Vincent Valdes: ITS Standards can facilitate the deployment of interoperable ITS systems, and make it easier to develop and deploy regionally integrated transportation systems. Transit standards have been developed by transit professionals like you at a national level to encourage competition and limit costs within our industry. However, these benefits can only be realized if you know how to write them into your specifications and test them. There are now a series of modules for public transportation providers that cover practical applications for promoting multi-modalism and interoperability in acquiring and testing standards-based ITS Transit systems.

Carol Schweiger: I want to welcome you to Module 13, which is an Introduction to Integrated Corridor Management.

Carol Schweiger: My name is Carol Schweiger, and I'm president of Schweiger Consulting, in the Boston area. I have about 36 years' experience in intelligent transportation systems consulting, and have done quite a bit of work in the public transportation, ITS arena, which has led me to help with some of the standards training that you'll be receiving today.

Carol Schweiger: So let's move right into our learning objectives for this particular module. The first learning objective is to give a definition of integrated corridor management and the key components of integrated corridor management. The second learning objective is to identify and describe the standards that are being used within integrated corridor management systems, and the third learning objective is to describe to you some actual ICM deployments, the standards that they have used in those deployments, and actually how they're being used. So those are our three Learning Objectives, and we'll move right into the first learning objective.

Carol Schweiger: So here what I want to start with is a definition of integrated corridor management, and as you may or may not be aware, corridors often have unused capacity in terms of things like being able to use a parallel route, using a non-peak direction on a freeway, transit services that actually could be used in a situation where there's congestion. And so in an ICM corridor, because of the proactive management that goes on, travelers can actually receive information that gives them a picture of the whole transportation network within which they're traveling. So travelers could actually make decisions on the fly to go to an alternate transportation option that they have, even if it's during the trip that they're taking. They may be able to get off and park at a park-and-ride and take transit, for example. So it gives them a lot of information about making decisions about their travel. So transit could be one of the options that's used. An alternate definition is that ICM is the proactive joint multimodal management of transportation infrastructure assets in a corridor that would be used by system operators and managers, and really the point here is to optimize the use of that existing infrastructure. One thing I want to briefly mention was that the USDOT had eight what they called pioneer sites in a five-year initiative that developed, deployed and evaluated ICM concepts, in eight of the United States' busiest corridors; and then from there they've selected two of those corridors to fully develop an ICM system, and we're actually going to talk about those two corridors-- one in Dallas, Texas, and one in San Diego-- when we get to the actual examples of ICM systems that have been deployed.

Carol Schweiger: I want to start by talking about four basic concepts that you need to understand when you're looking at potentially developing or deploying an ICM system, and the first one is called Corridor Modes of Operation. So the important thing here is to note that there is a distinction between the corridor modes of operation that we're going to talk about and the actual transportation modes themselves, like transit, auto travel, trucking, and those kinds of things. So a corridor mode of operation refers to a particular manner in which the corridor manager or the network operator in that corridor are operating the networks that comprise the corridor. So that's really what we're talking about in this particular concept. So this is how the manager and the operators are actually operating the networks.

Carol Schweiger: The second concept is the strategic areas for ICM, and there are four of them, and you can see them on the bullets here. So within the first three of those bullets-- the demand management, load balancing, and event response-- someone can develop control strategies or actions that establish what someone is actually going to do implementing the strategy. So those first three involve implementing the strategy. The last one, which is capital improvement, typically you don't develop control strategies for that. Instead, what you're really doing is making recommendations for capital expenditures, and those could be, for example, for facility improvements or adding assets to the corridor.

Carol Schweiger: Moving on to the third concept, this is called conceptual levels within the corridor, and you can see the three bullets here-- physical, information processing, execution or decision-making, and we're actually going to talk about those in a couple of slides in a little more detail.

Carol Schweiger: And finally, the fourth concept is the actual environment which encompasses the four strategic areas that we just quickly reviewed, and the three conceptual levels. So those are really the pillars that we use to describe ICM.

