Table 2.1 Operator Mission-Essential Task Force

1. We support UDOT and DPS activities to improve highway safety
Communicate effectively with the UDOT complex (headquarters) and DPS operators and dispatchers
Understand the DPS' computer automated dispatch (CAD) system; utilize it to pull real-time incident data
Understand internal processes (work orders, maintenance requests) between the TOC and other UDOT divisions
Understand and have access to current highway safety statistics, trends, and publications
2. We operate the highway system to provide reliable and efficient travel time
Understand the regional and local freeway system, surface streets, and geography
Understand the interstate highway system (numbering, signing, and impact on the local network)
Recognize local transportation trends and traffic patterns to enable more informed decision-making
3. We provide accurate, timely, and useful real-time traffic information
Operate the Commuterlink website
Operate closed-circuit television (CCTV) cameras throughout the network to enable incident detection
Operate variable message signs (VMS) throughout the network to communicate real-time with travelers
Operate the incident management system (IMS) to manage incidents and populate the Commuterlink website
Operate the 511 Traveler Information System Hotline
Operate Highway Advisory Radio (HAR
Monitor scanners and commonly-used radio frequencies to enable incident detection at earliest possible state
Operate the remote weather information system (RWIS)
Operate the traveler advisory telephone system (TATS)
Send text updates (J-Page) on incidents to appropriate UDOT personnel
4. We work together with other government agencies to serve the public
Understand emergency procedures, such as disaster evacuations or AMBER alert, and respond appropriately
5. We provide excellent customer service
Maintain appropriate dress, appearance and behavior at all times
Operate phone system with proper courtesies and competencies
Handle walk-in customers and group tours appropriately
Communicate with media members appropriately

2.3.2 Developing a Network-Centered Training Course

While the average traffic operator does not have to be a transportation engineer, they must have an understanding of the transportation network. The term "transportation network" defines the freeway and surface street network, as well as the travel trends, regional socio-economic factors, and geographic or topographic factors that can influence travel patterns. Understanding this transportation network is vital to the becoming a functional operator. Unfortunately, novice traffic operators often do not realize this when beginning work at the UDOT TOC.

Most casual observers assume the job of the traffic operator is to scan closed circuit televisions (CCTV) cameras and post variable message sign (VMS) messages. This is commonly accepted because these two devices are the most visible signs of a traffic management system. However, being able to operate these devices is useless if the operator does not understand the transportation network. Operators need to understand what they are looking at with the camera or who they are reaching with a VMS message, by doing this they use the capabilities of the devices efficiently. Since the job description is particularly vague, a new employee may often expect to learn how to operate cameras and signs, and little else. This expectation leads to a poorly trained operator. It is imperative, therefore, to dispel this misleading expectation early in the course.

The Basics: Local Transportation Network, Regional Geography, and Travel Trends

The software that operates advanced traffic management system (ATMS) devices comes with an attached operations manual to easily teach the correct usage of it. In contrast, there is no user manual to teach operators to understanding the transportation network. The training can be difficult because there are many challenges to teaching the transportation network. There is no checklist of items the trainee should understand. Further, all individuals are different and diverse training methods are needed. For example, an individual may simply be unable to think in terms of the larger transportation network. From a transportation engineer's standpoint, this is often difficult to imagine. Engineers are taught to consider the benefit of the system above the benefit to any one user. However, most commuters are not aware of the efficient operation of the system; they are concerned with the ease of *their own* commute and the length of *their delay* at a given intersection. Operator trainees have to essentially be "broken" of this thought process, and taught to see the system in all its complexity.

This inherent self-centered nature of commuters became evident after several training sessions with new operators. Operators were usually very familiar with the routes they routinely drive, and many had even noticed the locations of ATMS devices near their homes or workplaces. However, they often failed to realize how their local area fits into the larger regional network. As a result of operators not understating the larger network, the basic training module starts by teaching operators the transportation network from a larger overview and working to a smaller, localized understanding. This "larger to smaller" approach was applied to each major area taught: roadway design and characteristics, regional geography, and travel trends.

Roadway Design and Characteristics

To start with the big picture of the road network, the initial classification taught is the Interstate Highway System. Many people have driven on Interstate highways for years, but do not understand how the numbering system is organized, how mile posts are counted, or how bypass routes are designated. For many people, "interstate," "freeway," and "highway" are all synonymous. We teach how the local portion of the Interstate system is part of a much larger system that has national implications for both freight movement and passenger travel. Most individuals who travel on a particular freeway segment every day recognize it as the "road they take to work." Few also realize the vital role it may play in moving the nation's freight, or in connecting the east and west coasts. For example, in Utah, operators have to understand that if I-80 is closed through Parley's Canyon (the local pass through the Wasatch Mountains) it not only affects tourists visiting Park City, Utah, but also the nation's economy.

After gaining an understanding of the nation's highway system, operators are trained on the next "smaller" classifications, beginning with non-Interstate freeways and continuing to important U.S. and state highways, followed by principle arterials in the urbanized areas, and finishing with local roads. They are taught to recognize key parts of the highway infrastructure, particularly dangerous intersections, and basic principles of traffic flow and signal timing. Again, they do not need to be traffic engineers, but they should be able to communicate with professionals in engineering language. Figure 2.1 is from the basic training module in the road and traffic basics course. The figure is a summary of the road classification terms taught to the new employee.

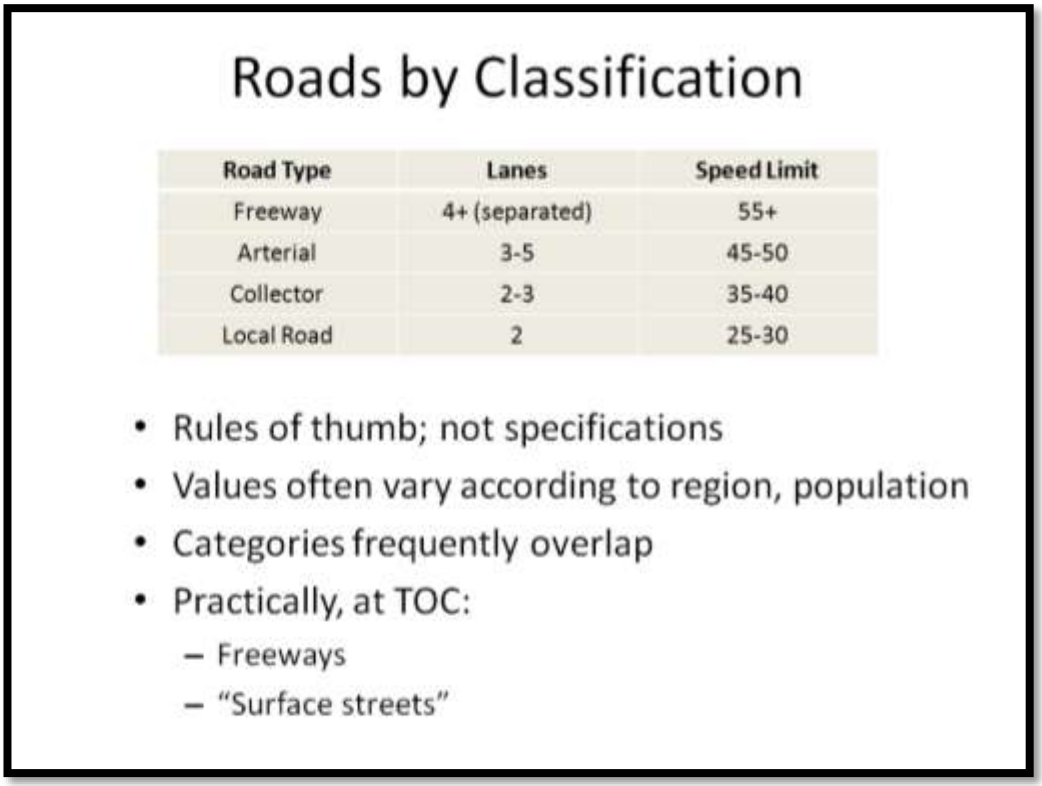


Figure 2.1 Roads by Classification

A unique technique to help trainees learn the transportation network was developed. On the first day of training, after a brief introduction, the trainee is instructed to sketch a map of the local system of roads. Trainers deliberately give limited guidance to encourage trainees to think for themselves. After the trainee draws the first map, which usually includes little more than I-15 and local roads near the trainee's home, the instructor draws a "better" map of the local network as an example. The better map is drawn in a specific method that helps the trainee learn more quickly. This specific method is to start with the big picture and work to the small – beginning with interstate highways, interstate bypasses, local freeways, and then principal arterials. The trainee is then asked to draw the local map again trying the new method.

Drawing the local map is repeated several times daily at the outset of training sessions. Figure 2.2 is an example of a completed local map compared with an actual Google image of the same area. After a few days, the operators are fairly comfortable with the local network. The instructors then introduce regional and state-wide maps, drawn the same way. The maps are to be drawn with as much detail as possible, as is appropriate to the scale of the map. On the state map, the trainee is required to include all freeways, as well as alternate routes, between major cities or through areas that may be impassible in winter conditions. On the regional map, the trainee is required to include regional cities, with all freeways and principal arterials that service each of the cities. On the local map, the trainee should include great detail in the metropolitan area, arterial streets, and mileposts along freeways. With constructive criticism throughout the week, each sketch becomes more and more complete until ultimately, the operator can draw each map as well as the instructor.

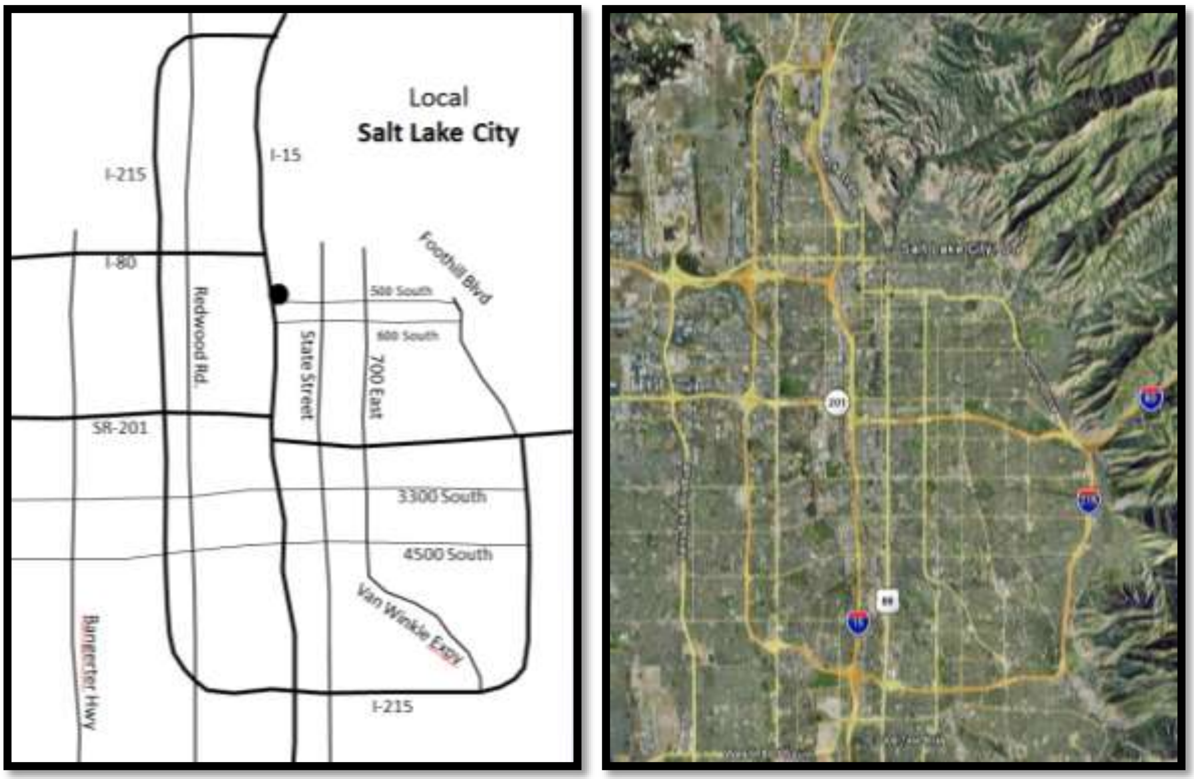


Figure 2.2 Local Map

The reason for creating these map sketches is that if trainees can draw a map of the area from memory, then they will also be able to consult that map in their head when they hear an incident location called out by a dispatcher. They should be able to place the incident on the map in their heads and immediately recognize what may be happening around the incident and what else it may affect. This proved to be the most effective technique of the entire course. Once the trainee had the map of the region visualized, it was easy to overlay cameras, signs, and other ATMS field devices onto the "mind map."

Regional Geography – Key to Incident Management

The UDOT TOC Mission Essential Task List can be summarized to state that traffic operators must provide efficient incident management. If a state TOC had a "wartime operational mission," as described in FM 7-0, it would be incident management. The most important operator skill, and the most difficult for the vast majority of operators, is locating and verifying incidents. TOCs are often the "eye in the sky" for incident management. Although operators are not first responders, CCTV camera access allows them to help the emergency service personnel. They can identify critical details about the incident and relay this information to the first responders. With a photographic mind map operators can quickly identify an incident's location and impact on traffic. Once they have digested this information, which takes a seasoned operator only a few seconds, they can begin the process of finding the incident on camera to verify critical information. This requires two skills that are often very difficult for operators to master – selecting the correct camera and locating the incident on that camera. Both of these skills rely on a traffic operator's detailed understanding of the geography of the area.

With a good mind map, the ease of selecting the correct camera is largely dependent on the software application that controls the cameras. Cameras that are named and listed logically will be helpful to the operator. Mileposts are the most common method of labeling the cameras TOC's have focused on freeways. However, mileposts are often unfamiliar to operator trainees who have grown up in Utah and understand the local grid system and crossing street names on freeways. Further complicating matters for operators is the fact that many arterials use a common name different than their grid number. For example, State Street in Salt Lake City, the largest arterial in Salt Lake County, is 100 East on the grid. Operators have to be aware of this, because if they are looking for an incident located on I-80 at 200 East, they should consider a State Street camera. If they are unaware that State Street is 100 East, they will waste valuable seconds searching for a camera on 200 East that may not exist. Another principal arterial in Salt Lake County is Bangerter Highway, which is one of the few roads in the valley that runs both south-north and west-east. In the northwest part of the county, Bangerter Highway is approximately 4000 West on the grid. It travels south out of the populated area and turns east at approximately 14000 South. Many operators who live in the southern portion of the county think Bangerter Highway is just a west-east running road at 14000 South, while many people from Salt Lake City think it is just a south-north running road at 4000 West. When traffic operators hear an incident on dispatch for Bangerter Highway, they have to be able to use the milepost or cross street provided to determine what effect the incident may have on the network and select an appropriate camera.

Understanding the area's geography and transportation network becomes even more important to the traffic operator once they have selected the appropriate camera. The operator will usually have to maneuver the selected camera, and often numerous cameras must be selected. This requires that the operator determine where the camera that they are viewing is located, where the incident is located in relation to the camera, and the direction in which the camera is looking. Adding to the difficulty is that many initial reports are unrefined and do not give an accurate incident location. For example, when a driver calls 911 to report a crash on the freeway, the DPS dispatcher will initially ask them their location. They will often look to the next guide sign to determine where they are. This is the location the dispatcher will enter into the computer automated dispatch (CAD) for the incident location. However, the driver can sometimes be a mile or more down the road before he gets through to a dispatcher and gives his report. In this case, the location he is giving is not an accurate location for the incident itself.

The knowledge, skills, and ability of operators all determine how effective they are at identifying incident locations through CCTV. By knowing which direction the traffic is headed, as well as the geographic and network conditions, an experienced operator can anticipate some of these problems, which will enable them to select the correct camera quickly. Although this is a skill that often takes operators months to master, teaching some universal methods for recognizing location and direction were very helpful in developing this skill quickly in new operators. One of the best ways to orient a perspective operator is by using topographical features, which are readily available in the Salt Lake Valley. The metropolitan area is bordered by the Wasatch Mountains in the east and the Great Salt Lake in the west. If an operator selects a camera but doesn't initially recognize the image, they can scan up to the horizon to look for mountains, or if mountains are on the left or right of the image they are seeing. If the mountains are in the background of an image, the operator is facing east. Along the Wasatch Front, this is the most universal method of recognizing direction. Buildings or local landmarks can be used similarly to orient a view, although they will not be as applicable in every region as the mountains. Along portions of the I-215 West loop in Salt Lake City, the freeway serves as a dividing line between residential and industrial areas. If an operator selects a view of I-215 West at 700 North, they can immediately determine that the houses are on the right of the freeway and the warehouses and trucks are on the left. With an understanding of the local geography and economic demographics, they should quickly identify that the camera is facing north.

Another method is using shadows. Most people understand that the sun rises in the east and sets in the west, but not nearly as many think to use this information to understand a given video image. This is particularly helpful during the busiest times of the day, the morning and evening commutes, when shadows will fall in opposite directions. Also helpful is the fact that operators usually work the same shift (either morning or evening), so the shadows are consistent when they are working. For example, if an evening operator looks at an image of I-15 and sees the shadows of a semi-truck falling to its right, the truck has to be northbound because the sun (and west direction) is to its left. The operator can then decide, based on the incident location, if they need to pan the image to the opposite direction or select another camera to verify the incident they are looking for.

A third method of orienting to a given camera view is by observing the traffic on the road. This is helpful on many routes in Salt Lake County because commuter traffic is heavy along I-15 and truck traffic is heavy along I-80. Most operators are less familiar with the camera images in Davis and Utah counties and sometimes have difficulties identifying the image they are seeing. During the normal commuter periods on I-15, operators can zoom out as far as possible and observe the overall volume in each direction. If an operator is viewing a Utah County camera at 7:00 A.M. and the heaviest traffic is coming toward them, they must be looking south because the commuter traffic is headed toward Salt Lake City. Similar techniques can be used with cameras along I-80 east of Salt Lake City. Through Parley's Canyon, I-80 climbs from 4500 to 7000 feet in about 15 miles; many stretches have 7% or 8% grades. This region is mountainous and the shadow method is often unusable. Also, I-80 is less affected by traveler trends. As a result, the commuter traffic trends method cannot be used. However, operators can still observe the traffic and use the speed of truck traffic to determine direction. In one direction, the trucks will usually travel at 25-35 miles per hour with other cars passing in the left lane, while in the other direction, both trucks and passenger vehicles will be traveling at comparable speeds. The slow trucks are always heading east up the mountain.

Figure 2.3 is an image taken from a CCTV at 2:46 P.M. It displays the three methods that can be used in determining orientation of the camera. The first method of locating the Wasatch Mountains can be used in this image. The Wasatch Mountains can easily be located in the background of the image and the operator can conclude that the yellow truck is headed southbound because the Wasatch Mountains will be on the east of I-15. Method 2 uses the position of the sun. In this image the sun is in the west. The yellow truck has no shadow on its left side so it can be concluded that the sun is located there and the truck is in the southbound lane on I-15. The final method of looking at the commuter trends and density is not easily determined from this image. But it does appear that the traffic is denser in the same lanes as the yellow truck. It can be concluded that because it is the afternoon at 5300 S on I-15 that the denser direction is southbound and the truck is heading in that direction.

Figure 2.3 Image from CCTV to Determine Camera Orientation

Travel Trends

Traffic operators must be taught a basic understanding of local travel trends. This can be helpful for identifying location and image, but it is equally important to understand the impact of an incident on the network. Operators should understand why a similar crash in the same location will have different impacts at 7:00 A.M. than it will at 5:30 P.M. They also have to understand where important facilities and businesses are located, as well as special events hosting sites. In Salt Lake City, the airport, the headquarters of the Church of Jesus Christ of Latter Day Saints, the Utah State Capitol Building, and the University of Utah are all population and economic centers in the city. As a result of Utah being very rich in natural resources, there are three oil refineries, numerous rock quarries, and the Bingham Canyon Mine, the largest open-pit mine in the world. There are also many regional distribution centers in the western portion of the valley that lead to Salt Lake City being called the "crossroads of the West." Traffic operators have to know the locations and general operations of these facilities to determine what type of traffic is projected onto the network. Although they do not need to capture the detail that an urban planner would, the operators should understand how the socio-economic characteristics of the region affect the local traffic.

The Rest: Software Programs, Policies, and Procedures

After an in-depth understanding of the network is achieved, the trainee still needs to learn various day-to-day operations and programs used by operators. The UDOT TOC uses the TransSuite software package to operate all ATMS devices and conduct incident management. These programs, as well as UDOT internal policies and procedures, comprise the remainder of the operator course. The unique technique of teaching the road network as the first subject to operators helps them to learn the location and capabilities of ATMS field devices.

The TransSuite package consists of four applications commonly used by operators: the ATMS map, incident management system (IMS), traveler information system (TIS), and the video control system (VCS). When learning these programs, the operators use them as they would in the course of managing an incident. The standard operator procedure for incident management is:

1. Verify incident on camera
2. Post VMS sign if applicable
3. Create incident in IMS (populates Commuterlink Web site and 511)
4. Monitor until incident is cleared

The programs were taught in the order they would be accessed, beginning with incident detection, followed by VCS, TIS, and IMS. This order follows the same order of the standard operator procedure to help with the training process. Initial training sessions revealed that none of the software programs were difficult to master for the newly-hired operator. All are Windows-based and operate with familiar toolbars and functions.

Understanding the initial incident report given over the radio can be difficult for a new operator. Since the UDOT TOC is directly linked to the highway patrol dispatch center, all traffic over the radio is in "police speak," using the state 10-codes and other acronyms. While all incidents called out over the radio will eventually be posted to a computer automated dispatch, it is very important for the operator to capture all relevant information from the first radio call-out. The seconds (sometimes minutes) between the radio call-out and the posting of the incident on CAD are critical. The operator can have a direct influence on the residual delay from a particular crash. The faster the response to the incident the faster the network will return to normal flow. Unfortunately, it usually takes new operators a few weeks to become proficient at picking up the radio traffic. The relevant state 10-codes and commonly used acronyms were taught in the classroom, allowing the operators to identify incident locations more quickly upon beginning work.