Carol Schweiger: Let's get into a little more detail about each of these that we've talked about-- each of the concepts. So again, the first one is corridor modes of operation. So all corridors operate in two modes, the normal mode and the event mode. So the normal mode is the mode that has all the actions that someone's going to take to make sure that the day-to-day transportation needs are addressed. So that's a normal mode where you're looking at day-to-day operations. The event mode has actually two submodes. One is called the Planned Event Mode and the other is Unplanned. So clearly the planned event mode is when there's a known event that's going to take place that reduces the corridor capacity. A good example of that is construction along a network that's going to temporarily reduce the capacity. It could also be an event like a sporting event or something that's going to increase the demand on the network. In an unplanned event, you can imagine, that's an event that you don't expect that reduces the capacity of the corridor. So it could be an incident on the freeway, for example, that changes the demand pattern, or it could be something like an emergency evacuation. So those are the two event modes.

Carol Schweiger: So let's move a little bit further and say that a corridor can actually shift between a Normal mode and an Event mode several times during one particular day, and in addition, if an event goes on for an extended period of time, the event mode can actually become a normal mode of operation. So a case where this might happen might be major road construction that actually takes several months to complete. Now, a corridor doesn't change its mode automatically if an event occurs. The person who's managing the corridor has to assess the severity of the particular situation, the impact on the whole corridor, and the expected duration of that event before deciding to switch between normal and event mode. So for example, if the severity of the event is low, there may be no need to switch into event mode. The operator could decide to just keep things at normal operations during something like that. Another example might be a very minor crash that happens during rush hour, but it's not severe enough to actually change to event mode. Another thing that needs to take place is the actual impact of the event needs to be analyzed, and here, later on in the presentation, we're going to give you an example of a truck fire on Interstate 5 in the Greater Seattle area. That might be a situation where the operator would want to shift to an event mode because of the impact of that particular event and the duration of it. The last thing I want to mention is we really need to look at the ability of these existing corridor and the systems within the corridor to support a shift from normal to event mode.

Carol Schweiger: So let's move into what we're calling the Strategic Areas for ICM, and I had mentioned that before kind of being the foundation of ICM. And so, again, the three areas: demand management, load balancing, and event response-- are where you actually have control strategies that are actually developed, and the capital improvement is where you're looking at strategies to actually change your infrastructure or add to it.

Carol Schweiger: Let’s get into each of these particular areas. So demand management actually addresses the usage patterns of the networks in the corridor. So the demand for the networks of course changes by the time of day with rush hour times, the day of the week-- so that would be weekdays versus weekends-- and the time of year, which could include there's a school vacation or there's a major holiday, like Thanksgiving or something like that. And so here, the actions that the corridor manager will take to manage the demand involve either changing the pattern of that demand or addressing changes in the patterns that have occurred without the manager doing anything. So that's really what we're looking at here. And the type of actions that a manager might apply depend on the mode of operation in the corridor. So the actions that address normal mode operation are actions that are usually fairly long-term-- they have long-term effects-- or they require longer lead times to actually implement.

Carol Schweiger: So let's move on to the second strategic areas, which is load balancing, and here load balancing addresses how travelers are going to use the networks within the corridor that's being managed. So ideally you have a situation where each network would carry as many travelers as it's capable of carrying without any kind of delay during the time that it's being used, and so it's really being used at its maximum effectiveness, but that's really not a realistic situation because networks don't really address all of the needs in a corridor. So what you have is load balancing, and during normal mode operation, that might involve actions that encourage people to shift trips from one mode to another mode. So it might be encouraging people to take transit in a corridor rather than driving alone in their car. Another example is really a corridor manager might have-- during a period of congestion, during peak times-- might encourage the transit folks to actually put on some extra service, and then the manager would inform travelers of the availability of transit, maybe at some parking locations within the corridor. So that's a good example of a shift from private vehicles to transit usage. Load balancing during an event mode involves shifting as well to make the best use of the network's capacity. So here you're really temporarily increasing the throughput of the network, and that can be planned in advance or something that is done on the fly, where you're making decisions in a very quick kind of a situation. And here you might be increasing transit service, for example, during a holiday to encourage travelers to use a different mode of operation.