VMS messaging techniques is a dynamic subject covered in the training module. VMS practices and standard procedure are changing as more research is done. At the TOC, TIS is the software that posts messages to signs, more classroom time is spent on messaging theory and application than on the TIS program itself. Operators must understand the importance of VMS messages since they reach the most critical travelers – those immediately approaching the incident. While IMS is important because it populates the Commuterlink Web site, the 511 travel advisory hotline, and other public outputs, none of these outlets have as much of an immediate effect on the network as a VMS message. Operators also must understand the basic human factors involved in VMS messaging, such as sign readability based on letter height and approach speed, use of easily recognizable phrases, and message phasing. These factors can cause VMS messages to be unclear or confusing. In the training module it is taught that when using a VMS message, the operator needs to keep the message as clear, concise, and direct as possible. Another technique is to ask the operator to try and rework the message so that it would convey a clear message if the operator himself or herself were on the roadway reading the VMS message.

PART 2: ADVANCED TRAINING

Part 2 describes the application of advanced training to operators who are qualified. Advanced training has not yet been implemented. This section describes the purpose of advanced training and key points to include in training when implemented. The curriculum is developed and presented in this part. The complete advanced training module and examples of training are given in the appendix.

3.1 Background

UDOT, like many businesses, is facing many challenges of providing a qualified workforce. Some of these challenges include a changing environment at the workplace and a demand for good service from the public. UDOT must recruit a talented workforce, retain this talent, and ensure that the knowledge and competence of the workforce is both maintained and increased. Many publications have been produced on the procedures to recruit, retain, and train this workforce.

The first comprehensive national publication to specifically cover the TOC and its workforce was the Federal Highway Administration's (FHWA) *Comparable Systems Analysis: Design and Operation of Advanced Control Centers* (2). This publication defines the objectives of TOCs and has an entire section dedicated to the staffing, selection, and basic training of employees. It does not explain the training of full time employees or advanced training to solve engineering problems. It highlights basic training observed from the FHWA's visits to 18 TOCs nationwide and discovered that nothing in the way of formalized recurrent training programs was seen at any of the sites visited in 1995.

In 2002, the FHWA produced a more comprehensive publication on staff development, *Guidelines for TOC Transportation Management Operations Technician Staff Development* (9). The publication developed a definition of what transportation management operations technicians (TMOT) or traffic operators should do. The traffic operator's responsibilities were separated into tasks, knowledge, skills, and abilities. Then these areas were separated into three different levels: entry level, full performance level, and advanced level. The publication did not discuss how operators can help TOCs in identifying and solving advanced transportation management and operations network problems.

The National Cooperative Highway Research Program (NCHRP) has compiled a synthesis to help state DOTs meet the challenges of training the workforce. The publication teaches state and federal agencies how to recruit, retain, and maintain their workforce. Their publication, *Training Programs, Processes, Policies, and Practices* (10), states in detail the challenges, the essential components of an effective training program, and the experiences of state DOTs. The publication is not a handbook of how to train operators but a collection of successful programs, processes, policies, and practices gathered from surveys from 16 states.

Various levels of training at a TOC help to retain and increase the knowledge and ability of employees. Training research and programs have recently focused on two areas. The first area is focused on the finding and basic training of new employees (11). The second area is training for large emergency management scenarios such as city evacuation or terrorist response (12,13,14,15). The emergency response training is built by federal agencies and done as a need-based training program.

These publications all provide important information on what is currently being done to solve the issues in the recruiting, retaining, and training of traffic operators. However, the training is often focused on the general practices and does not identify how to use the opportunities operators have in TOCs.

3.2 Problem Statement

This section proposes a specific training program to use the opportunities available to traffic operators. This is accomplished by training operators how to identify and solve advanced transportation management and operation problems. Important components of this report have been found and presented in this research.

1. Establish the definition of a good operator and the preparation needed to give advanced training.
2. Introduce a specific curriculum that develops the necessary knowledge, skill, and ability to identify and solve advanced transportation management and operation problems.
3. Suggest a method for measuring the performance of the operator on the knowledge, skill, and ability gained from the curriculum.

This report also proposes that a specific advanced training program can increase the capabilities of good operators to identify and solve advanced transportation management and operation problems. It defines the separate components of the advanced training program, including the definition of good operators, the specific curriculum, and ways to measure operator performance of the curriculum and learned capabilities.

3.3 Training Module

The advanced training module details the necessary elements of a complete training program to good operators. It explains what type of operator who is ready to receive the advanced training and the important subjects and information that needs to be included in training. All presentation and word documents are found in the appendix and should be adapted by UDOT according to the needs of each individual operator.

3.3.1 Levels of Operator Aptitude

To determine what a good operator is the description of a traffic operator and the different levels of aptitude need to be defined. The separation of the levels will be explained, including the training practices currently used at these levels.

The description of a traffic operator is described in Guidelines for TMC Transportation Management Operations Technician Staff Development (9).

> A Transportation Management Operations Technician is a person who is capable of working a typical shift in a Transportation Management Center (TMC). A typical shift may include operation under congested, non-congested, incident and non-incident conditions. The operator's work will usually consist of direct, "hands-on" accomplishment of tasks necessary to deliver one or more accepted TMC functions. An operator must also be able to show competent knowledge, skill, and ability.

The first level of aptitude of a traffic operator is the entry level. Entry level operators are new employees with no prior work experience in TOCs. They have a basic understanding of their purpose in TOCs and their responsibility to the public. Training for entry level operators includes the new employee or basic training, which can take up to two weeks. Basic training teaches the skills that an operator will need to retain throughout employment at a TOC. These skills can include traffic flow, roadway elements, and the overall understanding of the network (11).

The next level of aptitude is the full performance level. A full performance level for an operator should be able to carry out his or her responsibilities with a minimum of supervision, guidance, and direction (9). An operator can be considered full performance when they have an understanding of the knowledge, skill, and abilities to perform their duties and tasks. Training to reach full performance is done through recurrent training. Recurrent training helps operators gain important skills that are needed to effectively monitor the transportation network. Recurrent training is commonly given to operators in the form of monthly meetings or instruction from other operators. Recurrent training to entry level employees should be given from one to two years until the full performance level is met.

A good operator is an operator who can perform all the capabilities and duties of a full performance level operator. The capabilities of a full performance level operator may include:

- Manage multiple incidents at once
- Use all ATMS software effectively
- Understand all interchanges
- Reporting emergencies on 511/website
- Communicate with invested partners
- Work with no supervision
- Implement special event signal timing plans
- Fill a work order
- Issue a J-page
- Use TATS

Not all full performance level operators are considered good operators or are good candidates to receive the advanced training program. There are other traits shown by the operator that help to determine good candidates. Some key traits that have been identified are: what the operator does in his or her spare time, the operator's attention to detail, and a general interest shown in traffic and the TOC by the operator.

3.3.2 Preparation

Good operators help TOCs run smoothly in their duties to manage and control traffic in a transportation network. Good operators may start to receive more responsibilities because they show the knowledge, skill, and ability to accomplish all duties and tasks given to them in prior training. An operator with these responsibilities belongs to the advanced level of aptitude. Prior research has identified the general qualities of an advanced level operator as follows (9):

> An operator should be able to perform independently as an expert in the majority of functions at a TMC. Attainment of this level is measured by combining operator experience with advanced training and may also vary by the specific functional requirements of a TOC. The operator's job duties may be similar to those performed by a full performance level operator, but to exercise these duties by only receiving guidance about overall TOC priorities.

Figure 3.1 shows the process an operator follows to reach the advanced aptitude level. An operator that seeks to reach the advanced level must be fully capable in all the duties and tasks at each previous level. Other preparation in receiving advanced training is that an operator must show an ability to work with others and take interest in situations that are beyond the entry and full performance level tasks and duties. Some situations may include an operator notifying supervisors of areas of congestion at non-peak hour times or an operator suggesting better camera locations to supervisors.

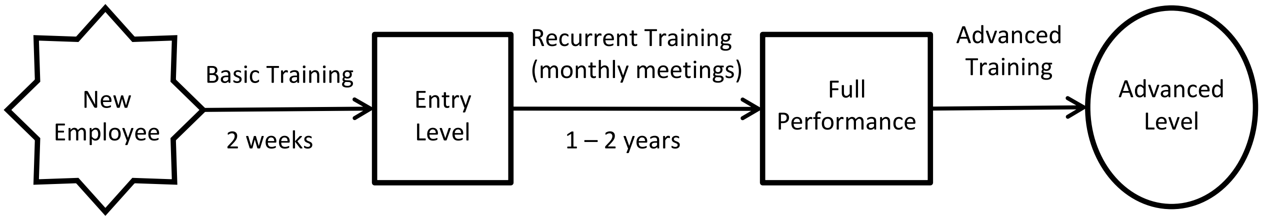


Figure 3.1 Levels of Operator Performance

Understanding the traveler information procedures is also an important part in preparing to receive the advanced training program. A brief one-hour recurrent training course can effectively teach the traveler information procedures of using 511, TATS, Emergency alert, Highway Advisory Radio, and IMS as related to traveler information. This training was developed at the UTL and the full document can be found in the appendix.

3.4 Specific Curriculum

A specific curriculum that helps good operators develop the necessary knowledge, skills, and ability is an essential part of the advanced training program. The curriculum is designed to teach them to identify and solve advanced problems that other TOC employees, specifically engineers, handle. The curriculum was divided into three different courses to accomplish this goal. Figure 3.2 shows the divisions with the subjects addressed in each course.

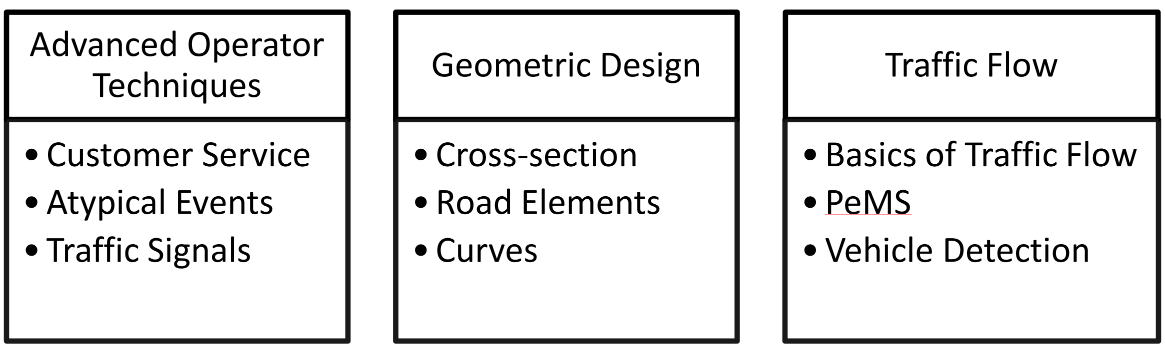


Figure 3.2 Curriculum for Advanced Training

A structured curriculum will help TOCs meet the overall goal to develop valuable employees, monitor the transportation network, and identify and solve transportation problems. The curriculum presented will help good operators obtain the specific capabilities to perform many of the responsibilities that are given to them. The capabilities that an advanced level operator should be able to complete are:

- Handle difficult phone calls
- HAZMAT response
- Fix broken traffic signal timing
- Identify all road elements
- Calculate superelevation
- Leadership/Train other employees
- Understand traffic flow theory
- PeMS – Report delay times
- Work zone management
- Ramp meter management

3.4.1 Advanced Operator Techniques

The first course in the advanced training curriculum is called advanced operator techniques. An operator who has received basic training and reached the status of a good operator should be able to understand the transportation network and use the advanced transportation management system software effectively and efficiently. This course adds to the full performance level by providing advanced customer service skills, knowledge to respond to atypical traffic crises, and the skills to manage traffic signals. The advanced operator techniques course develops the capabilities of good operators to identify and solve the advanced transportation problems in operations.

The interaction between the operators and the public and media, often referred to as customer service, is the first subject covered in the advanced operator technique course. This interaction improves upon the full performance level and helps develop capacities for the daily task. TOCs are information centers; they monitor the conditions of the transportation network and have access to all DOT agencies. To make use of the information, the TOC provides a direct phone line to the operators that they are required to answer during their shift. This means that part of the traffic operator’s job is to answer phones and use customer service techniques to successfully provide the information to both the public and the media.

The customer service aspect of the traffic operator’s duties can create challenges and must be handled appropriately. Techniques on how to handle the challenges of customer service and phone etiquette are addressed in the course. Figure 3.3 describes how an operator can create a good first impression on the phone and what they will be evaluated on. Operators are taught to be polite, informative, and professional. The qualities needed for good customer service skills include: listens well, gives verbal feedback, uses the caller’s name, and works to provide immediate feedback. These qualities are emphasized in the training.

Figure 3.3 Customer Service – First Impressions

Responding to atypical or emergency situations is taught in the next subject. The purpose of this subject is to inform the operators of their responsibilities and the actions they must take in these situations. An atypical situation is defined as any severe weather hazard or HAZMAT incident. These incidents are usually given with little to no warning and require the operator to seek supervisor help to resolve them.

The final subject covered in the advanced operator technique course is how to use the traffic signals at an operator level. TOCs usually employ engineers to develop and manage traffic signal timing plans. It is not the responsibility of the traffic operator. Understanding how to use the traffic signal software and how to implement created planes can be an asset for the operators. The principles taught to the operator in the advanced training are: how to implement a signal plan, how to deal with signal software in non-working hours, and understanding the basics of signal timing plans to identify problem areas.

3.4.2 Geometric Design

The next course in the curriculum is a geometric design basics training. Geometric design is the understanding of the road itself, the cross-section, road elements, and curvature. Understanding the road will help operators understand if problem areas are user related or a condition of the geometry of the road. Operators study the road looking for traffic incidents. By learning the geometric design training, the operators will begin to look for geometric design problems as they look at the road. The geometric design course is focused on the identification of advanced transportation problems.
The three subjects of cross-section, road elements, and curvature are taught as a foundation of roadway design. These subjects are often mathematically intensive, and finding the depth in which to teach the

subjects was found. Safety was the primary goal in the outline of this course. By implementing safety into the courses, proper depth was established in the geometric design course.

Cross-section design is the understanding of travel lanes, shoulders, and the physical separation of opposing directions of traffic. In the training, a common lane width of twelve feet was established. It was explained as the lane width was decreased, the comfort of the driver is weakened and travel speed is reduced while incident frequency is increased. Standard side slope is 6:1; the increase of the slope amplifies the severity of an incident. Figure 3.4, a slide taken from the geometric design course, describes the elements that are taught in the cross-section subject.

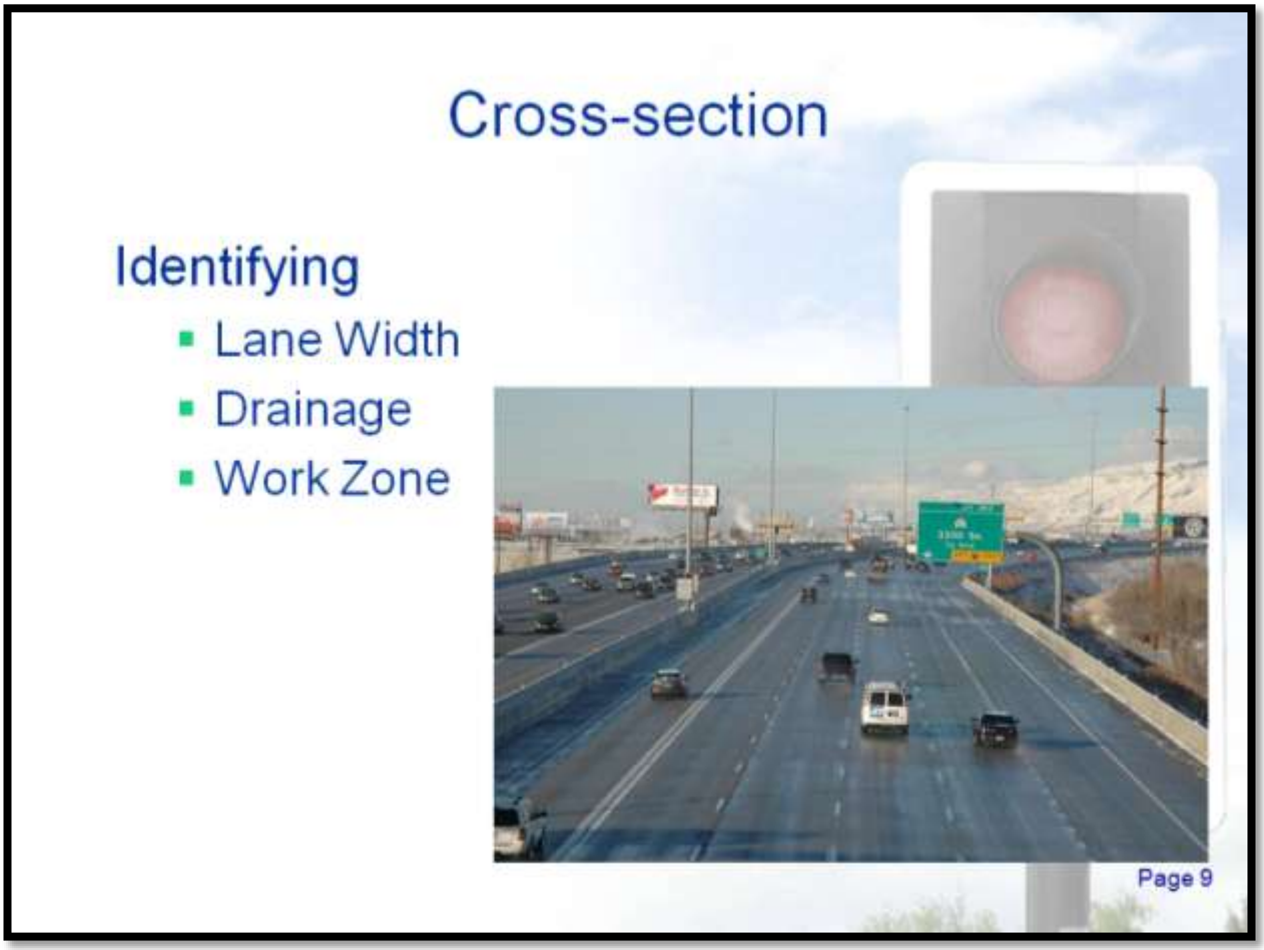


Figure 3.4 Cross-Section

The parts covered in the road element portion of the course are striping, barriers, and signage. The standard of each is taught so the different types and purposes are known. Knowledge of the roadway elements helps the operators find improper use and an identification of correct alternatives.

The final subject covered in the geometric design course is horizontal and vertical curve design. A traffic operator is not expected to design curves but have knowledge of the variables that are needed and identify the unsafe part. The basic components of superelevation, stopping sight distance, and design speed are taught. The safe values are identified and given in the training.

3.4.3 Traffic Flow

The final course developed in the curriculum is the traffic flow training. Understanding traffic flow is a key element in traffic management. The FHWA defines traffic incident management as the planned and coordinated process by multiple agencies to detect, respond to, and remove traffic incidents and restore traffic capacity as safely and quickly as possible. Understanding capacity, flow, and demand, the basic elements of traffic flow, helps operators see how efficiency in traffic management can benefit the travel time of the users. The other subjects covered in this course include the Performance Measurement System software usage and traffic monitoring through vehicle detection technologies. The traffic flow course will help good operators identify and solve advanced transportation problems in transportation management.

Traffic flow theory is way of describing the mathematical ways in which vehicles, drivers, and the infrastructure interact. This theory is an essential part of the design and operations of streets and highways. Traffic flow theory consists of knowing the terms of speed, density, capacity, and flow as they pertain to transportation. These terms are defined in the training for the operator; the relationship among the terms is also explained using the Greenshields model. Figure 3.5 shows how the terms are modeled using the Greenshields approach. The basics of how they relate to one another, including terms and equations, are also taught. The traffic flow theory is beneficial to operators because it helps them understand how an incident can reduce the capacity of a freeway. When the capacity is reduced, the flow and performance of the freeway is reduced, causing delays. Knowing that a faster response to an incident will reduce the overall delay of the freeway can help the operator work more efficiently and act more seriously at work. Understanding the traffic flow theory is essential to learning the next subjects in this course.