Carol Schweiger: During event response-- this is the third part of our strategic areas for ICM. So events are really-- we've talked about them before. They're a situation where either the capacity of a network has changed or the usage of the network has changed. So here, the events can be categorized by, you see here, duration, short-term versus long-term, for example, or by their effect. So some of the effects that you see here on the slide would be a reduction in the capacity, an increase in demand, or a change in the demand pattern. So that's fairly straightforward to understand based on what we've talked about before in terms of events.

Carol Schweiger: So now we come to the area where you're not developing control strategies; rather you're looking at potentially adding capacity with new facilities or adding assets. So really, when you think about capital improvements, it's a long-term approach, and that's because funding may need to be secured and capital improvements can take a very long period of time to actually implement. So the usage of the network or the transportation system can change while that capital improvement is taking place and you can actually plan for that before the completion of it. You also want to assess the changes that you expect because of putting that capital improvement in place. So you might be using some analytical tools, for example, to do that evaluation, and you may be using technology on new facilities that'll actually help you with the corridor management going forward.

Carol Schweiger: So just to reiterate, here are our four areas. We've talked about the three sort of pillars, but the demand management, load balancing and event response is where you're actually developing control strategies, and the capital improvement is a little bit longer of a period of time to plan for those additional assets or changes that you want to make from a facility perspective.

Carol Schweiger: So now we're going to talk about the three conceptual levels, and we kind of introduced them a little bit before, but I want to get into a little more detail. So let's start at the very bottom of the slide, where we're talking about the physical level. So the physical level is really the infrastructure within the corridor, and it's the most tangible because you can actually see the infrastructure. So it actually consists of those infrastructure components. So you'd have facilities, which would be the networks that use those facilities; the actual transportation modes that you have-- so transit would be one of those; the devices that are being used in the facilities, in the networks, or being used by the modes of travel; the data that is being generated by the devices in the field; and then the communication networks that actually transmit the data from the devices to the next level which we're going to talk about, which is information processing. So the second level, the next one up, the information processing and sharing level, that's where you have the tools and the information systems to actually utilize the data that's being generated and translate that data into actions or decisions that can be made by the corridor manager. So here we're talking about computers that are actually processing and storing the data that's being generated at the physical level that we talked about. You may have some display devices to present the information in different formats-- you might present it in graphic form or text form; the databases that actually store the data; the devices that are used by the corridor manager or operator to actually manually enter data into the system; and the communication devices that allow the exchange of information among the people who are managing the information. So then that allows us to go to the next level up, which is the decision-making level. This one is the most intangible, because this is where you're using the information generated in the analysis that was performed in the second level and you're actually making decisions and executing the actions that you've developed to change things in the corridor. So the intangible components-- you can probably already guess that they're actually the plans that you're putting in place to make changes to the networks within the corridor, and those on-spot decisions that you're making in response to the conditions within the corridor. So the controls that the manager is using to operate the networks are part of this level as well. So you're really dealing with the decision-making, based on those other foundations.

Carol Schweiger: Okay, so now we've talked about those three earlier concepts which really constitute now the fourth concept, which consists of those strategic areas that we spoke about and the conceptual levels that we just talked about, which are the stair steps.

Carol Schweiger: So now what we're going to do is we're going to move into “ hy do all these things?” what is really the benefit of using integrated corridor management, and so on this slide you can kind of see the overall benefits, and there aren't a large number of ICM projects that are fully deployed, but the several that have been fully deployed, there have been analyses done that have led us to these overall benefits that we can talk about when you deploy ICM. So in addition to these, which are the most prevalent benefits that have been experienced by some ICM systems, there are a few more that I want to briefly mention. ICM really gives you more of a corridor-wide or multimodal view of technology in operations, and that's primarily because the managers of the various modes are sharing information constantly as they operate their particular facilities and vehicles. This kind of leads directly to improved coordination and communication and the integration between the stakeholders, which is also very important and not something we really talked about a lot before. So it's improving the institutional situation. You're really providing an information clearinghouse for all the stakeholders, which is very, very important, so everyone is working off the same sets of information with which to make decisions. There's typically more standardization and system operability in ICM systems, and that's why we are talking about standards, and our next learning objective really addresses that. We talked a little bit about improved coordination of networks prior. We are developing actually, with ICM, models that we can use to simulate corridor operations. So we can do some things offline that help us understand the various scenarios that we might want to use in managing the corridor. It leads us sometimes the joint use of resources and infrastructure. There's really increased public outreach because one of the primary benefits of ICM is giving the traveler better information about their trip. It also can lead to increased transit usage in the corridor if the corridor managers are utilizing some capacity within the transit system that's being used, and it also leads us to developing methods to actually screen and monitor the corridor. So that's also very important, so you're constantly improving the knowledge base.