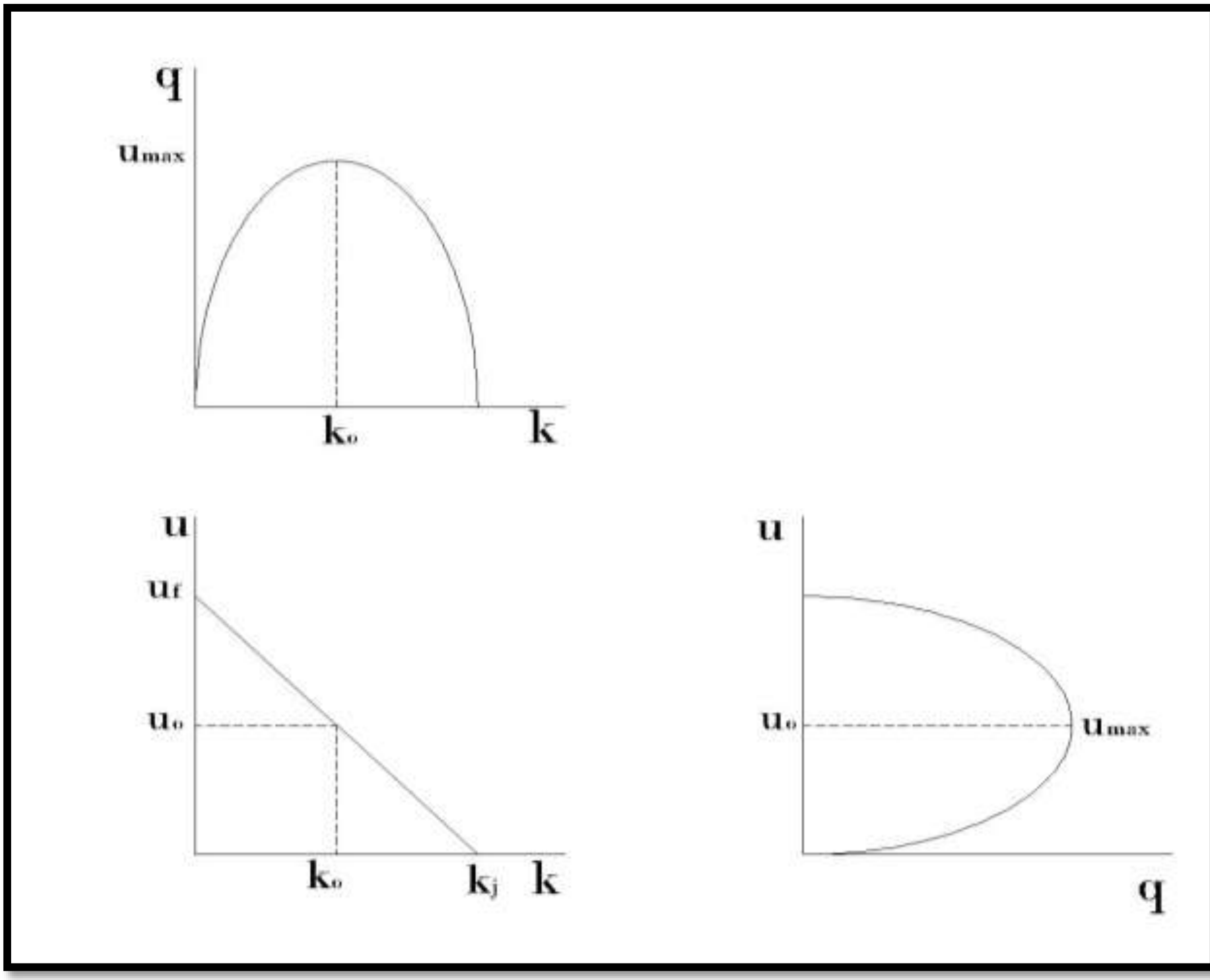


Figure 3.5 Greenshields Model

Performance Measurement System (PeMS) is software that collects data on the freeway system in Utah. The collected and stored information is speed and flow data. These data can be used to determine the trends that occur due to recurrent and non-recurrent congestion. The software can also be used to determine the delay time that an incident can cause. The training for this subject consisted of teaching how to use the software and how to calculate delay times. Delay times are calculated by taking the historical data and reducing the capacity by a reduction of lanes caused by an incident. The delay time is reported to the media and reported on variable message signs.

The final subject covered in the Traffic Flow course is an introduction to vehicle monitoring technologies. This subject helps operators understand how and from what sources TOCs get their traffic flow data. This subject introduces six different vehicle detection methods and explains what information they provide. The importance of vehicle monitoring in traffic management and TOCs is explained. The level to which the operators need to understand the vehicle detection technologies is also presented in this subject. The six detection methods are inductive loops, magnetic detectors, passive infrared system, ultra-sonic detectors, microwave radar, and video detection systems.

The advanced training curriculum delivers the necessary information to develop the knowledge, skill, and ability to prepare good operators to work at the advanced level. Figure 3.6 illustrates the process to attain the advanced level. The curriculum should be given in a two-week period but it does not automatically qualify operators as advanced level. A measure of the how well the operator can apply the information needs to be determined after six months to a year after the training. This will allow enough time for operators to master the information taught in the advanced training curriculum.

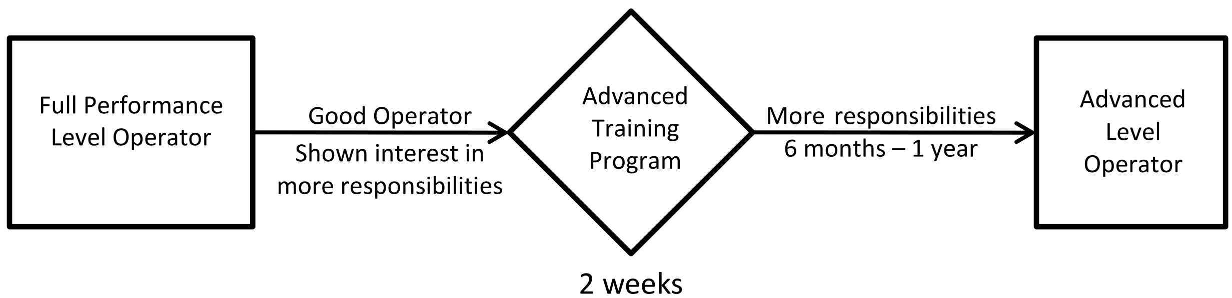


Figure 3.6 Good Operator Progression through Advanced Training

3.5 Performance Measuring

The final component of the proposal is to suggest a method for measuring the performance of the operator on the knowledge, skill, and ability gained from the curriculum. Performance measuring is the process of identifying current knowledge, skill, and ability and determining how well the trainee learned the training and how effective they were at applying the training. Performance was measured on how well operators could perform their capabilities, including identifying and solving advanced transportation management and operation problems. Three additional publications were used to help in the formulation of this specific performance measurement system, two from the FHWA (16,17) and one from the Transportation Research Board (18).

The performance measures are a balance of quality and quantity. The quality of the performance measures needed should be comprehensive enough to assess the knowledge, skill, and ability both of what is already known and what is taught. The quantity of the performance measures is found to assure that the evaluation does not become too cumbersome. The result from the performance measuring also needs to provide a way to help revise and improve the training service, quality, and productivity.

The quality of the performance measures can be evaluated against the Kirkpatrick Four Level Model of training evaluation (10). This ensures that the assessment and evaluation processes will accomplish their purposes of helping the operator understand the training and retain the information.

1. Student reaction – "What they thought and felt about the training."
2. Learning – "The resulting increase in knowledge or capability."
3. Behavior – "The extent of behavior and capability improvement and implementation and/or application."
4. Results – "The effect on the environment resulting from the trainee's performance."

The new method of performance measuring developed for the advanced training is that both assessment and evaluation methods are used. The performance measuring for the advanced training gives assessment of current employee levels through a checklist method. Next, an evaluation of the advanced training, consisting of short answer and problem solving questions, is given to the trainee. Finally, the frequency and duration of the performance measuring is given.

3.5.1 Assessment through Checklist

The assessment of current employee knowledge, skill, and ability levels is developed in the research and given by the employee's supervisor. The checklist was modeled after the generic activity groups presented in the FHWA staff development publication (9). Three checklists were developed for the basic, full performance, and advanced levels. The checklists follow the quality and quantity guidelines and limit the number of performance measures to no more than ten specific areas of assessment. The checklists are valuable in finding the strengths and weaknesses of each employee and allow the supervisor to focus on the development of the employees. The checklists follow the capabilities so that the supervisor and operator know exactly what the expected performance should be.

The basic level checklist measures the knowledge, skills, and ability of an employee after the basic training and two full weeks of on the job experience. The areas are measured by marking if the employee is at a certain capabilities as shown in Figure 3.7. The three levels of capability are: not capable, needs work, and fully capable. The areas of assessment for the basic level are: Hearing incident/Using radios, Create correct VMS signs, Create an incident on IMS, Select/Orient cameras, Salt Lake geography, Overall geography, Communication with other operators, Reading CAD system, Willingness to learn, and Productive during down-time.

Basic Level Operator Capabilities

	Not Capable	Needs Work	Fully Capable
Hearing Incident/Using Radios	☐	☐	☐
Create correct VMS signs	☐	☐	☐
Create an incident on IMS	☐	☐	☐
Select/Orient cameras	☐	☐	☐
Salt Lake Geography	☐	☐	☐

Figure 3.7 Basic Level Checklist

The full performance level checklist is given to an employee six months to a year after the basic level performance is achieved. The full performance level is the level at which an employee can work an entire shift and do the day-to-day tasks without supervision. The areas of assessment for the full performance level are: Manage multiple incidents at once, Use all ATMS software effectively, Understand all interchanges, Reporting emergencies on 511/website, Communicate with invested partners, Work with no supervision, Implement special event signal timing plans, Fill a work order, Issue a J-page, and Use TATS.

The advanced level checklist is given to the employee after the advanced training and after a month of using the knowledge and skills that were learned. The areas of assessment for the advanced level are: Handle difficult phone calls, HAZMAT response, Fix broken traffic signal timing, Identify all road elements, Calculate superelevation, Leadership/Train other employees, Understanding of traffic flow theory, PeMS – Report delay times, Work zone management, and Ramp meter management.

3.5.2 Evaluation after Training

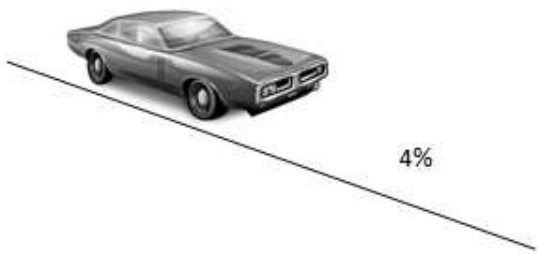
Evaluation or testing of the employee after training is critical to determine what was learned and how capable the employee is of applying the training, specifically in identifying and solving engineering problems. The following steps were used in creating the evaluation for advanced training. The information is from the FHWA Handbook for Developing a TMC Operations Manual (17).

1. Identify the critical activity.
2. Identify the goals and objectives of the activity.
3. Develop a set of candidate performance measures.
4. Identify performance targets.
5. Compare actual performance to targeted goals.
6. Determine corrective actions or progress needed to achieve goals.

The critical activities or tasks were identified for each course in the curriculum. These tasks were then compared to the goals of the training. The questions were then created to both help employees apply the tasks that were learned and fulfill the goals set in the training. The number of questions for each course followed the quantity and quality guidelines. The questions evaluate the employee’s understanding in ten questions.

Two techniques are used in the evaluation: short answer and problem solving questions. The two techniques were chosen because of the two methods in how information is retained. The short answer evaluates the employee on what they remember from the training. These questions are often easier and can appear multiple times. The method of learning this technique uses is short term memory recall and repetition. Problem solving problems require more thought and the actual application of the principles taught in the training. The problem solving technique uses the critical thinking method of learning. Figure 3.8 is an example of the short answer and problem solving question.

1. Solve the following problem for SSD. A car is traveling at 60 MPH downhill at a grade of 4%. A deer jumps into the road. How many feet will it take the vehicle to stop?



2. Describe the 3 types of barriers. Which is the strongest?

Figure 3.8 Evaluation of the Geometric Design Course

RESEARCH EVALUATION

To date we have trained fourteen UDOT TOC operators. These individuals had quite different backgrounds and levels of experience upon entering the training course. These diverse backgrounds were very helpful, as each trainee required different training goals and classes. The low volume of trainees makes it possible to customize the training program to the individual, a luxury many larger metropolitan areas may not have. For example, a young trainee was very familiar with the local area, but had only been driving for two years and therefore did not have a wealth of knowledge of transportation in general. A 32-year-old woman began the course with virtually no knowledge of the local transportation network, although she possessed many useful professional and interpersonal skills. These two individuals required very different training programs to reach the same level of proficiency in all tasks.

While the operator course has been effective to date, there are some limitations that still need to be addressed. One of the largest obstacles is the confidential nature of much of the information gathered, analyzed, and disseminated at the TOC. The UTL will most likely never have access to the CAD or radio traffic coming from the DPS dispatch center. Since the TOC is co-located with dispatch, operators have easy access to these outlets without compromising the confidential nature of the information. The UTL, however, is located five miles from the TOC, and is a less secure facility than the TOC building. So DPS is reluctant to provide access to the CAD and radio frequencies at the UTL. This is unfortunate because listening to the constant radio transmissions and extracting relevant information is one of the most difficult and important skills of the operator. This would prevent achieving a complete off site training at the UTL.

A final limitation is that the UTL cannot train and evaluate an individual's ability to cope with boredom. A common description of work in an operations center is "hours of tedium interspersed with moments of terror" (8). While traffic operators deal with periods of high stress and multi-tasking, they also deal with periods of very limited activity throughout the less busy times of day. Operators are allowed to take breaks throughout the day and to check email periodically. However, they are still required, even during slow periods, to monitor cameras and maintain situational awareness of the network. Ultimately, a large number of individuals will not be able to maintain focus during some of these slower periods, which will degrade their ability to manage an incident when it happens abruptly. In the current operator training program, there is no way for the trainer to evaluate how the individual will perform in a similar situation. As a result of the emphasis on a condensed course, the focus has to be on maximizing training, not on training to be bored. A recommendation is for the control room manager to consider the changing pace of the operator job when designing work schedules and break periods.

The advanced training program, as proposed in the method section, does increase the capabilities of good operators to identify and solve advanced transportation management operation problems. It accomplishes this by helping TOCs identify which operators qualify for the training, providing a specific curriculum, and providing a way to determine if the curriculum was successful in its training.

As the advanced training program was given to operators, several questions began to arise, such as, "Does increased responsibility mean increased performance?" This question is an important one because if no noticeable increase in performance at a TOC is seen, why implement the advance training program? If an operator correctly applies the training, then they can identify problems in the transportation network and solve the problems from the skills gained through the training.

An example of that was found in the process. This specific example illustrates the knowledge gained in the advanced operator techniques course in solving a traffic signal problem. TOCs usually have control of the signal timing plans of cities, and in Utah the public is encouraged to call the operators if there are signal timing problems. Traffic signal engineers work a standard eight-hour shift, so if a problem occurs during non-working hours the signal timing plan is noted and left to be fixed until the next day. An operator with signal timing knowledge can fix the problem immediately and improve the performance of the system.

Another possible concern about the advanced training program is determining if it provides benefits to the shareholders, which can include the public, the TOCs, and the operators themselves. An example showing the benefits of the advanced training program was found while teaching the geometric design course in the identification of poor design by an operator. Traffic operators manage incidents to inform the public of the incident and help reduce delay times. If an incident occurs in the same location frequently, it may be caused by bad design. An operator with advanced training can identify the problem as curvature design, narrow lanes, or insufficient merging distance. The problem can be reported to engineers at the TOC and potentially increase the performance of the network.

The delivery of the advanced training program was another problem that was discovered in the research. There are different methods in which training can be given to operators: power points, teacher-led seminars, or Web-based delivery. The first method of delivering the curriculum was an instructor-led PowerPoint presentation. This method allows for direct iterations of the courses because the feedback is given immediately and directly from the trainees.

The benefits that these examples provide to the public is that certain problems can be fixed any time of the day by advanced level operators, and congestion can be reduced by identification of poor design. The benefits to a TOC are that problems can be identified by observation of unusual congestion and TOCs will have more qualified employees in their workforce. Finally, advanced training can benefit operators by increasing the competency and responsibility at TOCs.

The advanced training program is designed to train traffic operators at TOCs to identify and solve advanced transportation management and operation problems. The component of identifying the definition of a good operator and preparing to receive advanced training helps to achieve this proposal. The component accomplishes this by providing TOCs with tools to help identify which operators are ready to take on more responsibilities and how to prepare them for these responsibilities. The component of providing a specific curriculum also assists the proposal by giving direct information and training courses that are not too general and can be successful immediately. The last component, suggesting a way of measuring the performance of operators under advanced training, also assists in the proposal. The performance measuring is a direct and concise method in determining how well the curriculum was received and can easily be used by the operator's supervisor.

The advanced training program is a specific program which will help direct TOCs in the advancement of their traffic operators. The training program deviates from the traditional methods of placing more responsibilities gradually on good operators. Instead, it focuses on a structured training method that prepares operators to identify and solve advanced problems and to share the results with other TOC employees.

The advanced training program is recommended to TOCs that have 24-hour, 7-day-a-week, transportation monitoring operators. The advanced training program is also recommended to TOCs that want to improve the production of operators. The recommended method for the delivery of the advanced training program is interactive training from a Web-based program or CD. The benefit of having a completely electronic training program is that the operator can receive training at any time. Having dedicated instructor-led training can cause the operator to miss critical time in the control room—time needed for traffic management. This training program can provide many benefits to help TOCs meet the demand for service from the public and their own goals of providing a reliable and efficient transportation network.

CONCLUSIONS

The basic training module is designed to teach the necessary knowledge, skills, and ability to new operators in a concise two-week program. Using the critical or mission-essential task list to guide the training of new operators achieves this. Using a military styled pedagogy helps new operators identify which skills are most important and how to gain the knowledge and ability to perform them. Finally, a network-centered training approach was found to be the best method in teaching new employees the importance of incident management. By focusing on the geography of the area, the employee gains an understanding of their role as operator in the travel of vehicles on the transportation network.

The advanced training program is designed to train traffic operators at TOCs to identify and solve advanced transportation management and operation problems. Defining what a good operator is and the preparation to receive advanced training helps accomplish this training. The program creates quality training by providing TOCs with tools to help identify which operators are ready to take on more responsibilities and how to prepare them so they can best be prepared for these responsibilities. The specific curriculum aids the training program by giving direct information and training courses that are not too general and can be successful immediately. The last element of the program, suggesting a way to measure the performance of operators under advanced training, also assists in the proposal. The performance measuring is a direct and concise method in determining how well the curriculum was received and can easily be used by the operator's supervisor.

The basic training and advanced training programs are specific programs which will help direct TOCs in the placement and advancement of their traffic operators. The training program deviates from the traditional methods of one-the-job training and of placing more responsibilities gradually on good operators. Instead, it focuses on structured training methods that prepare operators with the necessary knowledge, skills, and abilities.

RECOMMENDATIONS

There are opportunities for future study in the UDOT TOC advanced operation training project. The areas of study can be divided into three areas: basic training, advanced training, and table top scenario simulation training.

- Basic Training
  - Continue giving basic training to new employees
  - Develop interactive training module that can be given on a CD

- Recurrent Training
  - Create a recurrent training program that will help operators understand the UDOT approved procedure of handling:
    - Large incidents
    - VMS practices
    - E mergency and unusual situations
  - Hold a "think tank" meeting to determine procedures

- Advanced Training
  - Begin advanced training to good operators
  - Develop interactive training module that can be given on a CD at any time

- Scenario Simulation Training
  - June 22, 2010, meeting explaining beginning of project
  - Develop training program
  - Implement training program to TOC employees

REFERENCES

1. Carvell, James D. Jr., Kevin Balke, Jerry Ullman, Katherine Fitzpatrick, Lewis Nowlin, Christopher Brehmer (1997). *Freeway Management Handbook*. FHWA-SA-97-064, McLean, Va.

2. Kelly, Michael J., Jeffrey M. Garth, Christopher J. Whaley (1995). *Comparable Systems Analysis: Design and Operation of Advanced Control Centers*. FHWA-RD-94-147, McLean, Va.

3. Kelly, Michael J. (1999). *Preliminary Human Factors Guidelines for Traffic Management Centers.* FWHA-JPO-99-042, McLean, Va.

4. Mitta, Deborah A. and Michael J. Kelly (1996). *Design of an ITS-Level Advanced Traffic Management System: A Human Factors Perspective*. FHWA-RD-95-181, McLean, Va.

5. Baxter, Daniel H. (2002). *Guidelines for TMC Transportation Management Operations Technician Staff Development*. FHWA-OP-03-071, McLean, Va.

6. Gerfen, Jeff, Lianyu Chu, and Will Recker. "TMC Simulator for Operator Training Using Micro-Simulation." Transportation Research Board Annual Meeting, January 2008.

7. *Field Manual 7-0: Training the Force*. Headquarters, Department of the Army. October 2002.

8. *Transportation Management Center Concepts of Operation: Implementation Guide*. FHWA-OP-99-029, Washington, D.C.

9. Baxter, Daniel H. *Guidelines for TMC Transportation Management Operations Technician Staff Development.* FHWA-OP-03-071. FHWA, U.S. Department of Transportation, McLean, Va., 2002.

10. *Training Programs, Processes, Policies, and Practices, A Synthesis of Highway Practice,* Publication NCHRP Synthesis 362. Transportation Research Board, National Research Council, Washington, D.C., 2005.

11. Shepard, B. "A Network-Focused Approach to Training Operators at the UDOT Traffic Operations Center." Utah Traffic Lab, UTL-1207-93, December 2009.

12. *Transportation's Role in Emergency Evacuation and Reentry,* Publication NCHRP Synthesis 392. Transportation Research Board, National Research Council, Washington, D.C., 2009.

13. Nakanishi, Y.J. "Transportation Security Training and Education: Building Up Resources, Techniques, and Strategies." *TR News,* Number 238, May – June 2005, pp. 3-4.

14. Goldblatt, R.B. and K. Weinisch. "Evacuation Planning, Human Factors, and Traffic Engineering: Developing Systems for Training and Effective Response." *TR News,* Number 238, May – June 2005, pp. 13-17.

15. Ozbay, K. "New Frontiers in Emergency and Incident Management Training: Multiagency Models and Interactive Simulation Systems." *TR News,* Number 238, May – June 2005, pp. 18-23.

16. Park, B. *Transportation Management System Performance Monitoring. Evaluation, and Reporting – A Technical Handbook.* FHWA-HOP-07-124. FHWA, U.S. Department of Transportation, Washington D.C., 2005.

17. Seymour, E.J., J.D. Carvell Jr., J.L. Carson, and R.E. Brydia. *Handbook for Developing a TMC Operations Manual*. FHWA-HOP-06-015. FHWA, U.S. Department of Transportation, Washington D.C., 2005.

18. *Transportation Research Board Special Report 275: The Workforce Challenge: Recruiting, Training, and Retaining Qualified Workers for Transportation and Transit Agencies*, Transportation Research Board, National Research Council, Washington, D.C., 2003.