Carol Schweiger: So let's move into an example of a scenario that could happen. This is in the Interstate 5 corridor within the Greater Seattle area, and what you can see here, there's 30 miles of Interstate 5, which happens to have reversible high-occupancy vehicle lanes in the median. There's also 20 miles of Interstate 405 that also have HOV lanes, but the key thing is that it parallels Interstate 5. There's 24 miles of State Route 99, which also runs parallel to Interstate 5, and there's a commuter rail service which provides four trips daily between Everett, Washington, which is at the very top of the map, and Seattle, which is about two-thirds of the way down the map. So that kind of sets the stage for you. There are also three major crossroads that intersect the corridor, that you can see here.

Carol Schweiger: So we could have a situation-- our example scenario is: What happens if there's a major incident on Interstate 5, where that red marker is here on the map? And let's say that it actually closes Interstate 5 for an extended period of time. So this could be something like a truck fire that has occurred on Northbound Interstate 5 between Exits 170 and 172. So it's closed all the northbound lanes on Interstate 5, and the fire is expected to keep those lanes closed for an extended period of time-- let's say 12 hours, for example. And at the time of the incident, which was around 1 p.m., the HOV facility is closed at that particular time of the day.

Carol Schweiger: Let's take a look at what's actually happening here when you have an incident like this. So without an ICM approach, and without having an ICM system that would help the operator within the corridor to actually implement some ICM strategies, it actually might not have been possible for the operator to respond in an effective way to a major incident like this. So if you don't have those things in place, it could be very, very difficult for the manager to do something to get the pieces back together, and in general what does that manager or operator actually want to do? They want to ensure that the travelers are safe and away from the incident. They want to make sure that the travelers are not stranded completely. They will want to provide alternatives that are actually viable alternative, and they want to keep the traveler informed of what's happening throughout the course of this incident. So the emphasis is really on the traveler, because that's-- you want to get the traveler away from the incident, you want to keep them moving, and so here, remember we actually have some transit in place, our commuter rail system, and so the commuter rail system in this case actually has some unused capacity. Right now there's only about a thousand people per day that's using it, and so without an ICM we may not even think about the transit system as being an alternative for people. So we have to really be thinking about what's necessary to have all of the corridor stakeholders have the same information, but you can imagine, without having all the same information, there could be various reactions going on that actually don't go very well together to help the traveler to move through this incident.

Carol Schweiger: So now let's look at what we could do with ICM, and here is a list of the actions that could actually be taken during this incident. So we could implement signal timing plans that actually favor State Route 99, which we pointed as running in parallel to Interstate 5. You could coordinate the Interstate 5 ramp meters that are north of Exit 172-- remember our incident is between Exits 170 and 172. And you could also coordinate the traffic signals in that region so you're moving people through State Route 99 quicker. You could place some detour signage on State Route 99. You could use law enforcement people to facilitate the traffic at intersections that are not under the control of the ICM system. Obviously you're going to let travelers know about the incident and maybe give them suggestions for alternate modes or routes they can take. You could lift the HOV lane restrictions which are in effect at the time of the incident. You could eliminate parking restrictions. You could make some changes to transit service where you might add some vehicles. You might provide a free shuttle service and add service on the commuter rail system which is not highly used at the moment. So that's kind of a very long list of actions that could be taken, but they would be taken in concert with all of the stakeholders in the region so you can get the corridor back in working mode for those travelers that are on the road at the time.

Carol Schweiger: So I want to briefly talk about the role of standards. Clearly standards are going to make it a little bit easier for this coordinated approach in a corridor. So let's take a look at the types of standards. Under this general category of Control and Real-Time Management, we have these standards. We have some traffic signal standards, and we're going to speak about each of these, so I'm not going to talk about each of them at this point in time. But you have traffic signal standards that you can use, and you also have device standards that you can use. So really the point is to show the ability of these standards to facilitate integrated corridor management. That's what we're going to be talking about, so that all the operators in the facilities are really speaking the same language.

Carol Schweiger: We have another category of standards that are used in integrated corridor management, and those are called Data Sharing Standards. And again, we're going to speak about each of these standards so I'm not going to spend any more time. Just giving you the list here, and then we'll get into more detail.

Carol Schweiger: So now we have a question, and it's our first quiz, if you will, about the material that we just covered.

Carol Schweiger: The question is: Which of these is not a benefit of integrated corridor management? And we have four answer choices. A is reduced fuel consumption. B is improved customer service. C is reduced travel time variability. D is better utilization of transit excess capacity. So again, which of these is not a benefit of ICM?

Carol Schweiger: So let's talk about the answers now. The correct answer is B, improved customer service. So while there could be improved customer service as a result of having ICM in place, it's actually not a direct benefit, as we discussed the direct benefits before. So answer A is actually incorrect because this is a benefit of ICM. ICM is really expected to save hundreds of thousands of gallons of fuel that are being used by travelers on an annual basis. Answer C, reduced travel time variability, is incorrect because, again, this is a direct benefit of ICM, and there is an expectation that ICM will improve travel time reliability from a reduction in the variance in travel times. And then D is also incorrect because ICM is expected to utilize that excess capacity that transit may have in a corridor.

Carol Schweiger: So now let's move right into the standards discussion. So as you recall the Learning Objective 2 is to identify standards that are being used within ICM systems and describe those.

Carol Schweiger: So let's move into that first big group that we talked about-- we're going to talk about each of these individually-- and the first one is the National Transportation Communications for ITS Protocol, or NTCIP, and I suspect that some of you are aware of several the NTCIP standards, and we're actually going to talk about them.

Carol Schweiger: But I want to show you sort of graphically what's more important in a corridor situation here. So we're talking about NTCIP, which is a family of standards, that defines protocols and profiles that are open-- basically open standards-- so everybody can utilize them. So when they're used, for example, for the remote control of roadside or other devices that might be used in a corridor, NTCIP-based devices and software can help achieve that interoperability that we talked about previously, and when you're using a transportation or an emergency management center, for example, those standards are going to facilitate the agency coordination and information-sharing among the agencies that might be resident in that center. So here we're talking about, again, interoperability. We're also talking about interchangeably, which are really two key goals of NTCIP standards, and those terms really reflect the ability to use different brands of devices on the same communications channel within the same corridor, along with the ability to utilize maybe a new asset by a different manufacturer, for example. So that's what we're talking about. And what this diagram really shows you is that there's going to be a lot of exchange of information among assets that are out in the field. So we're talking about center-to-center communications, which is that oval in the middle, that is exchanging information among all of these various systems that might be present in the corridor. So that's really what we're looking at, and you can see that we actually have several transit-related systems that could be in operation within the corridor that are exchanging information with all of the other systems. So that's the overall picture of using NTCIP in ICM.

Carol Schweiger: Let's talk about some of the other standards that we listed. So we have here the actuated traffic signal controller, which is NTCIP 1202, and it happens to be version 2-- that's the most covered version-- and really, that provides the vocabulary, the commands, the responses, and the information that's necessary for the managers and the operations people to control, to manage and monitor the signal controller units that are out in the field. So you have a situation where there might be communication between a transportation management center and the signal controller units that are in the field. So they would actually be utilizing this particular standard. And users of this need to determine which objects and groups of objects are really needed to support the functionality for ICM specifically. So that's an important point.

Carol Schweiger: Moving into the next set of standards, it's called the Signal Systems Masters, and it's NTCIP 1210 and at the current time it's version 1, and here again, we have the vocabulary, the commands, the responses, and the information that are necessary to monitor the signal system masters and the signal system locals through the masters that are currently in the field. So the signal system master device actually acts as a surrogate for the traffic management system, and this particular standard provides a means to communicate from the traffic management system to a local device. Here we actually have a concept of operations that you can look at, functional requirements that you can actually use in a specification, and object definitions to support the functionality in the field. So that's the signal system masters.