APPENDIX

The Appendix is a collection of both Word documents and Microsoft PowerPoint presentations used in the basic and advanced training modules. An electronic copy is also delivered to allow UDOT full access to the modules. The Appendix is organized as follows:

1. Basic Training Module Word Documents
2. Basic Training Module Presentations
3. Advanced Training Module Word Documents
4. Advanced Training Module Presentations

BASIC TRAINING MODULE WORD DOCUMENTS

CLASSROOM SCRIPT

Introductions

- Expectations
- Research partnership
- Paper and pen
- "I write-you write"
- Classroom portion
- Console portion
- Acronyms

"**Operator Introduction**" slideshow
Testable Material:

- UDOT Regions
- TOC Functions
- Most important task of operator: incident management
- Primary outputs
- Control room layout
- Acronyms: UDOT, TOC, TMC, ATMS, CCTV, 511, HAR, VCS, IMS, CMS/VMS, TIS
- Commuterlink website

Draw local map (guidance = freeways and big surface streets)
Instructor draw local map
"Drawing Local Map" slideshow

Draw local map
Critique map

"**Road and Traffic Basics**" presentation
Testable Material:

- Road types (in TOC)
- Difference in freeway and surface street
- Lane numbering
- Express lane basics
- Flow, speed, density
- Typical cross section
- Typical signal structure
- Gore, soundwall
- Measuring distance
- Barrier types
- Sign types/examples

Questions/Review: Road and Traffic Basics

Draw regional map (guidance = include Ogden and Provo)
Instructor draw regional map
"Drawing Regional Map" slideshow

Break

"**National and Regional Geography**" presentation
Testable Material:

- Interstate numbering system
- Cities in each UDOT Region
- MP 270, 300, 340
- MP on I-215
- Lakepoint Junction, Point of the Mountain, Silver Creek Junction, Kimball Junction
- North Interchange, South Interchange, Spaghetti Bowl, Parley's Canyon
- Surface street grid: State, Bangerter, Redwood, California, I-215 South, I-215 West
- Special events locations
- Economic/population centers

Draw State Map (guidance = state boundaries, alternate routes)
Instructor draw state map

ROADWAY AND TRAFFIC BASICS

Infrastructure and Environment
- ID: Gore, shoulder, median, lane numbering, park strip
- Pavement Markings
- Detectors
- Barriers
- Signal
- ATMS
- RWIS

Freeway
- Speed/Flow/Density graphically
- Shockwave, Jam density
- Level of Service
- Conversions (FPS – MPH)
- Heavy Vehicles: percentages, where are they heavy (West side); where are they slow (Parleys)
- Ramp Meters
- Using infrastructure to measure distance and speed (namely skipped lines)
- Mileposts: how are roads numbered
- HOV Lane: who can use it? Why do we have it?

Surface Streets
- Arterials, Collectors, Local roads
- Signals
  - Detection types
  - Troubleshooting (work orders; identifying the correct deficiency)
  - Pedestrian signals
  - Time-Space diagram ("green wave")

Regional Knowledge
- SLC Freeway network
- Nationally (interstate highway system)
  - Numbering
  - Mileposts
  - Bypasses

Safety
- Construction
  - Workzone design
  - Secondary crashes
  - High risk intersections (201/7200W; Bangerter/3500S)
- Pedestrians

Signing
- Regulatory, Warning, Guide signs
- Road identification: Interstate, State Route (Beehive), County Road
- Intro to MUTCD

ADVANCED TRAFFIC MANAGEMENT SYSTEM (ATMS) MAP TUTORIAL

Adjusting level of detail
Zooming in/out
Pan

Layers
Incidents
Planned Events
Scats Controller
SCS Controller
TATS
VCS
TIS
CCS
RWIS
Location
Information
Region
Detector Link

Video Control System (VCS) Tutorial

Camera list: digital, analog feeds; order cameras listed (I215, I80, 201, I15 S-N, surface)

View → Inputs Tree: shows/hides camera list
View → Tabs: shows/hides wall monitor bank
View → Select Wall Monitor Bank: choose displays (TOC, Trax, U of U, etc.)

Applications:
Selecting camera for individual console view; displaying on wall monitor
Customizing console view: Single 1, Single 2, quad (which are digital, analog)
Moving camera
Right click on camera display: lock/block camera, “Control” → advanced control (speed, auto focus), last 10 inputs
Which wall monitors are digital, which are analog
Displaying image for DPS
Using “Test Incident” feeds
Media 9Plex (16Plex??)
Selecting cameras on a specific road (type in dialogue box)
Can you group cameras by a particular area or street?

“Camera ethics”: what do we look at; what is a good view of an incident

Incident Management System (IMS) Tutorial

Action Buttons (shortcut keys): new incident, new planned event, clear incident, new note

New Incident required fields:
Reported by source: usually 911 if heard from DPS
Description: whatever appropriate (usually accident); second box is what caused it
Severity: check scale on back wall of TOC
Impact: should make sense with severity
Duration: best guess (usually 1 hour for average crash)
Location: county, city, direction
Main: freeway or larger road on which incident occurs
Cross: minor road on which incident occurs
Addr: address along larger road; can use either cross or addr
Type: facility (onramp, offramp, freeway, arterial, etc.)
Lanes affected: select all appropriate
On site: select all appropriate
Remarks: any additional information, intials, on camera?
"Add" at bottom. Once you add, you have to select area to place incident if your location is not accurate enough. After adding, you have to acknowledge the incident for it to appear on ATMS map and Commuterlink
<u>Updating:</u>
As incident progresses, add net notes (action button) to update situation
As lanes open/close or personnel arrive on scene, update with buttons at bottom

Cleared Incidents: system stores all incidents indefinitely in "Cleared Incidents" tab. Takes a long time to access, but you can find incidents here if you have cleared them mistakenly

Traveler Information System (TIS) Tutorial

Used to control Variable Message Signs

What do you put on a sign? What, where, action; avoid phases if possible; if necessary use phases for only part of the sign

Different types of devices
Mark IV Full Matrix; Mark IV Full Matrix Dialup; Daktronics; Wanco; Surface Street; Adaptive; ISS AP55 HAR; DR200 HAR, DR2000 HAR Beacon
How do you group signs by highway?

Action Buttons
Device List
Message List
Plan List
Schedule List
Channel List
Device Type List
Font List
Send Message
Quick Message
Blank

Inputs Tutorial

Radios:
CAD: Login access; S, U (Davis not available)
Websites (UHP Active incidents, VECC Fatpot gateway, SLCPD Incidents)
Citizen reports: ask lots of questions, get all information (name, #, street, direction)

Outputs Tutorial

VMS Signs: most immediate effect on traffic, should go up first
Commuterlink website: updates from IMS software
511 messages: should update from IMS software; doesn't always recognize incident type; must practice recording in event that it doesn't recognize
HAR:
Media feeds

Changeable Message Signs

Also known as variable message signs (VMS) or dynamic message signs (DMS). Dynamic message signs are generally those that have standard messages in a library from which to choose. On a VMS or CMS sign, an operator can vary the specific message he wants to display. VMS has been our standard, but we are moving toward CMS, as the new draft of the MUTCD will refer to them only as CMS.

Sign Types

- Overhead freeway
  - Largest
  - 8' x 40'; maintenance crew can walk inside to service
  - Typically $50,000 for sign and $150,000 - $200,000 for structure
  - Smart enough to treat individual characters differently ("m" is bigger than "I")
- Surface street
- Hybrid
- Portable construction sign
  - Treats all characters the same
  - Limited to 3 lines of 8 characters

Messaging Philosophy and Policy (human side of messaging)

- Research shows numerical dates ("02/03 – 02/05") are only retained by 20% of drivers, whereas "Sun-Wed" is retained by 80% of drivers
- In critical traffic periods, posting a sign can do more harm than good if it is not important
- Mile markers and exit numbers are universal, whereas surface streets (4500) are local
- Good to give the distance to the incident, not just the location – everyone doesn't know how far away 4500 South is
- Can be used to warn of incidents on adjacent/alternate streets (message on I-15 for I-215)
- Show example: letter size = reading distance from sign; reading distance from sign @ given speed = time before you pass the sign

UDOT Policies

- We do not do public service announcements except on rare, individual basis
- Restricted to 2x phases; phase change can only affect final line of message
- Use a generalized format for messages: what, where, response

Traveler Information System (TIS)

- Post a quick message
- Post a regular message
- Create a message in the message library
- Develop a plan
- Schedule the plan to launch
- Blank a sign (difference between blanking the sign and releasing the sign)
- Sign intensity (for discussion only): brighter in the day, dimmer in the evening/night
- LEDs, problems with glare
- Types of messages: crash, debris, construction, weather, special event, travel time

Console Script

What is difficult about working at the UDOT TOC

Three things:
1. Hearing/understanding incident location on radio
2. Selecting the correct device (camera) to view
3. Orienting the camera/locating the incident

These three things are the ones that we have to perfect in the TOC at a console

ATMS Software Introduction

VCS Video Control System
Device list (cameras listed by freeway, in MP order)
Output video devices (console, wall, DPS, media, Davis county)
Dragging a feed from device list to an output; from one output to another
Pan, Tilt, Zoom
Block or Lock a camera view; when is it appropriate to do so

TIS Traveler Information System
The name of the sign is also the location of the sign
Message Library v/s Quick Message
Keep is simple – two lines are better than three
Use phasing only if absolutely necessary
Know the location of the signs so you don’t have to search for one

IMS Incident Management System
Active incident log (how to retrieve information and notes from an active incident)
Cleared incident log (how to re-open an incident if necessary)
New Incident (step-by-step selection)
Using “Cross Street” or “Address” to identify location
Acknowledging incident
Making changes as incident is managed

ATMS Map
“Home View”
Navigating around map (zoom, drag, etc.)
Introduce all layers (incident, cameras, signs, and MP should always be on)
Note that cameras appear on the correct side of the road (where they really are on the ground)

CAD Computer Automated Dispatch
Open from “Programs;” enter login and password
Select “Status” → “Incident”
Enter “S,U” in the “Term” box for Salt Lake and Utah county incidents
Explain block by block (10-codes should have been introduced in classroom)
Explain how to get CAD online through Commuterlink website if unavailable

Other Programs

VECC Valley Emergency Communications Center CAD
Salt Lake City Police Department CAD
Mapquest map or Google Earth image of SLC

Orienting Your View to a Camera Image

Shadows (good morning and evening, not mid-day)
Topography (big mountains, little mountains, lakes)
  Mountain in West at northern end of Oquirrah Mountains
  “Ugly mountain” in North at SL-Davis county line
Landmarks (downtown, malls, structures)
Overall traffic flow (during commute periods)
Guide Signs (see what exit or MP is ahead of you with respect to where the camera is located)
Knowing which side of the road the camera is on (use ATMS Map)

*Without making them select an incident location, have them pull up random camera images and talk through the above methods:
I-80 at 1000W: downtown in the distance
SR201 at 800W: mountain in the West
I-15 at 400S SW: mountain in the North
I-15 cameras are all good for shadows (as long as it’s early or late)
Parley’s Canyon: all cameras marked “ns” (North side) or “ss” (South side) of the freeway
I-215W at 5100S: looking South, can see “Redwood Road” guide signs and you can see the road curving to the East where it becomes I-215 South

Incident Locations

<u>“Connector from US40 West to I-80 West”</u>
Teaching Points:
- US40 is West, not North as most assume
- There are very few landmarks with which to orient your view
- Easiest way to recognize is that SPIU cannot be I-80, so I-80 must be on the bottom
- There will be two ramps, one for US40 West and one for Silver Creek Road. Silver Creek Road will have to go up to the SPUI and through the signal. US40 West will get their own flyover ramp
- If operator has no idea what you’re talking about, go back to Regional Map (make them draw it if necessary) and talk them into Silver Creek Junction

<u>“I-15 at 12300 South SB Offramp”</u>
Teaching Points:
- 12300 South camera will be the first they choose; however it is no good because it is on the East side and is not high enough to see the mainline traffic
- When they select the 11900 South camera next, point out how it offers a much better view even though it’s about a half mile away
- Point out how you can see the first half of the ramp with the 11900 South camera, and you have to get the 12400 South camera to see the second half of the ramp

<u>“I-80 West Eastbound at 2200 West”</u>

- Operator may look for a grid numbered camera close to 2200 West without realizing that 2200 West is right under the I-215 West interchange
- Once they understand it is under I-215, they have to choose from the NE or SW camera (or both) to see the entire stretch of I-80. Good segway into discussion of I-80/I-215 interchange

<u>"SB Bangerter Highway at 2700 West"</u>
- Operator should be confused initially because they'll expect all Bangerter Highway cross streets to be North/South numbers on the grid; many do not realize that it turns to the East at 14000 South

Locating Incidents in Interchanges

Before you look for anything, envision what the traffic is doing on a map
Consult imagery of interchange
Select a camera that can see the traffic as they enter the interchange; follow them until you can't see them anymore; ID a reference point that you can find from another camera
Select another camera farther in the interchange; pick up connector ramp from where you lost it with the previous camera

South Interchange
Spaghetti Bowl
North Interchange
I-80 and I-215
Parley's Canyon

<u>"Connector from SR201 EB to I-15 NB"</u>
- Best camera to see initial portion of the ramp is 201 at 800 West
- Point out that 2100 S 700 W camera is a surface street camera; explain how 2100 South and 201 are different; 201 is often referred to as the "2100 South Freeway," which is confusing

<u>"I-215 East NB to I-80 East Westbound"</u>
- Best camera for initial view is 'I-215 East Parley's Canyon'
- 'Foothill S to I-80' is best for following it beyond Parley's

Questions

Name:

1. How many degrees from its original position must a signal head be twisted to warrant an emergency work order?

2. List all freeways in Utah.

3. East of Salt Lake City, I-80 runs through which canyon?

4. What is the highest possible Level of Service you can achieve? What is the lowest?

5. Who is authorized to use the express lane on I-15?

6. What is the part of the signal that has the green, yellow, and red bulbs?

7. On the CAD screen, what does a “T” before a unit’s identification number represent?

8. In a traffic signal structure, what is the horizontal pole called?

9. What county’s incidents do not appear on the CAD?

10. What is the name of the (normally black) piece that surrounds a signal head?

11. Name three types of roadside barriers.

12. Name four types of road signs.

13. Name two types of concrete barriers. What are the practical differences?

14. Name three facilities in the SLC area that host special events.

15. List the steps an operator should take (in order) once notified of an incident.

16. When viewing an image on a CCTV camera, what are two methods you can use to determine the direction the camera is facing?

17. Name an interstate highway that could be in Texas and Florida.

18. Name an interstate highway that could be in North Carolina and New York.

19. What is the local name for the junction of I-80 and SR-201 West of Salt Lake City?

20. What is the local name for the convergence of I-15, I-80 East, and SR-201?

21. What is the 10-code for a traffic accident or crash? What different types are there?

22. I-80 East Eastbound is blocked through Parley's Canyon. A caller from Provo requests another route to Park City. What would you tell them?

23. What is the local name for the Salt Lake and Utah County line on I-15?

24. What is the local name for the junction of I-80 and US-40 Northeast of Park City?

25. What is the local name for the junction of I-80 and US-224 North of Park City?

26. What are the Western and Eastern terminuses of I-80?

27. The city of Ogden is located at approximately what milepost on I-15?

28. Why is it often more difficult to find incidents on camera on I-215 South than on other freeways?

29. Name two current UDOT freeway construction projects.

30. Why are CMS messages important?

31. What three elements always go on a CMS message?

32. What are three methods of identifying location on a CMS message?

33. Define the levels of severity of crashes.

34. How many words are allowed on a CMS in a 65 mph zone? A 40 mph zone?

35. According to the current version of the MUTCD, a one inch letter is readable at what distance?

36. What incident severity levels require an operator to send out a J-Page message?

37. How many lines of a CMS message can you phase? How many phases can you use?

38. How long are skipped lines? How long are the gaps between them?

39. The city of Provo is located at approximately what milepost on I-15?

40. At 6:45 AM, similar incidents occur at the following two locations. Which will have a greater impact on the transportation network?

Location
I-15 South @ 500 South in Bountiful
I-15 South @ 12300 South in Draper

41. What is the phone number to the TOC?

42. How many mileposts are there on I-215?

43. There is a quarry located on I-80 East of Salt Lake City. On which side of the road is it located?

44. List some differences between freeways and surface streets.

45. What facility is located at the Northern end of Bangerter Highway?

46. How many mileposts are there on I-15 (approximately)?

47. What are the names of the two TRAX lines in Salt Lake City?

48. Name a city in each of the UDOT regions.

49. List every acronym you can think of associated with the Traffic Operations Center. Next to each, write what they stand for.

50. Draw maps of the local, regional, and state transportation networks on the last three pages of this test.

What surface street connects I-215 East with the University of Utah?
Operators place work orders for traffic signals that are owned and maintained by UDOT. What other agencies own and maintain signals in the Salt Lake City area?
What counties border Salt Lake County in each cardinal direction?
What are control cities? From Salt Lake City, what are the control cities in each cardinal direction?
What is the name of the grassy area between the curb and the sidewalk?
What is the complex?
What is unique about the intersection of Bangerter Highway and 3500 South?
What is unique about the exit ramp from I-15 Northbound to 400 South?

BASIC TRAINING MODULE PRESENTATIONS

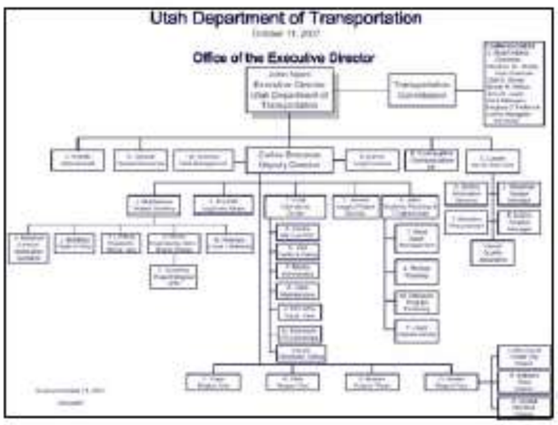
Operator Introduction

Traffic Operations Center (TOC)
Operator Introduction

UDOT TOC Operator Basic Training

Agenda

- UDOT Overview
- Traffic Management Centers (TMC)
- TOC Mission Statement
- UDOT TOC
  - Functions
  - Role
  - Personnel
- Training Program
  - Regional transportation – based



UDOT Overview

- Utah Department of Transportation
  - Regions
  - Departments
  - Locations
    - Complex
    - TOC (Region 2)

UDOT Regions

- Region 1
  - Logan, Brigham City, Ogden
- Region 2
  - SLC, Park City, Tooele
- Region 3
  - Provo, Orem
- Region 4
  - St. George, Cedar City

Traffic Management Center

- How do we improve performance of a given transportation network?
  - Increase supply (build more roads)
  - Decrease demand (fewer travelers)
  - Improve efficiency of existing system
    - Transit
    - Real-time information dissemination

Traffic Management Center

- In large urban areas
- Support advanced traffic management system (ATMS) infrastructure
  - Changeable message signs (CMS)
  - Closed-circuit television (CCTV) cameras
  - Incident management
  - Ramp meters

TOC Functions

1. Monitor the transportation network
2. Provide traveler information
3. Operate traffic control devices
4. Communicate with partners

TOC Hierarchy

Operations Center Generalized

"Operations center" = information hub

UDOT TOC Operations

Incident Management

- Receive report of incident
- Find on camera if possible
- Post CMS messages
- Create incident
  - Updates Commuterlink website
  - Updates 511
- Notify appropriate agencies
- Monitor for changes and updates

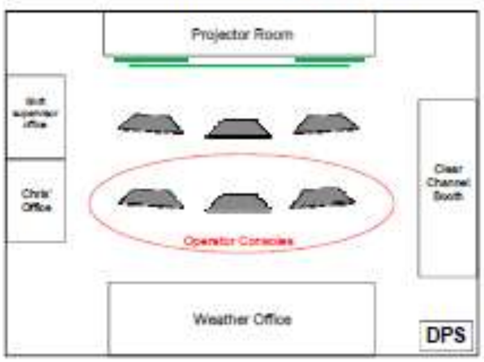
Incident Management

- Receive
- Verify
- Post
- Create
- Monitor
- Clear

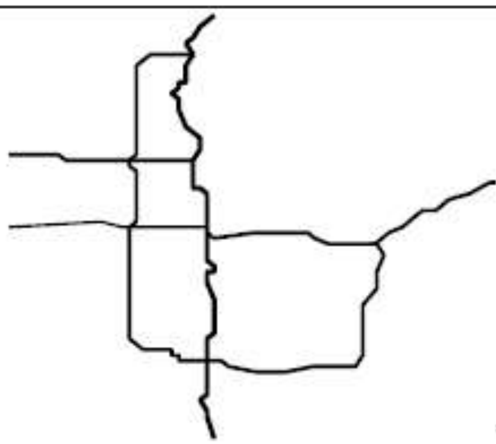
Traveler Information

- CMS/VMS Signs
- Commuterlink website
- 511
- Highway Advisory Radio (HAR)
- Media
  - TV feeds
  - Radio broadcasts

TOC Control Room Layout



Console Layout



Traffic Operator Role

- Incident Management
  - Incident Detection
    - Incident Verification
      - CCTV Cameras (Traffic Operator)
- Hardest part of being a traffic operator
  - Hearing incident location on radio
  - Selecting correct camera to view
  - Orienting view and locating incident

Road and Traffic Basics

Road & Traffic Basics

UDOT TOC Operator Basic Training

Agenda

- Highway Basics
  - Categories of roads
  - Freeway traffic flow
  - Infrastructure & environment

Road Categories

- Primary purposes of roads are to provide movement and access. Larger roads are primarily for movement. They connect to smaller roads which provide access.
  - Freeways
  - Arterials
  - Collector Roads
  - Local Roads