Carol Schweiger: And then we have the Signal Control and Prioritization standard, which is NTCIP 1211. Right at the current time it's in version 2, and again, we have the same things where we want the operations folks and the monitoring folks to implement vehicle prioritization schemes that may be resident out there. So a good example of that might be where you're going to provide transit with a priority at a particular signalized intersection. So it also describes the scenarios that could take place, the prioritization scenarios, and configuration of devices that are in the field, and here you really want all the devices to be speaking the same language. That's really what you're getting at by using this particular standard. Also it's important to note that this standard actually has to be used with one of the NTCIP communications profiles that we talked about before, which provides the communication channel so that information is being shared among devices like this.

Carol Schweiger: Let's move on to the next standard, which is actually a family of standards that's being used, and it's really a combination of ITE, AASHTO and NEMA ATC standards. And so here, this family of standards defines the field controller devices that are used in management applications for traffic signal control. So there are three components you can see here on the slide-- the controller, the cabinet, and the software-- and these standards define the initial software platform for the application's programming interface, the cabinets and the controller. So that's basically the ATC family of standards, and we're going to talk briefly about each of them.

Carol Schweiger: So the cabinet is a standard, and it specifies the functional physical design requirements for the cabinet that supports having multiple ITS functions in the cabinet itself. So it's in a single cabinet. And you can see here the major components of the cabinet, and there may be a few other components that are also included but these are the major ones, and then within this standard, three cabinet assemblies are actually defined.

Carol Schweiger: Now we can move on to the actual application programming interface standard, and this particular one specifies the interface for application programs designed to operate on the ATC controllers regardless of the manufacturer. So again, we're using standards to ensure that you can use devices from different manufacturers. It allows multiple applications to be interoperable on a single controller, and that's because you're sharing the resources of the controller. You also have a software requirements specification that defines this five-layer structure that you can see here in the bullets, and the requirements of the software. It also provides the basis for the support package, which is the layer underneath the API that's part of the controller standard that was discussed earlier.

Carol Schweiger: So now let's move to the device standards, which you can see here, there are three of them that we're going to talk about that are used within ICM.

Carol Schweiger: So the first one is the NTCIP Dynamic Message Signs standard, and you can see here is an example of an actual dynamic message sign that's on the highway.

Carol Schweiger: So let's move right into that particular standard. So this standard is NTCIP 1203, and it's version 3 at the current time and, again, it's the same setup as the other standards with the vocabulary to advise the managers and the operators of the current highway conditions, which they're going to place on the sign. So a dynamic message sign, it can provide any message to the viewer that you need to provide, and you can imagine, as I mentioned before, the vocabulary part of it. So here, this standard actually includes what's called a message syntax, or MULTI, which stands for Mark-Up Language for Transportation Information, and that allows objects to be grouped into one message object. The message object is analogous to having a sentence rather than separate words so that the message object and the sentence requires some kind of syntax. So that's why you have this message syntax that's contained within this particular standard. So that's the NTCIP dynamic message sign standard.

Carol Schweiger: Let's move to ramp metering, and in this particular photo I just want to point out that it's ramp metering, but there's an interesting change a little bit from what we're used to seeing. In the left lane, it's actually a carpool lane, and if you are in the carpool lane with the appropriate number of people in the vehicle, you actually don't have to use the ramp meter; you're allowed to merge with the traffic on the highway or freeway on your own. So I just wanted to point that out, and you can see the ramp meter on the right-- that signal that's on the right.

Carol Schweiger: So let's talk a little bit about the standard, which is NTCIP 1207. Currently it's version 2. So what is a ramp meter? It's actually a traffic controller that's equipped with software and algorithms specific to a freeway ramp to control the flow of traffic that's entering the freeway, and ramp metering is actually a rate which is expressed in vehicle per hour per lane. So that's where vehicles are actually allowed to proceed through that metered lane that we showed you the photo of on the prior slide at a particular release rate. So you might say that a ramp meter is going to allow 500 vehicles per hour per lane release rate, and that's what the ramp meter would be set at. Ramp metering control is actually a system in itself in which the entry of the vehicles onto the freeway is controlled by this ramp meter that we talked about. So the ramp meter control unit consists of the field controller, the suite of sensors, the warning signs, and a stop bar that you could use on the pavement. It's a pavement marker. So that's basically our ramp metering standard.