More movement
Less access

More access
Less movement

Freeways

- Controlled access
- Grade separation (no signals)
- High speeds (55+ mph)
- Maximum safety measures
- Highest level of scrutiny in design
- Examples
  - I-15
  - I-80
  - SR201 East of 7200 West

Arterials

- No grade separation, but limited access
- Can be principal (major) or minor arterials
- Often multiple travel lanes
- Moderate speeds (40-45 mph)
- Examples
  - Bangerter Highway
  - State Street
  - Foothill Blvd.
  - 10600 South

Collectors

- "Collect" traffic from arterials to service local and residential areas
- Can be major or minor collectors
- Compromise of speed and access
- Generally 35-40 mph
- Examples
  - 2100 South frontage road

Local Roads

- Smallest roads in network
- Allow essentially unlimited access
- Low speed (20-25 mph)
- Lowest level of scrutiny in design
- Examples
  - Everything else

Example – Road Types

Example – Road Types

Roads by Classification

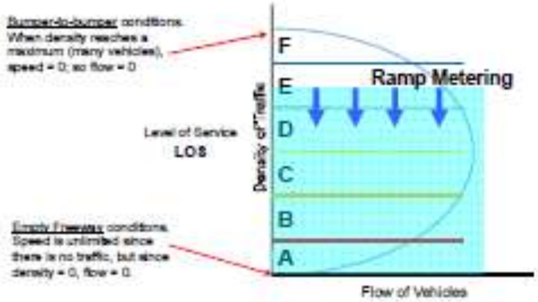
Road Type	Lanes	Speed Limit
Freeway	4+ (separated)	55+
Arterial	3-5	45-50
Collector	2-3	35-40
Local Road	2	25-30

- Rules of thumb; not specifications
- Values often vary according to region, population
- Categories frequently overlap
- Practically, at TOC:
  - Freeways
  - "Surface streets"

Traffic Flow

- Speed, Density, and Flow are the primary evaluation criteria
  - Flow = number of vehicles that pass a given point in a given time period
  - Flow = Density * Speed

Flow = Density * Speed



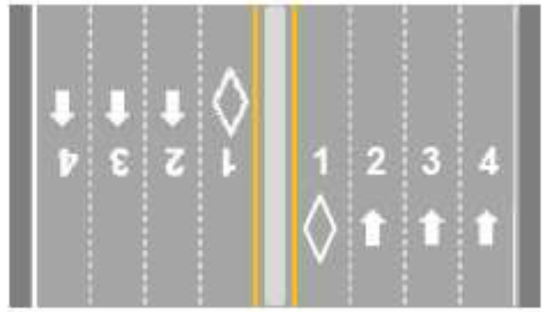
Lane Numbering

- Lanes are always numbered from the driver's left to right; or from the center and working to the outside

HOV Lane

- 38 miles in length
- University Pkwy in Orem to 600 N in SLC
- Authorized users
  - Vehicles with 2+ passengers
  - Clean-fuel vehicles
  - Toll users
  - Motorcycles, busses, emergency vehicles
- "Express Lane" is more appropriate

Lane Numbering



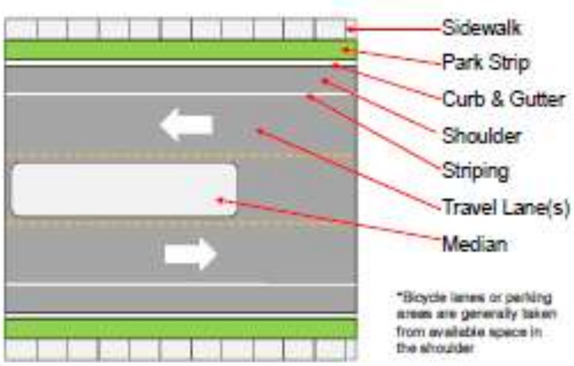
Terminology

- Queue
  - A line of waiting vehicles
- Platoon
  - A group of vehicles moving together

Roadside Infrastructure

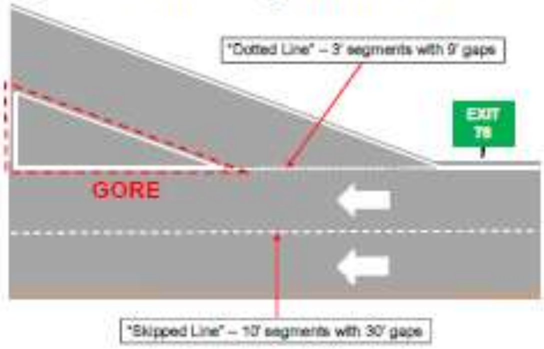
- Typical cross section
- Traffic signals
- Barriers
- Signs
- Detectors

Typical Cross Section



Freeway Elements

Freeway Elements



Freeway Elements

Single Point Urban Interchange (**SPUI**)

Freeway Elements

Diamond Interchange

Traffic Signals

- Timing
  - Cycle length
  - Split
  - Offset
- Infrastructure
- Timing plans

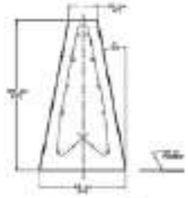
Traffic Signal Infrastructure

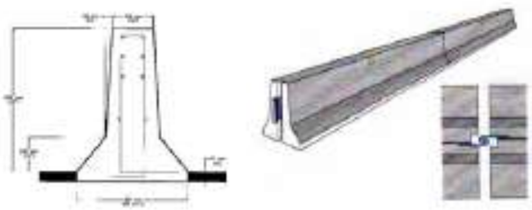
Signal Timing Plans

- Known as "flush" plans
- Used for special events
  - U of Utah football games
  - Utah Jazz basketball games
  - Plans available for certain traffic emergencies
- Built by Siemens technicians, but often implemented by operators after hours

Barriers

- Permanent concrete barriers
  - Separate lanes of traffic





Barriers

- Guardrail
- Cable barrier

Barriers

- Crash attenuators (crash cushions)

Barriers

- Mobile crash attenuators

Road Signs

- Manual on Uniform Traffic Control Devices (MUTCD)
  - Regulatory Signs
  - Warning Signs
  - Guide Signs
  - Information Signs

Regulatory Signs

- Used to inform travelers of regulations and laws; placed at the point of application

Warning Signs

- Used to call attention to unexpected conditions on or adjacent to the highway

Guide Signs

- Direct users along streets and highways and inform them of intersecting routes in the most direct manner possible

Information Signs

- Alert drivers of nearby areas of interest

National and Regional Geography

National & Regional Roadway Geography

UDOT TOC Operator Basic Training

Agenda

- Roadway Geography
  - National
  - State
  - Wasatch Front
  - Salt Lake City & vicinity
  - Local landmarks
  - Local traffic patterns

Interstate Highway System

Interstate Highway System

- Numbering System
  - West – East highways have even numbers
  - South – North highways have odd numbers
  - Bypass routes have a third number before the road they are connecting (I-215 is bypass for I-15)

Interstate Highway System

- Mileposts
  - Increase from West to East; South to North
  - Begin and end in each state
  - Exits are always numbered with mileposts

Interstate Highway System

Utah Population Demographics

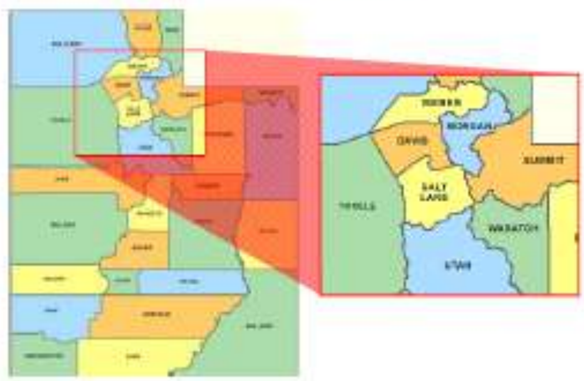
Area	Population
Salt Lake City (proper)	200,000
Salt Lake County (valley)	1,100,000
Provo-Orem	495,000
Ogden-Clearfield	518,000
St. George	67,000
Brigham City & Logan	120,000

- Total Wasatch Front population: 2,050,000

UDOT Regions

- Region 1
  - Logan, Brigham City, Ogden
- Region 2
  - SLC, Park City, Tooele
- Region 3
  - Provo, Orem
- Region 4
  - St. George, Cedar City

Local Counties



Utah Interstate Mileposts

Utah Interstate Mileposts

I-80 Mileposts

I-15 Mileposts

Local Interstate Mileposts

Local Freeway Terminology

- I-80
  - East v/s West
  - Eastbound v/s Westbound
- I-215
  - East, South, West, North
  - South = depressed
  - Any travel direction


Local Landmarks
Kimball Junction
Lakepoint Junction
Silver Creek Junction
Point of the Mountain


Interchanges
North Interchange
Parley's Canyon
Spaghetti Bowl
South Interchange


Travel Trends
• Commuter trends
• Attractions
– Canyons
– Bingham Mine
• Construction
• Weather

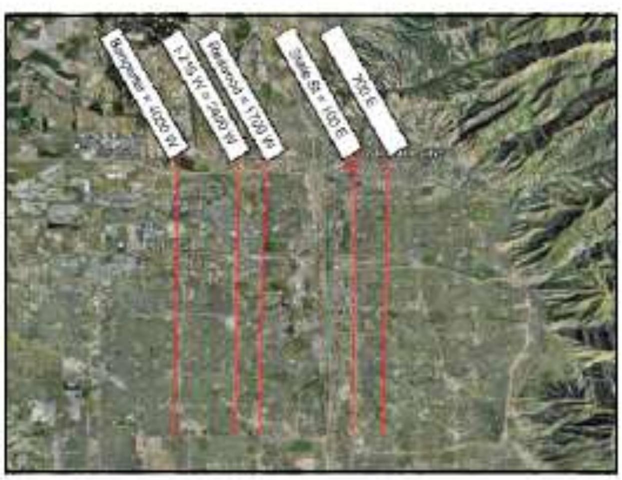

Travel Trends
• Commuter trends
• Industrial areas
• Retail areas
• Attractions
– SLC IA
– U of Utah
– Refineries


Travel Trends
• Special Events
– Rice-Eccles Stadium (U of U football)
– Energy Solutions Arena (Utah Jazz)
– E-Center (hockey, concerts)
– Franklin-Covey Field (SL Bees baseball)

Regional Map

Surface Street Grid

- South Temple = 0 North/South
- Main Street = 0 East/West
  - State Street = 100 East
- Reference (approximations)
  - I-215 West = 2400-2500 West
  - I-215 South = 6000 South
  - Bangerter Highway = 3800-4000 West
  - Redwood Road = 1700 West
  - California Avenue = 1300 South



CMS and CAD

Changeable Message Signs (CMS) & Computer Automated Dispatch (CAD)

UDOT TOC Operator Basic Training

Agenda

- CMS Basics
- Messaging philosophy and policy
- UDOT TOC Signing policies
- TIS Software
- CAD

CMS Basics

- Why use CMS?
  - Quickest possible way to inform travelers
  - Informed travelers make good decisions, reduce delay
- Types of signs
- Locations of signs
- Utilizing signs appropriately

Types: Overhead Highway

- Approximately 40′ long x 8′ high
- Maintenance personnel can enter the sign
- "Smart" characters: can display more "I"s than "M"s

Types: Surface Street

- Smaller than overhead
- Maintenance performed at a control box
- Limited messaging capability; should not be phased

Types: Hybrid

- Often used seasonally or at specific locations
  - Big & Little Cottonwood Canyons

Types: Construction

- Offer least flexibility
- Implemented by construction contractors, not TOC
- Very difficult to manage and control

Use of VMS/CMS Signs

- Governed by Manual on Uniform Traffic Control Devices (MUTCD)
- Extensive Research
  - Legibility
  - Placement
  - Readibility
  - Information processing

Considerations

- What is the purpose?
- Which sign should be used?
- What should the message be?
- How long should it be displayed?
- Are there any signing conflicts?

Message Priorities

- Emergency (evacuation, military action, etc.)
- Incident
- Construction or maintenance
- Adverse weather or environmental conditions
- AMBER alert
- Special event information
- Speed limit reinforcement
- Travel time information

Acceptable Messages

- Traffic incidents
- Construction/maintenance activities
- Weather/road conditions
- Traffic safety related warnings
- Emergency evacuation/AMBER alert
- Alternate route information
- Special events notification
- Test messages

Unacceptable Messages

- Advertising messages
- Non-transportation public service announcements
- Inaccurate or vague messages

Messaging Philosophy & Policy

- Driver processing of information
  - Letter height
  - PR distance
  - Sign location
- Message format must be clear and concise
  - What (is the incident)
  - Where (is it located)
  - Action (driver should take)

Message Content

- Clear, Concise, Directive
  - Legibility: 1 inch letter height = 40 feet (soon 30)
  - Driver comprehension: 1 word per second

Message Content (cont'd)

Crash Ahead
I-15 North Bound at 4500 South
Use Alternate Route

(11 words)

Crash Ahead
I-15 NB at 4500 South
Use Alternate

(9 words)

Crash
4500 South
Use Alternate

(5 words)

Message Content (cont'd)

Letter Height (Inches)	Legible Distance (Feet)	MPH	50	55	60	65	70
		FPS	73.5	80.9	88.2	95.6	102.9
10	400	Time to Read Sign (s)	5.4	4.9	4.5	4.2	3.9
11	440		6.0	5.4	5.0	4.6	4.3
12	480		6.5	5.9	5.4	5.0	4.7
13	520		7.1	6.4	5.9	5.4	5.1
14	560		7.6	6.9	6.3	5.9	5.4
15	600		8.2	7.4	6.8	6.3	5.8
16	640		8.7	7.9	7.3	6.7	6.2
17	680		9.3	8.4	7.7	7.1	6.6
18	720		9.8	8.9	8.2	7.5	7.0
19	760		10.3	9.4	8.6	7.9	7.4
20	800		10.9	9.9	9.1	8.4	7.8
21	840		11.4	10.4	9.5	8.8	8.2
22	880		12.0	10.9	10.0	9.2	8.6
23	920		12.5	11.4	10.4	9.6	8.9
24	960		13.1	11.9	10.9	10.0	9.3

Crash Ahead
I-15 North Bound at 4500 South
Use Alternate Route

(11 sec. to read)

Message Content (cont'd)

Letter Height (Inches)	Legible Distance (Feet)	MPH	50	55	60	65	70
		FPS	73.5	80.9	88.2	95.6	102.9
10	400	Time to Read Sign (s)	5.4	4.9	4.5	4.2	3.9
11	440		6.0	5.4	5.0	4.6	4.3
12	480		6.5	5.9	5.4	5.0	4.7
13	520		7.1	6.4	5.9	5.4	5.1
14	560		7.6	6.9	6.3	5.9	5.4
15	600		8.2	7.4	6.8	6.3	5.8
16	640		8.7	7.9	7.3	6.7	6.2
17	680		9.3	8.4	7.7	7.1	6.6
18	720		9.8	8.9	8.2	7.5	7.0
19	760		10.3	9.4	8.6	7.9	7.4
20	800		10.9	9.9	9.1	8.4	7.8
21	840		11.4	10.4	9.5	8.8	8.2
22	880		12.0	10.9	10.0	9.2	8.6
23	920		12.5	11.4	10.4	9.6	8.9
24	960		13.1	11.9	10.9	10.0	9.3

Crash Ahead
I-15 North Bound at 4500 South
Use Alternate Route

(11 sec. to read)

Message Content (cont'd)

Letter Height (inches)	Legible Distance (feet)	MPH / FPS	50 / 73.5	55 / 80.9	60 / 88.2	65 / 95.6	70 / 102.9
10	400	Time to Read Sign (s)	5.4	4.9	4.5	4.2	3.9
11	440		6.0	5.4	5.0	4.6	4.3
12	480		6.5	5.9	5.4	5.0	4.7
13	520		7.1	6.4	5.9	5.4	5.1
14	560		7.6	6.9	6.3	5.9	5.4
15	600		8.2	7.4	6.8	6.3	5.8
16	640		8.7	7.9	7.3	6.7	6.2
17	680		9.3	8.4	7.7	7.1	6.6
18	720		9.8	8.9	8.2	7.5	7.0
19	760		10.3	9.4	8.6	7.9	7.4
20	800		10.9	9.9	9.1	8.4	7.8
21	840		11.4	10.4	9.5	8.8	8.2
22	880		12.0	10.9	10.0	9.2	8.6
23	920		12.5	11.4	10.4	9.6	8.9
24	960		13.1	11.9	10.9	10.0	9.3

Crash Ahead
I-15 NB at 4500 South
Use Alternate

(9 sec. to read)

Message Content (cont'd)

Letter Height (inches)	Legible Distance (feet)	MPH / FPS	50 / 73.5	55 / 80.9	60 / 88.2	65 / 95.6	70 / 102.9
10	400	Time to Read Sign (s)	5.4	4.9	4.5	4.2	3.9
11	440		6.0	5.4	5.0	4.6	4.3
12	480		6.5	5.9	5.4	5.0	4.7
13	520		7.1	6.4	5.9	5.4	5.1
14	560		7.6	6.9	6.3	5.9	5.4
15	600		8.2	7.4	6.8	6.3	5.8
16	640		8.7	7.9	7.3	6.7	6.2
17	680		9.3	8.4	7.7	7.1	6.6
18	720		9.8	8.9	8.2	7.5	7.0
19	760		10.3	9.4	8.6	7.9	7.4
20	800		10.9	9.9	9.1	8.4	7.8
21	840		11.4	10.4	9.5	8.8	8.2
22	880		12.0	10.9	10.0	9.2	8.6
23	920		12.5	11.4	10.4	9.6	8.9
24	960		13.1	11.9	10.9	10.0	9.3

Crash Ahead
I-15 NB at 4500 South
Use Alternate

(9 sec. to read)

Message Content (cont'd)

Letter Height (inches)	Legible Distance (feet)	MPH / FPS	50 / 73.5	55 / 80.9	60 / 88.2	65 / 95.6	70 / 102.9
10	400	Time to Read Sign (s)	5.4	4.9	4.5	4.2	3.9
11	440		6.0	5.4	5.0	4.6	4.3
12	480		6.5	5.9	5.4	5.0	4.7
13	520		7.1	6.4	5.9	5.4	5.1
14	560		7.6	6.9	6.3	5.9	5.4
15	600		8.2	7.4	6.8	6.3	5.8
16	640		8.7	7.9	7.3	6.7	6.2
17	680		9.3	8.4	7.7	7.1	6.6
18	720		9.8	8.9	8.2	7.5	7.0
19	760		10.3	9.4	8.6	7.9	7.4
20	800		10.9	9.9	9.1	8.4	7.8
21	840		11.4	10.4	9.5	8.8	8.2
22	880		12.0	10.9	10.0	9.2	8.6
23	920		12.5	11.4	10.4	9.6	8.9
24	960		13.1	11.9	10.9	10.0	9.3

Crash
4500 South
Use Alternate

(5 sec. to read)

Message Content (cont'd)

Letter Height (inches)	Legible Distance (feet)	MPH / FPS	50 / 73.5	55 / 80.9	60 / 88.2	65 / 95.6	70 / 102.9
10	400	Time to Read Sign (s)	5.4	4.9	4.5	4.2	3.9
11	440		6.0	5.4	5.0	4.6	4.3
12	480		6.5	5.9	5.4	5.0	4.7
13	520		7.1	6.4	5.9	5.4	5.1
14	560		7.6	6.9	6.3	5.9	5.4
15	600		8.2	7.4	6.8	6.3	5.8
16	640		8.7	7.9	7.3	6.7	6.2
17	680		9.3	8.4	7.7	7.1	6.6
18	720		9.8	8.9	8.2	7.5	7.0
19	760		10.3	9.4	8.6	7.9	7.4
20	800		10.9	9.9	9.1	8.4	7.8
21	840		11.4	10.4	9.5	8.8	8.2
22	880		12.0	10.9	10.0	9.2	8.6
23	920		12.5	11.4	10.4	9.6	8.9
24	960		13.1	11.9	10.9	10.0	9.3

Crash
4500 South
Use Alternate

(5 sec. to read)

Maximum Number of Words

- MUTCD
  - "Entire cycle should be readable at least twice by drivers traveling at the posted speed."
  - "Sign should be limited to not more than three lines with not more than 20 characters per line." (Sec 2E.21)
- UDOT Policy

Message Length	Speed
8 words	55 mph or less
7 words	60 mph or more

Message Elements

• Descriptor	• Crash
• Location	• Exit 307
• Lanes affected	• Right Lane Blocked
• Effect on travel	• 15 Minute Delay
• Audience for action	• Airport Traffic
• Action	• Use Alternate

Descriptor

Application	Descriptor
Maintenance or Construction	ROADWORK
	SHOULDER WORK
Closure	[FREEWAY] CLOSED/BLOCKED
Incident	CRASH
	[MAJOR/MINOR] CRASH
	STALL
	DEBRIS
	CONGESTION
	AMBER ALERT
Weather	ICY BRIDGES
	FOG
	STANDING WATER
	HIGH WINDS
	DRIFTING SNOW
	FLOODING

Messaging Content: Location

- Identifying location
  - Milepost (MP 307, Exit 307)
    - Best method for long-distance & through travelers
  - Local street (400 South)
    - Best method for locals
  - Distance from sign/notification (1 mile ahead)
    - Universal; easiest for driver to rationalize and make a decision
- Locally, our grid system of addresses encourages us to rely on surface streets

Location

Location Descriptors	Proximity of VMS to Incident Location					
	Near (Within 5 miles or 1 interchange)		Medium (5-15 miles or outside 1 interchange)		Far (Beyond 15 miles or outside 1 interchange)	
	Same Road	Adjoining Road	Same Road	Adjoining Road	Same Road	Adjoining Road
Cross Street	X	X	X			
Exit Name	X	X	X			
Exit Number	X	X	X			
Landmark	X	X	X	X		
Crossing Highways	X	X	X	X	X	X
Cities or Towns	X	X	X	X	X	X
Distance Ahead	X		X		X	X
Mile Markers					X	X

Generic Message Format

DESCRIPTION
LOCATION
ACTION

CRASH
I-80 WB AT 5600 WEST
USE SR-201

UDOT TOC Message Format

DESCRIPTION / ACTION
LOCATION

LEFT LANES BLOCKED
AT 4500 SOUTH

UDOT TOC Message Format

DESCRIPTION / ACTION
LOCATION

CRASH ON RAMP
TO EB I-80

Message Content

- Messages should be directive in nature
  - "Use I-215" is better than "Use Alternate"
  - "Use Alternate" is better than "Delays Likely"
  - You make the decision for them
    - You know what's going on better than they do
    - They don't have to take the time to think and decide

Message Content

- When identifying calendar periods, letters are better than numbers
  - 6/6 – 6/8/08 v/s Tues – Thurs
  - Numerical dates only identified and absorbed by about 20% of all drivers
  - Days identified and absorbed by about 80% of all drivers

Message Content: Phasing

- Most signs can have more than one phase
  - Generally ineffective and unsafe to use more than one phase
  - When more than one phase is used, it is only used for one line, and shouldn't change the meaning

LEFT LANES BLOCKED
AT 4500 SOUTH
EXPECT DELAYS

Message Content: Phasing

- Most signs can have more than one phase
  - Generally ineffective and unsafe to use more than one phase
  - When more than one phase is used, it is only used for one line, and shouldn't change the meaning

LEFT LANES BLOCKED
AT 4500 SOUTH
USE ALTERNATE

Trans Suite Software

Video Control System (VCS) 

Incident Management System (IMS) 

Traveler Information System (TIS) 

Advanced Traffic Management System (ATMS) Map 

Traveler Information System (TIS)

CAD

- Computer Automated Dispatch
  - Spillman
- VECC
- SLCPD

Spillman

VECC CAD

- VECC – Valley Emergency Comm. Center

SLCPD CAD

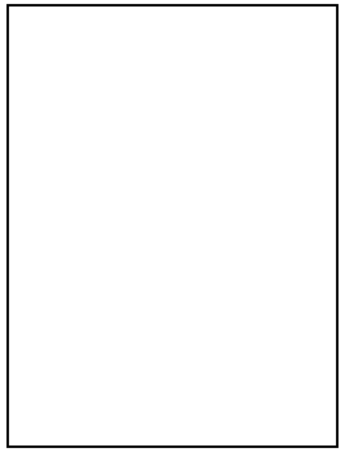
State of Utah 10-codes

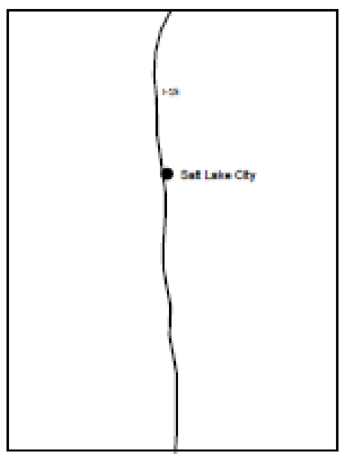
- Abbreviations for commonly used phrases or activities; ensure security of sensitive information
- Relevant
  - 10-46 Assist Motorist
  - 10-50 Accident
  - 10-57 Hit and Run
  - 10-59 Reckless Driver
  - 10-60 Out on Violator (ticket)
  - 10-85 Victim's Condition (followed by severity)

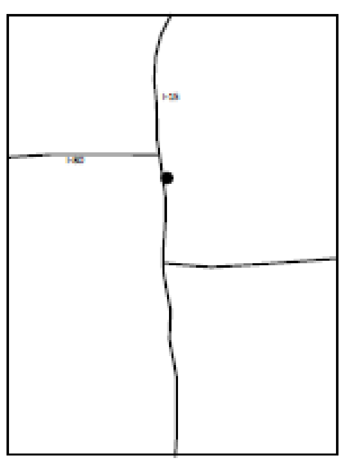
State of Utah 10-codes

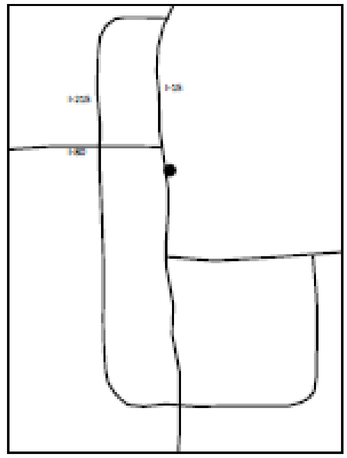
- 10-50 / 10-57
  - PD, PI, F
- 10-85
  - A Fair
  - B Poor
  - C Critical
  - D Possibly Fatal
  - D Obviously Fatal

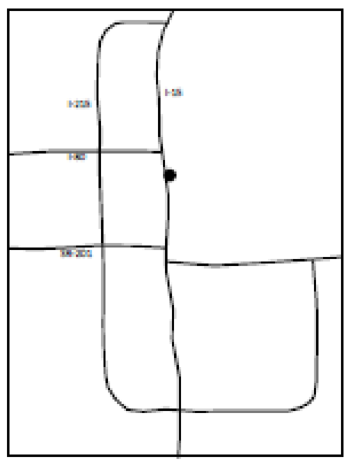
Drawing a Local Map

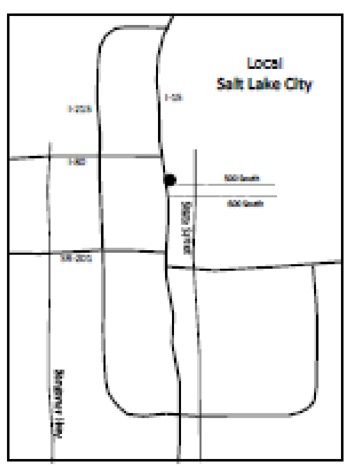






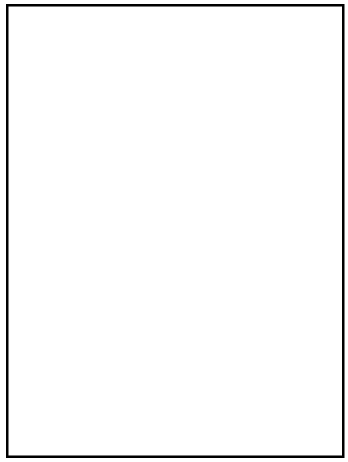


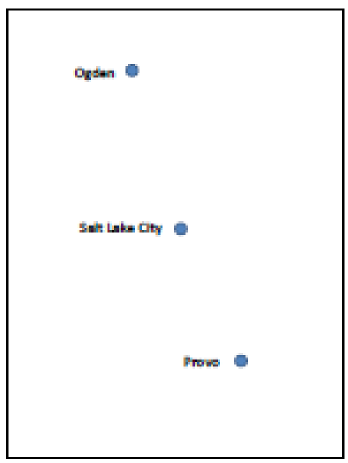


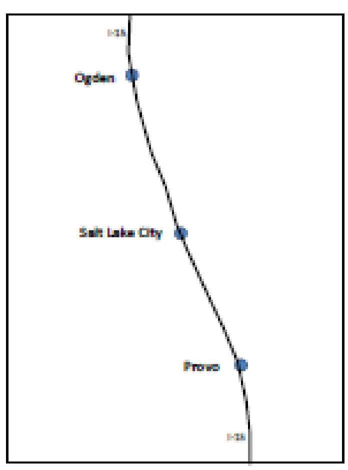

Local
Salt Lake City
State Street

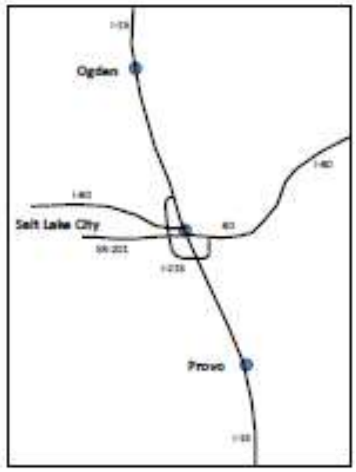

Local
Salt Lake City
I-215

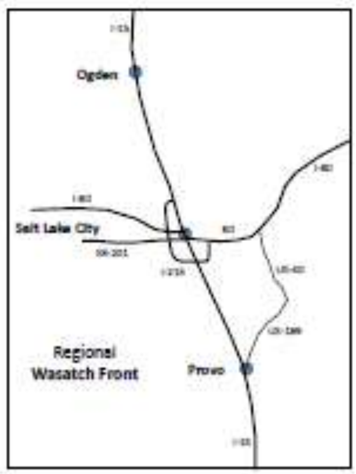
Drawing a Regional Map







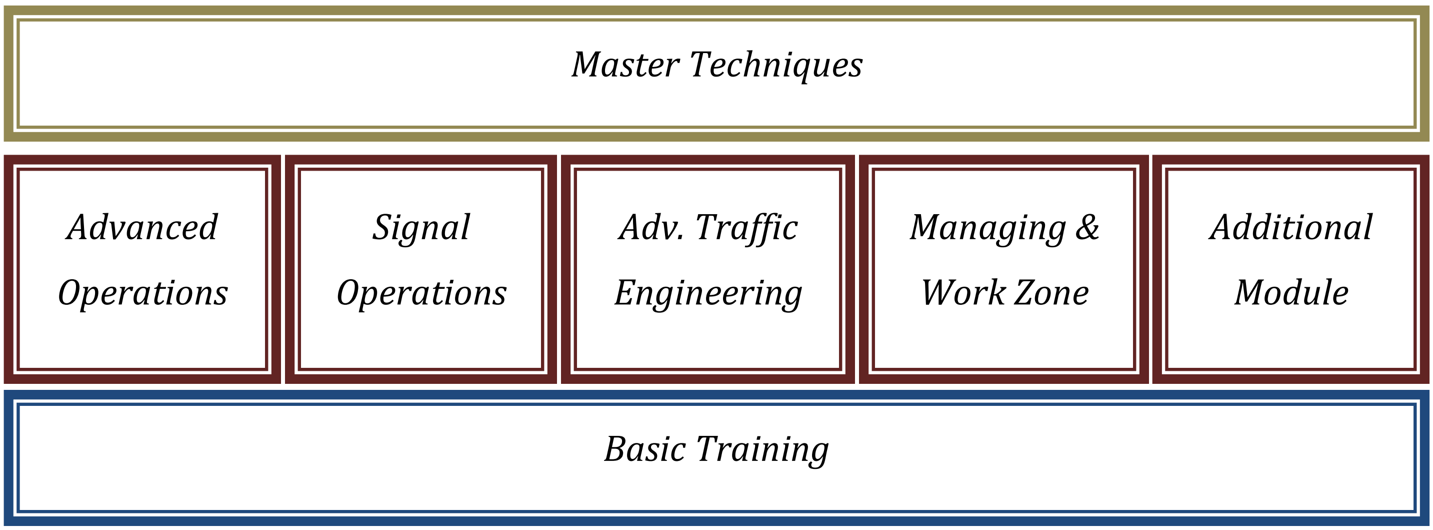

Ogden
Salt Lake City
Provo


Ogden
Salt Lake City
Regional
Wasatch Front
Provo


Ogden
Salt Lake City
Regional
Wasatch Front
Provo

ADVANCED TRAINING MODULE WORD DOCUMENTS

Outline of Advanced Training



Basic Training:
Maps - TOC functions
Road and Traffic basics – intro to the AASHTO green book
ATMS intro – sign best practice

Advanced Operations:
Advanced customer service skills

Signal Operations:
Software

Advanced Traffic Engineering:
MUTCD
Green Book
Standard Drawings

Managing and Work Zone
Advanced procedures for managing traffic incidents
Advanced procedures for managing special events
Work zone best practices

Curriculum

Advanced Operator Training

Customer Service

- **Phone Skills**
  - **First impressions**
  - **Improving skills**
  - **Difficult situations**
- **Visitors**
  - **Appearance**
  - **Operator procedure**

Atypical Events

- **Definition**
- **Types**
- **Operator procedure**

Traffic Signals

- **Timing**
- **Maintenance**
- **Operator procedure**

Geometric Design

Cross-section

- **Travel lane**
- **Shoulder**
- **Side slope**
- **Drainage**
- **Barriers**

Road Elements

- **Road categories**
- **Striping**
- **Signs**

Curvature

- **Horizontal curve**
  - **Design**
  - **Operator perspective**
- **Vertical curve**
  - **Design**
  - **Operator perspective**

Traffic Flow

Basics of Traffic Flow

- **Volume**
- **Occupancy**
- **Speed**
- **Density**
- **Flow**
- **Capacity**

Queuing theory
Perspective of operator

PeMS

Validation of data
Cumulative curve
Software
Operator usage

Vehicle Detection

Types
Inductive loops
Magnetic detectors
Passive infrared system
Ultra-sonic detectors
Microwave radar
Video detection systems
Perspective of operator

Basic Level Operator Capabilities

	Not Capable	Needs Work	Fully Capable
Hearing Incident/Using Radios	☐	☐	☐
Create correct VMS signs	☐	☐	☐
Create an incident on IMS	☐	☐	☐
Select/Orient cameras	☐	☐	☐
Salt Lake Geography	☐	☐	☐
Overall Geography	☐	☐	☐
Communication with other operators	☐	☐	☐
Reading CAD system	☐	☐	☐
Willingness to Learn	☐	☐	☐
Productive during down time	☐	☐	☐

Full Performance Level Operator Capabilities

	Not Capable	Needs Work	Fully Capable
Manage multiple incidents at once	☐	☐	☐
Use all ATMS software effectively	☐	☐	☐
Understand all interchanges	☐	☐	☐
Reporting emergencies on 511/website	☐	☐	☐
Communicate with invested partners	☐	☐	☐
Work with no supervision	☐	☐	☐
Implement special event signal timing plans	☐	☐	☐
Fill a work order	☐	☐	☐
Issue a J-page	☐	☐	☐
Use TATS	☐	☐	☐

Advanced Level Operator Capabilities

	Not Capable	Needs Work	Fully Capable
Handle difficult phone calls	☐	☐	☐
HAZMAT response	☐	☐	☐
Fix broken traffic signal timing	☐	☐	☐
Identify all road elements	☐	☐	☐
Calculate superelevation	☐	☐	☐
Leadership/ Train other employees	☐	☐	☐
Understanding of traffic flow theory	☐	☐	☐
PeMS – Report delay times	☐	☐	☐
Work zone management	☐	☐	☐
Ramp meter management	☐	☐	☐

Traffic Operations Center (TOC) Role in Freeway Management and Operations Handbook

Part 1 – The TOC

1. TOC Functions

The TOC is a part of UDOT that falls under the traffic management division. The Traffic Management Division is a division within UDOT that consolidates the Intelligent Transportation Systems (ITS) Division and the Traffic Operations Center (TOC) into one technology-oriented division. The Traffic Management Division is responsible for planning, designing, installing, operating, and maintaining advanced ITS technologies to improve transportation mobility, safety, economic prosperity, and customer satisfaction.

The Traffic Management Division has five key missions: To improve highway safety, to improve the efficiency of Utah's highways, to provide timely and accurate real-time traffic information, to facilitate cooperative public and private partnerships that integrate transportation services, and to provide customer service directly to the public on the operation of the transportation system. These services are cooperatively provided with a number of government agency partners, including Salt Lake County, Salt Lake City, the Utah Transit Authority and the Utah Department of Public Works through the CommuterLink traffic management system.

Services provided by the Traffic Management Division include computer-controlled coordinated traffic signals, management of traffic incidents on state highways, operation of ramp meters on I-15, control of electronic variable message signs, operation of the state's 511 traveler information telephone system, and the CommuterLink web site at **www.CommuterLink.utah.gov**. The Division is dedicated to providing outstanding transportation service through the use of advanced technology.

TOC Mission Statement

1. We support UDOT and DPS activities to improve highway safety.
2. We operate the highway system to provide reliable and efficient travel.
3. We provide accurate, timely, and useful real-time traffic information.
4. We work together with other government agencies to serve the public.
5. We provide excellent customer service.

TOC Functions

1. Monitor the transportation network
2. Provide traveler information
3. Operate traffic control devices
4. Communicate with partners

2. Management and Operations

Freeway traffic management and operations is the implementation of policies, strategies and technologies to improve freeway performance. The over-riding objectives of freeway management programs are to minimize congestion (and its side effects), improve safety, enhance overall mobility, and provide support to other agencies during emergencies. The TRB Freeway Operations Committee's Millennium Paper states: "Freeway operations, in its broadest context, entails a program to combat congestion and its damaging effects: user delay, inconvenience and frustration, reduced safety, and deteriorated air quality." Moreover, this "context" includes a vast array of freeway uses – the daily commute, commercial vehicle operations, personal and recreational trips, emergency service response, and evacuations during emergencies.

3. Incidents

An incident is any non-recurring event that causes a reduction of roadway capacity or an abnormal increase in demand. Incidents include; traffic crashes, disabled vehicles, spilled cargo, highway maintenance, reconstruction projects, planned incident, and special non- emergency events such as ball games, concerts, or any other event that significantly affects roadway operations.

It is clear that mitigating incident impacts is critical in improving traveler and responder safety, transportation system efficiency, and the nation’s economic competitiveness. In order to understand how to minimize incident impacts, an understanding of incident types is also helpful.

Incident Classification UDOT-TOC

- Level 1 – Not blocking any lane
- Level 2 – Blocking less than half of through lanes
- Level 3 – Blocking at least one half of through lanes
- Level 4 – Blocking all lanes and shoulder, no passage possible or permitted

Incident Classification FWHA

- Level 4 – Traffic is only slightly impacted
- Level 3 – Moderate impact on traffic flow
- Level 2 – Impact on the flow of traffic is significant
- Level 1 – Major events that close the roadway and cause major area-wide congestion

Planned events are a public attended activity or series of activities, with a scheduled time and location that may increase or disrupt the normal flow of traffic on affected streets or highways. Typical responsibilities are; managing intense travel demand, mitigating potential capacity constraints, influencing the utility associated with various travel choices, and accommodating heavy pedestrian flow. Some examples of planned incidents in Salt Lake City are; Utah athletics, Jazz games, and parades

.

4. Traffic Incident Management (TIM)

Traffic Incident Management is a planned and coordinated program process to detect, respond to, and remove traffic incidents and restore traffic capacity as safety and quickly as possible. Each of these aspects will be discussed in detail.

A. Detect

Incident detection is the process by which an incident is brought to the attention of the agency or agencies responsible for maintaining traffic flow and safe operations on the facility. Methods commonly used to detect and verify incidents include:

- Mobile telephone calls from motorists
- Closed circuit TV cameras viewed by operators
- Automatic vehicle identification (AVI) combined with detection software
- Electronic traffic measuring devices (e.g., video imaging, loop or radar detectors) and algorithms that detect traffic abnormalities
- Motorist aid telephones or call boxes
- Police patrols
- Aerial surveillance
- Department of transportation or public works crews reporting via two-way radio
- Traffic reporting services
- Fleet vehicles (transit and trucking)
- Roaming service patrols

B. Verify

Incident verification entails confirming that an incident has occurred, determining its exact location, and obtaining as many relevant details about the incident as possible. Verification includes gathering enough information to dispatch the proper initial response. Incident verification is usually completed with the arrival of the first responders on the scene. However, when hazardous materials are involved, the verification process may be quite lengthy. Methods of incident verification include the following:

- Closed circuit TV cameras viewed by operators
- Dispatch field units (e.g., police or service patrols) to the incident site
- Communications with aircraft operated by the police, the media, or an information service provider

- Combining information from multiple cellular phone calls

C. Respond/Inform

Incident response includes dispatching the appropriate personnel and equipment, and activating the appropriate communication links and motorist information media as soon as there is reasonable certainty that an incident is present. Response requires preparedness by each responding agency or service provider. This is fostered through training and planning, both as individual, and collectively with other response agencies. Effective response mainly involves preparedness by a number of agencies (i.e., planned cooperatively) for a variety of incident types, so that response to individual incidents is coordinated, efficient, and effective. Motorist information involves activating various means of disseminating incident-related information to affected motorists. The means of informing motorists at the TOC are; 501, commuter link, VMS using TIS software, media outlets, and using the IMS software.

Notes

5. TOC Review

Question 1.
What are the four different incident levels at the TOC?

Question 2.
What is the name of the online tool used to inform motorists of traffic conditions?

Question 3.
Where is the DPS office located?

Question 4.
What are the TOC functions?

Part 2 – Maps

Follow instructions on slide.
Practice drawing the local, regional, and state maps on this page.

Part 3 – Engineering Standards

1. AASHTO Green Book

The American Association of State Highway and Transportation Officials (AASHTO) A Policy on Geometric Design of Highways and Streets 2004, commonly referred to as the green book, is a book that provides design aids for engineers in many different areas. The areas that will be discussed here are; categories of roads, freeway traffic flow, infrastructure & environment, and an intro to horizontal and vertical curves. The foreword in the green book states:

> As highway designers, highway engineers strive to provide for the needs of highway users while maintaining the integrity of the environment. Unique combinations of design requirements that are often conflicting result in unique solutions to the design problems. The guidance supplied by this text, A Policy on Geometric Design of Highways and Streets, is base on established practices and is supplemented by recent research. This text is also intended to form a comprehensive reference manual for assistance in administrative, planning, and educational efforts pertaining to design formulation.

A. Road Categories

The Classification of roads into different categories is necessary for communication among engineers, administrators, and the general public. Different categories have been set for different purposes, which include access and movement. The four categories to be discussed are; freeways, arterials, collectors, and local roads. At the TOC it is common to combine the four categories into two classifications. The classifications are Freeway and Surface Streets. Freeway classification only includes the freeway road category while the Surface Streets include the arterial, collector, and local road categories.

Freeways are roads with full control of access. They are intended to provide for high levels of safety and efficiency in the movement of large volumes of traffic at high speeds. A freeway is the largest road category with the most movement and least access.