Carol Schweiger: And now we move to the Transportation Sensor System standard, which is NTCIP 1209. Currently they're at version 2. These devices include things like smart inductive loop amplifiers, machine vision video detection, and microwave radar monitoring systems. What they're doing, as the name implies, is they're providing various methods of sensing the presence of traffic. That's really the whole point of this particular standard. So this standard defines the vocabulary of objects that are used to make sure that the TMC, or the transportation management center devices.The devices that are controlled by the TMC and the sensor systems speak the same language so they can communicate with each other.

Carol Schweiger: Now we have something that's actually called TCIP, which is contained within NTCIP, and it's the Transit Communications Interface Profiles. It's a standard that is managed by the American Public Transportation Association, and it provides a library of information exchange building blocks that allow transit systems and suppliers to create interfaces among various pieces of equipment or various parts of the transit agency.

Carol Schweiger: So here over the next slide, I'm going to show you what those building blocks are that may include interfaces. So it's NTCIP the 1400 series of standards-- that's important to know, because it's within NTCIP-- and here are the actual building blocks that we're talking about. So we have objects that speak to each of these particular areas within a transit system. So you have schedules that are developed for fixed route and demand response transit. You're providing passenger information. You may be connected to a signal priority system. We talked a little bit about that earlier. You have your operations control center within a transit agency. You have some onboard technology that's onboard buses or trains. You may be doing some spatial referencing when you're monitoring the actual transit vehicles in the field, and you'll be doing fare collection. So these are the various building blocks. What I want to point out is I could spend a lot more time on TCIP, but the ITS PCB program actually provides two modules that directly address training for TCIP so that you can understand that group of building block and the standards associated with them in specific training, and here we've actually given you the link that you can use.

Carol Schweiger: Let's now cover the data sharing standards, and we'll quickly go through these because we have actually talked about a few of them before.

Carol Schweiger: The first is center-to-center, and you may remember that diagram that I showed you before. So here, the types of communication that involve messages that are sent between two, what we call, centers, which you saw in that diagram, that's what's called center-to-center communications, and so that involves peer-to-peer communications between any of those center systems in that diagram. This type of communication is similar to the internet in the sense that any center can really request information from or provide information to any of the centers you saw in that diagram. So an example of this kind of communication is where you might have two TMCs that exchange real-time information about the inventory and the status of all the control devices in the corridor. So this allows each system, each center, to know what, for example, the timing plans are for traffic signal coordination or things of that nature that cross geographic boundaries. And then another example is where transit systems might be reporting schedule adherence exceptions that are taking place so they can communicate that to a regional traveler information center so that you can inform people about the on-time status of that transit system, and you may in fact decide that you need to use signal priority so you may be communicating with one of the TMCs to then invoke signal priority. So we talked about the peer-to-peer communications. It's similar to the Internet.

The Society of Automotive Engineers, it's the advanced traveler information system message set standard, which is J2354, and here we're providing the messages and the data elements that are exchanged among the information providers and the travelers who are consuming the information that's being provided by the information providers. So here, the most recent revisions to this standard, which is in version 2, include the use of this International Traveler Information System phrase lists for communicating things like event information, and it also added the XML-based versions of each entry and the reuse of data elements from other data dictionaries. For example, the one you see here is very prevalent in the standards for ICM-- you're actually going to see that in some of our examples-- called the Traffic Management Data Dictionary. So here the standard really provides standards for two types of traveler information systems based on whether the traveler is communicating with the provider of the information or not. So you have a situation where you might have one-way communication, where the traveler information is simply providing information to the traveler, like in a radio broadcast or on a dynamic message sign. The other is the two-way communication, where the traveler information might be accessed by the traveler actually making a specific request for information and receiving customized information. So that's the two-way traveler information. And you have things like the types of messages are in a group of actually seven types. There's traveler information; there's trip guidance; there are directory services-- like a Yellow Pages, for example-- there's information on parking; there's a settings information, which would be where the traveler would actually indicate their personal preferences for the format of the information that they receive and the content of that information; there's a category called May Day, which is about emergency information; and then there's information about reduced bandwidth, which is where you can actually provide certain data that accommodates using it in a reduced bandwidth situation.