Notable features of freeways include grade separated intersections and high travel speeds. Some examples of freeways in Utah are I-15, I-80 and SR 201 east of 7200 W. The green book defines a freeway as follows:

> Control of access refers to the regulation of public access rights to and from properties abutting the highway. With full control of access, preference is given to through traffic by providing access connections with selected public roads only and by prohibiting crossings at grade and direct private driveway connections.

An arterial road is the next largest category. Arterials provide a high-speed, high volume network for travel between major points. They are different from freeway in that the intersections are at grade and need some sort of control to manage them. This means there is usually a limited access. Some examples include State St., 10600 S. and Bangerter Highway.

A collector road is the next category. The function of a collector may be understood by referring to those functional classes above and below it – the arterial and the local road. The collector has aspects of both arterials and local roads and often serves as a connection between them. Since the function of a collector combines aspect of both arterials and local streets, collectors serve a dual function: collecting traffic for movement between arterial streets and local roads and providing access to abutting properties. Some examples of collector roads are 1300 S. and 2100 S. Frontage Road.

A local road is the smallest category. The green book describes a local road as follows:

> A local road or street serves primarily to provide access to farms, residences, businesses, or other abutting properties. Although local roads and streets may be planned, constructed, and operated with the predominant function of providing access to adjacent property, some local roads and streets serve a limited amount of through traffic. Such roads properly include geometric movement of trough traffic. On these roads the through traffic is local in nature and extent rather than regional, intrastate, or interstate.

Notes

____
____
____
____
____
____
____
____
____
____
____
____
____
____

B. Traffic Flow

Traffic flow is a parameter used to describe how traffic is moving on roads, either on freeways or surface streets. Traffic flow is important to help determine shockwave relationships and to define queues. The text book Traffic & Highway Engineering by Garber and Hoel describes traffic flow effectively:

> Traffic flow theory involves the development of mathematical relationships among the primary elements of a traffic stream: flow, density, and speed. These relationships help the traffic engineer in planning, designing, and evaluating the effectiveness of

implementing traffic engineering measures on a highway system. Traffic flow theory is used in design to determine adequate lane lengths for storing left-turn vehicles on separate left-turn lanes, the average delay at intersections and freeway ramp merging areas, and changes in the level of freeway performance due to the instillation of improved vehicular control devices on ramps.

Traffic flow is the mathematical relationship of density and speed. That is that density multiplied by speed will give flow. Flow (q) = speed (u) * density (k). The units of flow are vehicles per hour. This can be found by looking at the units of speed and density. Density, sometimes referred to as concentration, is the number of vehicles traveling over unit length of highway at an instant in time. The unit length is usually 1 mile, thereby making vehicles per mile (veh/mi) the unit of density. Speed is the distance traveled by a vehicle during a unit of time. It can be expressed in miles per hour (mi/hr). When multiplied together the units become vehicles per hour (veh/hr).

In traffic flow there becomes an optimal point in the flow. This can be seen on the Slide 17. When the density of the traffic goes above this mark a shockwave can occur and general flow of the traffic stream will be reduced. A shockwave occurs when there is a sudden reduction of capacity. Reduction in capacity can be due to accidents, reduction in the number of lanes, restricted bridge sizes, work zones, a signal turning red, and other similar situations.

One of the greatest concerns of traffic engineers is the serious congestion that exists on urban highways, especially during peak hours. This congestion results in the formation of queues on expressway on ramps and off ramps, at signalized and unsignalized intersections, and on arterials, where moving queues may occur. A queue is basically a line that is formed when a vehicle arrives awaiting a service or an opportunity like waiting for the light to turn green. Understanding how shockwaves occur and queues will help an engineer design more efficient freeway and surface street flows.

C. Infrastructure

The infrastructure of a road is the physical part that is involved in the design. The slope of the road, the pavement, medians, and all other physical features can be considered the infrastructure of a road. Infrastructure is important for doing work orders and better describing the interaction of the vehicle with the road.

An important part of understanding the road infrastructure is knowing that there are numbers associated different lanes in multi-lane roads. The standard for multi-lane roads is to begin counting on the inside lane and counting out, or from median to shoulder in direction of travel. Each direction will have their own lane numbering and if there is a HOV lane in the inner lane than that will be the number 1 lane then count out.

The layout, or cross section of a road, helps operators and engineers communicate to each other. Important elements shown in the cross section include; shoulder, travel lane, median, gore, and soundwall.

D. Introduction to Geometry

The alignment of a highway or street produces a great impact on the environment, the fabric of the community, and the highway user. The alignment is comprised of a variety of elements joined together to create a facility that serves the traffic in a safe and efficient manner, consistent with the facility’s intended function. Each alignment element should complement others to produce a consistent, safe, and efficient design.

The basic objective in geometric design of highways is to produce a smooth-flowing, crash-free facility. This can be achieved by having a consistent design standard. This consistent design can be found in the green book with specific standards for horizontal curve and vertical curve design.

The basic elements of what is needed to design a simple horizontal curve will be discussed. The end result of the basic calculations will be to find the minimum radius of the horizontal curve to operate safely. The elements needed to find minimum radius are design speed, side friction factor and superelevation. Design speed is the highest speed expected on the road, usually 10 MPH higher than the posted speed. The side friction factor represents the vehicle’s need for side friction. This value is usually given as a constant or a variable value in the green book. Superelevation is tilting the roadway to help offset centripetal forces developed as the vehicle goes around a curve. Superelevation values can be determined from charts in the green book.

Basic Formula

$$R_{min} = \frac{V^2}{15(0.01 e_{max} + f_{max})}$$

The vertical alignment of a road consists of straight sections of the road known as grades, or tangents, connected by vertical curves. The design of the vertical alignment therefore involves the selection of suitable grades for the tangent sections and the design of the vertical curves. The topography of the area through which the road traverses has a significant impact on the design of the vertical alignment. The two types of vertical alignment are vertical sag and vertical crest curves.

The length of the vertical curve is the end result of most calculations. To determine the length the stopping sight distance (SSD), speed (V), and the differences between the tangents (A) are needed. SSD is the distance that is needed to stop a vehicle after seeing an obstacle. SSD is a combination of sight distance and braking distance. The length of a crest vertical curve can be determined with SSD and A. Sag vertical curve is a function of speed and A.

Notes

2. MUTCD

The *Manual on Uniform Traffic Control Devices or* **MUTCD** defines the standards used by road managers nationwide to install and maintain traffic control devices on all streets and highways. The MUTCD is published by the Federal Highway Administration (FHWA). The MUTCD gives standards in the following areas; signs, markings, highway traffic signals, traffic control devices for low volume roads, temporary traffic control, traffic controls for school areas, traffic controls for highway-rail grade crossings, traffic controls for bicycle facilities, and traffic controls for highway-light rail transit grade crossings. The areas to be introduced here are signs, markings, signals, and temporary traffic control or work zone control.

A. Signs

Signs provide the driver to understand the road they are on and to reach their destinations. There are 4 different types of signs; regulatory, warning, guide, and information. Each different sign has specific regulations and information that needs to be followed.

Regulatory signs shall be used to inform road users of selected traffic laws or regulations and indicate the applicability of the legal requirements. Regulatory signs shall be installed at or near where the regulations apply. The signs shall clearly indicate the requirements imposed by the regulations and shall be designed and installed to provide adequate visibility and legibility in order to obtain compliance. Regulatory signs shall be retro-reflective or illuminated to show the same shape and similar color by both day and night. Regulatory signs are usually white in color and rectangular in shape. Except for stop and yield signs.

Warning signs call attention to unexpected conditions on or adjacent to a highway or street and to situations that might not be readily apparent to road users. Warning signs alert road users to conditions that might call for a reduction of speed or an action in the interest of safety and efficient traffic operations. Warning signs are usually yellow in color and diamond in shape.

Guide signs are essential to direct road users along streets and highways, to inform them of intersecting routes, to direct them to cities, towns, villages, or other important destinations, to identify nearby rivers and streams, parks, forests, and historical sites, and generally to give such information as will help them along their way in the most simple, direct manner possible. Guide signs are usually green in color and rectangular in size. Guide signs also include route signs which designate which road the driver is traveling like. Examples are the I-15 and US-89 route signs.

Information signs are other signs that help provide information to the road users along streets and highways. These include specific service signs, tourist-oriented direction signs, and recreational and cultural interest area signs. These signs are either blue or brown in color and rectangular in shape.

B. Markings

Markings on highways have important functions in providing guidance and information for the road user. Major marking types include pavement and curb markings, object markers, delineators, colored pavements, barricades, channelizing devices and islands. In some cases, markings are used to supplement other traffic control devices such as signs, signals and other markings. In other instances, markings are used alone to effectively convey regulations, guidance, or warnings in ways not obtainable by the use of other devices.

Important pavement markings to understand now are what color to use and how long and wide different markings are. White pavement markings separate traffic lanes that go in the same direction and mark the right edge of the roadway. Yellow pavement markings separate traffic in opposing directions, mark the left edge of the roadway, and separate two-way left turn lanes and reversible lanes from other lanes. Pavement markings, white or yellow, are between 4 and 6 inches in width. Skipped lines have 10 ft segments with 30 ft gaps. Dotted lines have 3 ft segments with 9 ft gaps.

C. Signals

When properly used, traffic control signals are valuable devices for the control of vehicular and pedestrian traffic. They assign the right-of-way to the various traffic movements and thereby profoundly influence traffic flow.

Traffic control signals that are properly designed, located, operated, and maintained will have one or more of the following advantages: They provide for the orderly movement of traffic. They increase the traffic-handling capacity of the intersection if: Proper physical layouts and control measures are used, and The signal operational parameters are reviewed and updated (if needed) on a regular basis (as engineering judgment determines that significant traffic flow and/or land use changes have occurred) to maximize the ability of the traffic control signal to satisfy current traffic demands. They reduce the frequency and severity of certain types of crashes, especially right-angle collisions. They are coordinated to provide for continuous or nearly continuous movement of traffic at a definite speed along a given route under favorable conditions. They are used to interrupt heavy traffic at intervals to permit other traffic, vehicular or pedestrian, to cross.

D. Work zone

When the normal function of the roadway is suspended, Temporary Traffic Control (TTC) planning provides for continuity of the movement of motor vehicle, bicycle, and pedestrian traffic (including accessible passage); transit operations; and access (and accessibility) to property and utilities.

The primary function of TTC is to provide for the reasonably safe and efficient movement of road users through or around TTC zones while reasonably protecting workers, responders to traffic incidents, and equipment.

Of equal importance to the public traveling through the TTC zone is the safety of workers performing the many varied tasks within the work space. TTC zones present constantly changing conditions that are unexpected by the road user. This creates an even higher degree of

. At the same time, the TTC zone provides for the efficient completion of whatever activity interrupted the normal use of the roadway.

3. Standard Drawings

It is important that the same work is performed on all highways in the state of Utah. Therefore, a set of standards has been contracted so that all work can be done to the quality. Standard Drawings are written to the Contractor, defining Contractor responsibility. A Plan Sheet may provide more detailed information or revise the Standard for a specific contract. These standard drawings are approved by a Standards Committee. The Standards Committee reviews and approves all standard drawings, specifications, and related policies and procedures prior to implementation. The Committee also considers relevant matters presented to it by interested units or individuals, formulating appropriate action within its scope of responsibility.

The standard drawings are set up into different sections which describe how to design each element. The sections are as follows:

AT – Advanced Traffic Management Systems
BA – Barriers
CB – Catch Basins and Cleanouts
CC – Crash Cushions
DB – Diversion Boxes
DD – Design Drawings
DG - Drainage
EN – Environmental Controls
GF – Grates, Frames, and Trash Racks
GW – General Road Work
PV - Paving
SL – Signals
SN – Sings
ST – Striping
SW – Structures and Walls
TC – Traffic Control

Notes

Question 1.

What is the primary difference between Freeways and Surface Streets?

Question 2.

Show the units of flow by expressing it in a relationship of speed and density.
(hint: $q = u * k$)

Question 3.

Draw a cross section of a typical freeway and label each important element.

Question 4.

Which curve design is dependent on superelevation?

Question 5.

Describe the following signs. e.g. purpose, color, shape.

Regulatory:
Warning:
Guide:

Question 6.

What is the gap between pavement markings on a skipped line? Dotted line?

Question 7.

What section of the standard drawings would you most likely find work zone signing standards?

Horizontal Curve Assignment

1. Describe the elements of the figure on next page. What can you determine from it?
2. In your opinion what was a greater impact on the radius of the curve? Design speed or superelevation?
3. What would be more cost effective?
4. Using your results from the curve you found on your commute. Use the chart to estimate the superelevation needed. (Note design speed is usually 10 MPH greater than posted speed)

The figure is what is used in practice to determine horizontal curve. The e max = 6% means that it is to be used for roads that will allow a 6% superelevation (rural roads, arterials, collectors).

5. Using the figure above solve the following problem:

   A curve being designed has a radius of 3200 ft. What is the design speed for e = 1.5%?

   What is the maximum speed possible for any value of e?

US CUSTOMARY

e (%)	V_d = 15 mph R (ft)	V_d = 20 mph R (ft)	V_d = 25 mph R (ft)	V_d = 30 mph R (ft)	V_d = 35 mph R (ft)	V_d = 40 mph R (ft)	V_d = 45 mph R (ft)	V_d = 50 mph R (ft)	V_d = 55 mph R (ft)	V_d = 60 mph R (ft)	V_d = 65 mph R (ft)	V_d = 70 mph R (ft)	V_d = 75 mph R (ft)	V_d = 80 mph R (ft)
1.5	868	1580	2290	3130	4100	5230	6480	7870	9410	11100	12600	14100	15700	17400
2.0	614	1120	1630	2240	2950	3770	4680	5700	6820	8060	9130	10300	11500	12900
2.2	543	991	1450	2000	2630	3370	4190	5100	6110	7230	8200	9240	10400	11600
2.4	482	884	1300	1790	2360	3030	3770	4600	5520	6540	7430	8380	9420	10600
2.6	430	791	1170	1610	2130	2740	3420	4170	5020	5950	6770	7660	8620	9670
2.8	384	709	1050	1460	1930	2490	3110	3800	4580	5440	6200	7030	7930	8910
3.0	341	635	944	1320	1760	2270	2840	3480	4200	4990	5710	6490	7330	8260
3.2	300	566	850	1200	1600	2080	2600	3200	3860	4600	5280	6010	6810	7680
3.4	256	498	761	1080	1460	1900	2390	2940	3560	4250	4890	5580	6340	7180
3.6	209	422	673	972	1320	1740	2190	2710	3290	3940	4540	5210	5930	6720
3.8	176	358	583	864	1190	1590	2010	2490	3040	3650	4230	4860	5560	6320
4.0	151	309	511	766	1070	1440	1840	2300	2810	3390	3950	4550	5220	5950
4.2	131	270	452	684	960	1310	1680	2110	2590	3140	3680	4270	4910	5620
4.4	116	238	402	615	868	1190	1540	1940	2400	2920	3440	4010	4630	5320
4.6	102	212	360	555	788	1090	1410	1780	2210	2710	3220	3770	4380	5040
4.8	91	189	324	502	718	995	1300	1640	2050	2510	3000	3550	4140	4790
5.0	82	169	292	456	654	911	1190	1510	1890	2330	2800	3330	3910	4550
5.2	73	152	264	413	595	833	1090	1390	1750	2160	2610	3120	3690	4320
5.4	65	136	237	373	540	759	995	1280	1610	1990	2420	2910	3460	4090
5.6	58	121	212	335	487	687	903	1160	1470	1830	2230	2700	3230	3840
5.8	51	106	186	296	431	611	806	1040	1320	1650	2020	2460	2970	3560
6.0	39	81	144	231	340	485	643	833	1060	1330	1660	2040	2500	3050

Exhibit 3-26. Minimum Radii for Design Superelevation Rates, Design Speeds, and e_{max} = 6%

Vertical Curve Assignment

There were some things I did not teach all the way through on our discussion a couple of weeks back. I put all equations on here and help you understand more about vertical curves.
Vertical curves are designed with a number of factors. Comfort, drainage, and stopping sight distance to name a few. Stopping sight distance is almost exclusively talked about in the green book and I talked a little about it in class. A couple of notes, stopping sight distance is a combination of breaking distance and reaction distance as shown in the equations below.

$SSD \ or \ S = d_{brake} + d_{reaction}$

$d_{brake} = \dfrac{V^2}{30\left(\left(\frac{a}{32.2}\right) \pm G\right)}$ where a is usually 11.2

$d_{reaction} = 1.47\ V\ t$ where t is usually 2.5 sec

Then from this can apply the other formulas:

- Length of the curve is a function of Stopping Sight Distance
  - For Crest

Algebraic difference of tangents

$When\ S < L \quad L = \dfrac{AS^2}{2158} \qquad When\ S > L \quad L = 2S - \dfrac{2158}{A}$

Stopping Sight Distance (ft)

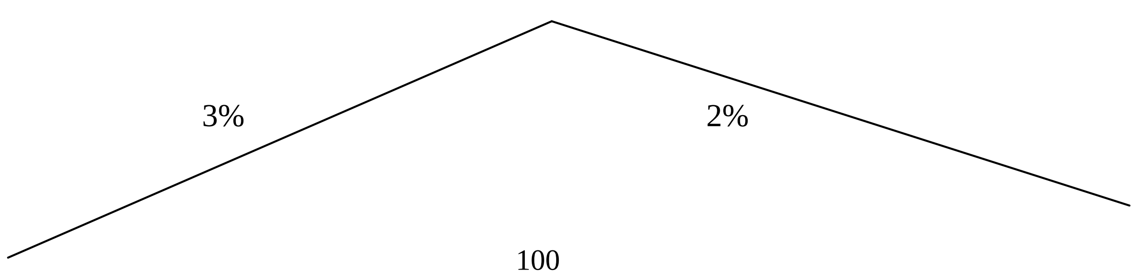
  - For Sag

$L = \dfrac{AV^2}{46.5}$ Velocity (MPH)

Another important factor in sag curves is the passing sight distance I won't discuss it here because the table on the next page helps to design sag vertical curves.

Solve the following problems:

1. Find a vertical curve on camera and guess the grade?
   Is it a large number of relatively small grades?
2. Given the crest curve below find S and L. Design speed 55 MPH.



Another important part of designing vertical curves is finding the K value. This is the numerical value of L/A. Below is the table found in the green book to easily find design curves.

US Customary (sag curve)		
		Rate of vertical curvature (K)
Design Speed (mph)	Passing Sight Distance (ft)	Design
20	710	180
25	900	289
30	1090	424
35	1280	585
40	1470	772
45	1625	943
50	1835	1203
55	1985	1407
60	2135	1628
65	2285	1856
70	2480	2197
75	2580	2377
80	2680	2565

This helps to design curves because the one value you are looking at is the K column if your designed curve length/ by the algebraic difference is higher than the K value you want to design at you will need to lower the a value or the speed. S values are calculated for you and it makes the process faster when you get to know how to use the table.

3. Find the minimum length of a sag vertical curve given a design speed of 75 MPH and an algebraic difference of 4. How would it change if a = 7?

ADVANCED TRAINING MODULE PRESENTATIONS

Advanced Operator Techniques

Phone Skills

- Why important?
- Examples
- UHP

First Impressions

In 7 seconds customer evaluates your performance

- They like you
- They dislike you
- They are indifferent

1. Clean
2. Attractive
3. Credible
4. Knowledgeable
5. Responsive
6. Friendly
7. Helpful
8. Understanding
9. Courteous
10. Confident
11. Professional

Improving Skills

- Your **attitude** is the first key to customer satisfaction
- Your **actions** are the second key to customer satisfaction
- You **affect** a lot of business
- You can make customers **glad** they talked to yo

Improving Skills

Brain first
Answer in 2 or 3 rings
Say your name, Ask for their name and use it
Indicate action
Courteous
Smile or Solution to the problem

Difficult Situations

5 Star Attitude

- Sit up straight
- Breathe, energize
- Give your full attention
- Be extremely patient, paraphrase
- Be efficient

Difficult Situations

- Act Quickly
  - Clarify
  - Confirm
  - Connect
  - Offer choices
  - Offer callback
- Be Personal
  - Exceptional courtesy
  - Try to understand their view


Difficult Situations
Just Do It
- Do what you said
- Do it immediately
- Call back with updates
- Call back to ensure satisfaction
- Transfer call
Page 13


Visitors
- Appearance
- Dress Code
- Clean work station
- Procedure
- Expected
- Unexpected
Page 14


Visitors
Expected
- Attitude
- Prepare "presentation"
- Cameras, VMS examples
- Be prepared to answer questions
Page 15


Visitors
Unexpected
- Accompanied
Show "presentation"
- Unaccompanied
Introduce yourself
If not authorized to be there notify Control Room Manger
Page 16


Atypical Events
- Definition
- Major traffic incident
- Non-recurring event
- Reduction of roadway capacity
- Not large emergency or evacuation
- Types
- Hazardous material spills
- Incidents in work zones or planned events
- Freeway closures
Page 17


Atypical Events
Common signs in determining duration of event
- Fluids
- Smoke/fire
- Damage to road
- Officer injury
- Vehicle size
Page 18


HazMat Spills
Definition
Procedure
Page 19


Work Zone Incident
Definition
Procedure
Page 20


Planned Event Incident
Definition
Procedure
Page 21


Freeway Closure
Definition
Procedure
Page 22

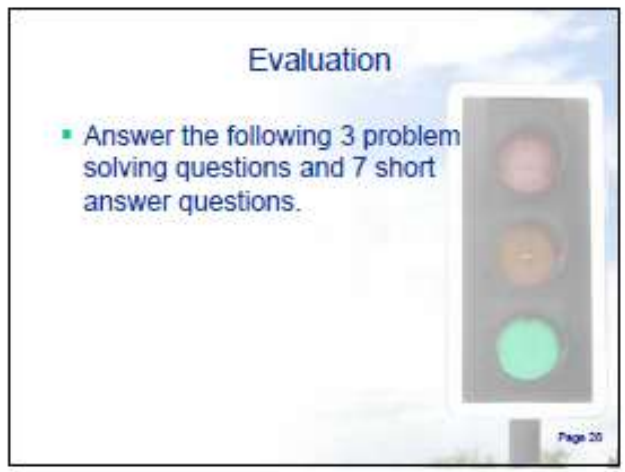

Traffic Signals
Operator prospective
Understand vocabulary
Identify what type of problem is being presented
Procedure
Page 23


Traffic Signals
Timing
Cycle length
Split
Offset
Maintenance
Operator perspective
Page 24


Traffic Signal Vocabulary
Traffic signal vs light
Timing
Cycle length/split/offset
Page 25


Operator Perspective
Page 26


Summary
Page 27


Evaluation
Answer the following 3 problem solving questions and 7 short answer questions.
Page 28

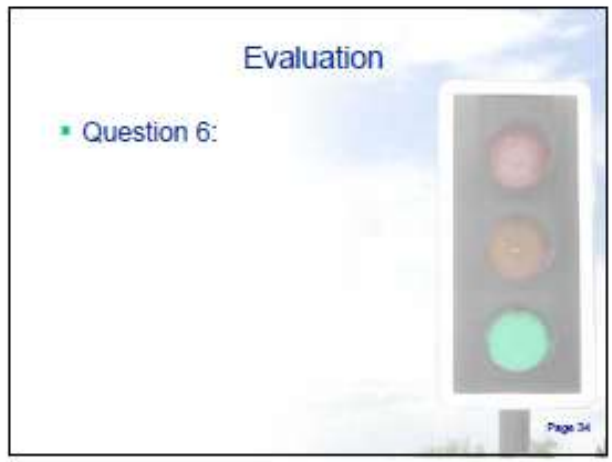

Evaluation
Question 1:
Page 29


Evaluation
Question 2:
Page 30


Evaluation
Question 3:


Evaluation
Question 4:

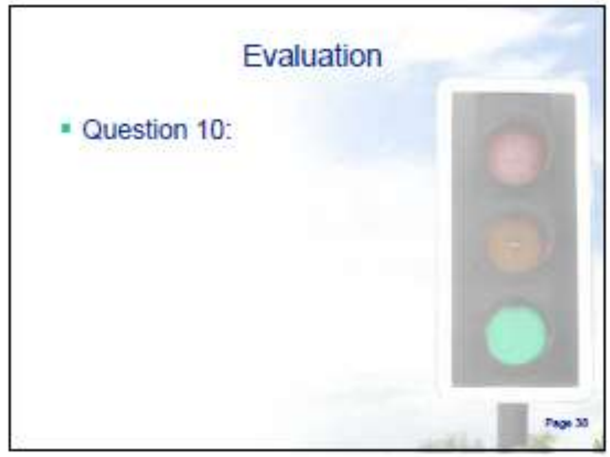

Evaluation
Question 5:


Evaluation
Question 6:


Evaluation
Question 7:


Evaluation
Question 8:


Evaluation
Question 9:
Page 37


Evaluation
Question 10:
Page 38

Geometric Design

Geometric Design

Outline

- Purpose
- Roadway elements
- Horizontal curve
- Vertical curve

Page 2

Purpose

- Understand the road
- Recommend improvements
- Identify reoccurring crash locations and determine if crashes happen there because of bad maintenance or design

Page 3

Purpose

At the end of this course you should be able to:

- Identify correct cross section design
- Identify components of a road
- Identify the design elements of horizontal and vertical curves
- Identify proper maintenance

Page 4

Manuals for Standards

MUTCD – Signs, striping, work zone

AASHTO Green Book Roadway design

Page 5

Cross-section

Elements

- Travel lane
- Shoulder
- Side slope
- Drainage slope on pavement
- Barriers

Page 6

Cross-section

Safe Standards for Freeways

- Lane Width = 12'
- Cross slope = 2%
- Shoulder Width = 10' or more
- Side slope = 6:1

Reference – Highway Safety Manual

Page 7

Cross-section

Page 8

Cross-section

Identifying

- Lane Width
- Drainage
- Work Zone

Page 9

Barriers

- Permanent Concrete

- Steel
  - Guard rail
  - Cable

- Crash Cushion

Components of Road

- Road Categories
- Striping
- Signage

Page 11

Road Categories

Primary purposes of roads are to provide movement and access. Larger roads are primarily for movement. They connect to smaller roads which provide access.

- Freeways
- Arterials
- Collector Roads
- Local Roads

More movement
Less access

More access
Less movement

Page 12

Freeways

- Controlled access
- Grade separation (no signals)
- High speeds (55+ mph)
- Maximum safety measures
- Highest level of scrutiny in design
- Examples
  - I-15
  - I-80
  - SR201 East of 7200 West

Page 13

Page 14

Arterials

- No grade separation, but limited access
- Can be principal (major) or minor arterials
- Often multiple travel lanes
- Moderate speeds (40-45 mph)
- Examples
  - Bangerter Highway
  - State Street
  - Foothill Blvd.
  - 10600 South

Page 15

Page 16

Collectors

- "Collect" traffic from local roads to arterial roads
- Can be major or minor collectors
- Compromise of speed and access
- Generally 35-40 mph
- Examples
  - 2100 South frontage road

Page 17

Page 18

Local Roads

- Smallest roads in network
- Allow essentially unlimited access
- Low speed (20-25 mph)
- Lowest level of scrutiny in design
- Examples
  - Cul-de-sac

Page 19

Page 20

Page 21

Page 22

Striping

- Color
  - White
  - Yellow
- Type
  - Solid
  - Skipped – 10' stripe, 30' gaps
  - Dotted – 3' stripe, 9' gaps

Page 23

Striping Standards

- Good
  - Striping should be visible
  - Correct striping in correct locations
- Bad
  - Striping that is fading and deteriorating
  - Striping in travel lanes through intersections

Page 24

Signage

- Regulatory Signs
- Warning Signs
- Guide Signs
- Information Signs

Page 25

Signage Standards

- Good
  - Correct size and color
  - Good location
- Bad
  - Repetitious (2 stop signs)
  - Vague or incorrect information
  - Knocked down
    - Severity (category)

Page 26

Curvature

- Horizontal Curves
- Vertical Curves

Page 27

Horizontal Curve

Designed to provide safe, continuous operation at a design speed

Page 28

Horizontal Curve

Designing a curve

- Find safe minimum radius
- Radius is a function of speed, superelevation and friction
- Superelevation - slope of the road around a curve

$$R_{min} = \frac{V^2}{15(0.01e_{max} + f_{max})}$$

Velocity (MPH)

Superelevation

Friction typical = 0.15

Page 29

Horizontal Curve

What does it mean?

- If incidents reoccur on a curve it is because the design of the superelevation, posted speed, or length of the curve was incorrect.
- Other causes
- Try to visually see what could be the cause. Report findings.

Page 30

Vertical Curve

Gradual change between two tangent grades

- Crest
- Sag

Page 31

Vertical Curve

- Crest

- Sag

Page 32

Vertical Curve

- Reaction Distance + Breaking Distance
- Reaction Distance is the length of the roadway ahead that is visible to the driver

  $d_{reaction} = 1.47Vt$ V = velocity, t = time (2.5 sec)

- Breaking Distance is the physical distance needed to stop a vehicle

$$d_{brake} = \frac{V^2}{30\left(\left(\frac{a}{32.2}\right) \pm G\right)}$$

Acceleration (feet/sec) Usually 11.2

Grade (%)

Page 33

Vertical Curve

- Stopping Sight Distance (SSD) = Reaction Distance ($d_{reaction}$) + Breaking Distance (d_{brake})
- With SSD or S the length of a vertical curve can be determined

Page 34

Vertical Curve

Length of the curve is a function of Stopping Sight Distance

- For Crest

$$When\ S < L \quad L = \frac{AS^2}{2158} \qquad When\ S > L \quad L = 2S - \frac{2158}{A}$$

Algebraic difference of tangents

Stopping Sight Distance (ft)

- For Sag

$$L = \frac{AV^2}{46.5}$$

Velocity (MPH)

Page 35

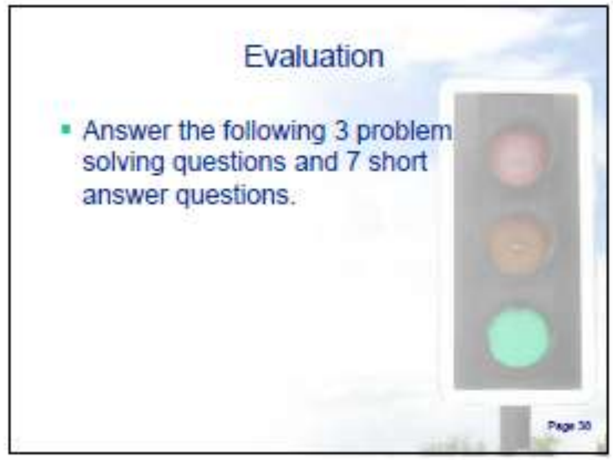
Vertical Curve

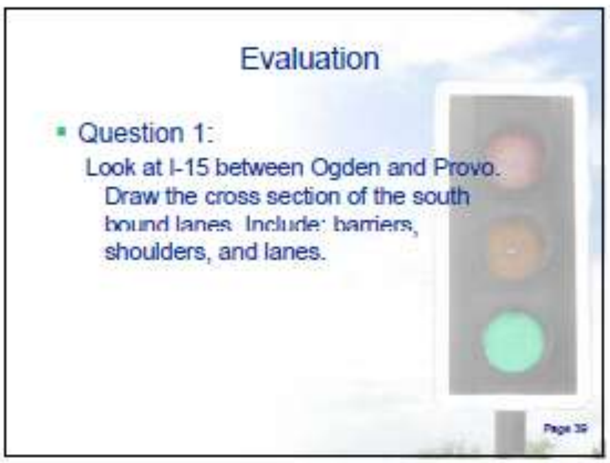
What does it mean?

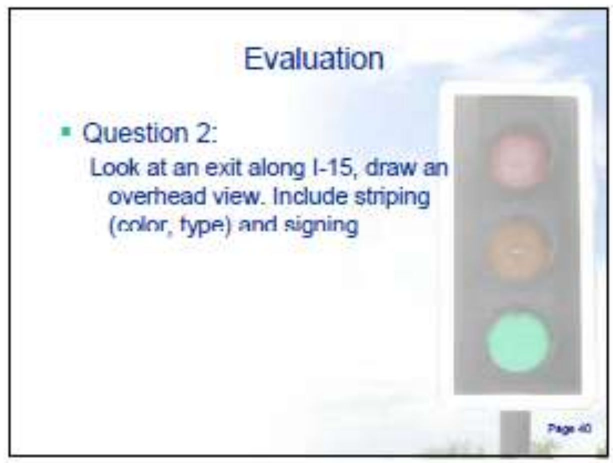
- If incidents reoccur on a curve it is because the design of the Stopping Sight Distance (SSD) for the curve was incorrect.
- Look at problematic vertical curves. Are accidents fender benders because drivers can't see cars in front of them? Report.

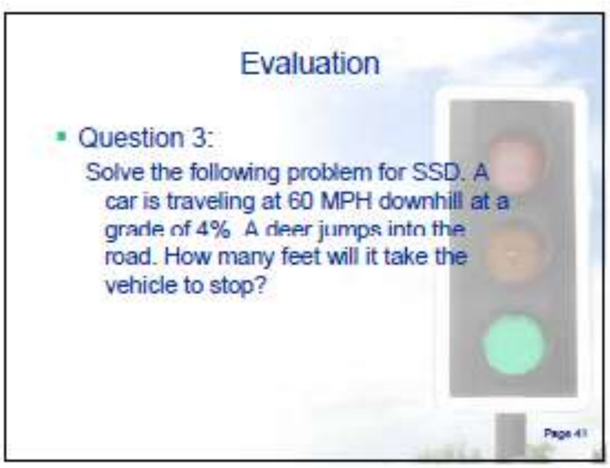
Page 36


Summary
Understanding of road design
How to Identify bad design or maintenance issues
Page 37


Evaluation
Answer the following 3 problem solving questions and 7 short answer questions.
Page 38


Evaluation
Question 1:
Look at I-15 between Ogden and Provo. Draw the cross section of the south bound lanes. Include: barriers, shoulders, and lanes.
Page 39


Evaluation
Question 2:
Look at an exit along I-15, draw an overhead view. Include striping (color, type) and signing
Page 40


Evaluation
Question 3:
Solve the following problem for SSD. A car is traveling at 60 MPH downhill at a grade of 4%. A deer jumps into the road. How many feet will it take the vehicle to stop?
Page 41


Evaluation
Question 4:
Describe the 3 types of barriers.
Which is the strongest, used to separate different directions of travel on freeways in cities?
Page 42

Evaluation

- Question 5:

  Name a freeway, an arterial, and a local road.

  (name roads you are most familiar with, roads you use to get to work)

Page 43

Evaluation

- Question 6:

  How long is each stripe and the gap in between on skipped striping?

  On dotted striping?

Page 44

Evaluation

- Question 7:

  What is superelevation?

  Explain a crest vertical curve and sag vertical curve. (use drawings)

Page 45

Evaluation

- Question 8:

  What are some of the design elements in cross-section that you as an operator can see through the cameras?

Page 46

Evaluation

- Question 9:

  What are some of the design elements in the road way elements that you as an operator can see through the cameras?

Page 47

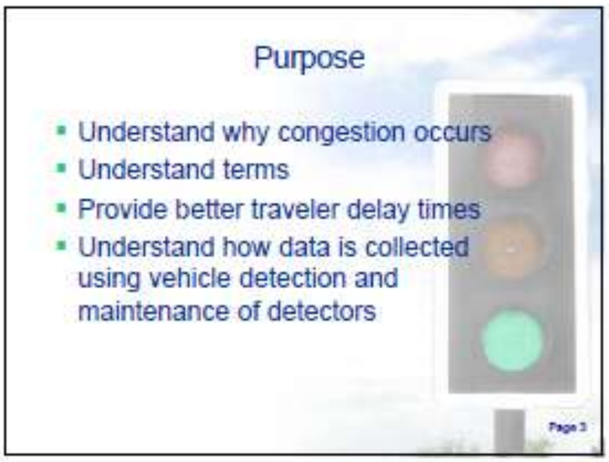
Evaluation

- Question 10:

  What are some of the design elements in curvature that you as an operator can see through the cameras?

Page 48

Traffic Flow



Occupancy

Defined as the percent of time a given section of roadway is occupied by a vehicle and can be used as a surrogate for density. Occupancy is measured using presence detectors and is easier to measure than density. Occupancy is measured on a lane-by-lane basis, with values ranging from 0 percent (no vehicles passing over a section of roadway) to 100 percent (vehicles stopped over a section of roadway).

Page 7

Speed

An important measurement in determining the quality of traffic operations. Speed is frequently used to describe traffic operations because it is easy to explain and understand. Speed measurements are typically taken for individual vehicles and averaged to characterize the traffic stream as a whole. Measured speeds can be compared to optimum values to estimate the level of operations for a freeway or to detect incidents. For example, an alarm for an incident detection system might be triggered if average speeds fall below a target value.

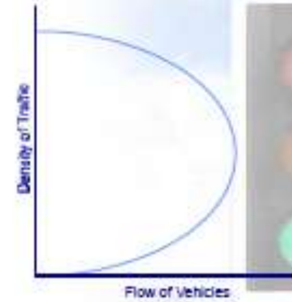
Page 8

Flow

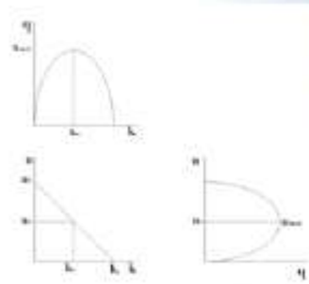
- Flow (q) is the number of vehicles passing a reference point per unit of time, and is measured in vehicles per hour. The inverse of flow is headway (h), which is the time that elapses between the ith vehicle passing a reference point in space and the i+1 vehicle. In congestion, h remains constant.

Page 9

Relationships



Page 10



Page 11

Perspective of Operator

Page 12

Queuing Theory

- Queue = line
  - Queue is formed when arrivals wait for a service or an opportunity.
  - Characteristics needed
    - (1) Arrival Distribution
    - (2) Service Method
    - (3) Characteristics of the Queue Length
    - (4) Service Distribution

Page 13

PeMS

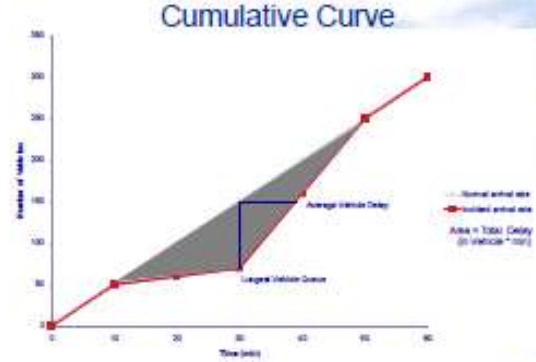
- Validation of data
- Cumulative curve
- Software

Page 14

Validation

Page 15

Cumulative Curve



Page 16

PeMS Software

- What is it?
- Purpose
- Procedure

Page 17

Page 18

Vehicle Detection

- Types
  - Inductive loops
  - Passive infrared system
  - Microwave radar
  - Video detection systems
- Perspective of operator

Page 19

Inductive Loops

Page 20

Passive Infrared System

- Tolling

Page 21

Microwave Radar

Page 22

Video Detection Systems

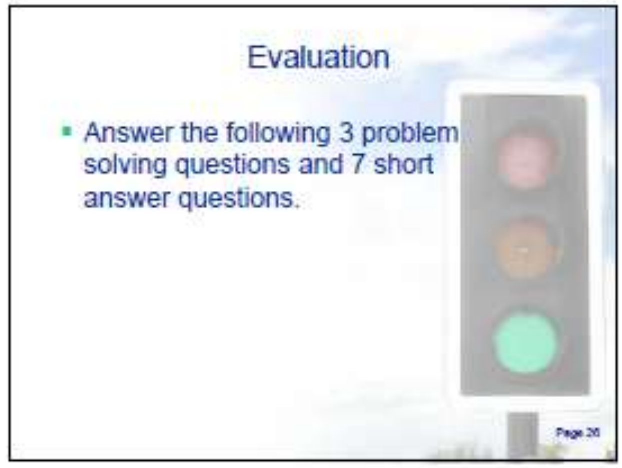
Page 23

Perspective of Operator

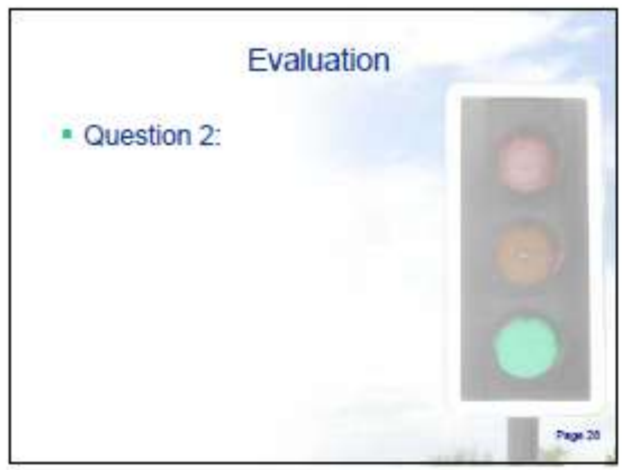
- Identify on CCTV

Page 24


Summary
Page 25


Evaluation
Answer the following 3 problem solving questions and 7 short answer questions.
Page 26

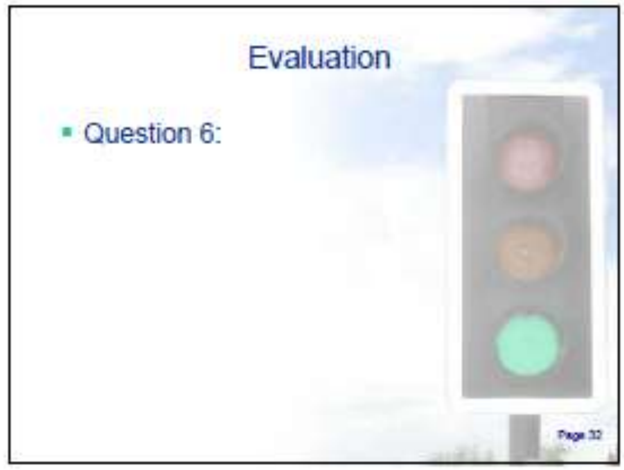

Evaluation
Question 1:
Page 27


Evaluation
Question 2:
Page 28

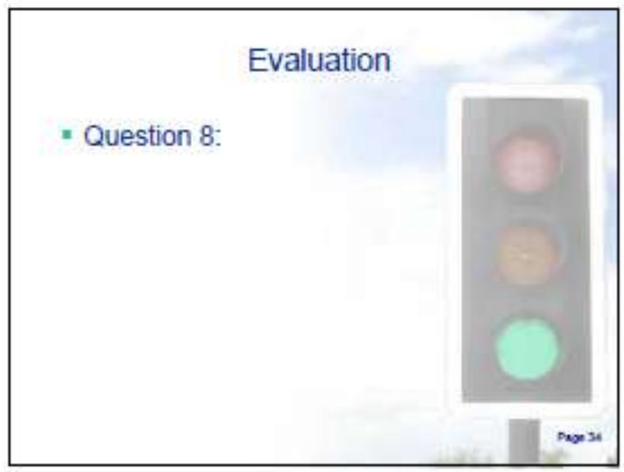

Evaluation
Question 3:
Page 29


Evaluation
Question 4:
Page 30


Evaluation
Question 5:
Page 31


Evaluation
Question 6:
Page 32


Evaluation
Question 7:
Page 33


Evaluation
Question 8:
Page 34


Evaluation
Question 9:
Page 35


Evaluation
Question 10:
Page 36