Carol Schweiger: Let's move into another data sharing standard, which is J2266, which is the Local Referencing Message Specification, or LRMS. And you can see here-- I'm not going to read these for you-- but here we are talking about location referencing. Obviously you'd like to have a standard way of defining geographic situations, geographic objects. It could be where vehicles are located; it could be where devices are located. So here are actually 17 profiles, and they're all fairly explanatory, that talk about location referencing. So you might have actually an address, a physical address. You might have an area, like a town or a city. You could have a sequence of links that utilize nodes and the direction of the links to name a particular jurisdictional boundary, for example-- a state line or a county line, cross streets. All of these are provided within this standard.

Carol Schweiger: So let's move to the Closed Circuit TV Camera Control standard, which is NTCIP 1205, and it's in version 1, but there was an amendment to version 1. So here, this kind of standard is necessary for the control, the management and the monitoring of any cameras, lenses, or pan-tilt units that are used in the field. So you've probably seen a lot of these that are monitoring traffic on a particular highway facility, for example. So here, we're defining the vocabulary of objects for closed circuit television so that they speak the same language. Again, we're looking at that vocabulary to ensure that we're speaking the same language among devices.

Carol Schweiger: Now, another category that we've talked about previously is standards that are associated with monitoring the conditions of a corridor, and we've actually done those already, so we're not going to go back and review them again, but the TSS, the signal standards, and the closed circuit TV standards that we just covered.

Carol Schweiger: So now we have a little quiz question that we're going to ask based on the information that I gave you about the standards that are being used.

Carol Schweiger: So the question is: Which one of these device standards does not provide control and real-time management? And the answer choices are, A, NTCIP ramp metering; B, ATC application programming interface, or API; C, NTCIP transportation sensor system, or TSS; and D, NTCIP dynamic message signs. So those are your answer choices.

Carol Schweiger: Now, let's review the answer to the quiz question. The correct answer is B, ATC application programming interface, and the reason why this is correct is because this particular standard happens to be in the category of traffic signal standards for control and real-time management. The other answer choices are incorrect because they are part of the control and real-time management. So we had ramp metering, we had the TSS or the transportation sensor system, and that one provides control and real-time management as well, and we have the dynamic message signs standard. So that's the review of our answers.

Carol Schweiger: So now let's move into the last learning objective, which is actually running through some very good examples for you of real integrated corridor management systems and points out the standards that they actually are utilizing.

Carol Schweiger: So we're going to start with San Diego, which was one of the two integrated corridor management sites that was selected after the original eight sites that were used, called pioneer sites, that I mentioned a little bit earlier. So in San Diego, there's an integrated corridor management system that we show the basic components here. We are in the Interstate 15 corridor, which you can see on the map is sort of to the right of the center of the map, going from north to south. And the vision for the integrated corridor management system itself was to proactively and collaboratively manage that I-15 corridor to maximize the system performance and to enable travelers the opportunity to make convenient shifts among the various modes that are being used in this particular corridor. So let's look a little more closely as to what the components are. So I zoomed in on the map a little bit for you to see the 21-mile segment of Interstate 15 that's part of the corridor management system, and here, why is that particular corridor important?

Carol Schweiger: It is because it's used by commuters and goods movement providers from north of San Diego to the downtown area. So it's a very heavily used corridor, and you can tell by the volumes of traffic here that show you how heavily it's used. It also has managed lanes within that corridor and also bus rapid transit, and it also has variable pricing within the managed lanes. So it's a pretty good use of integrated corridor management.

Carol Schweiger: And really, again, to sort of reiterate what we've said here, is we're trying to improve the mobility in that particular corridor. So all of the corridor operations are coordinated through this ICM system where the various networks and agencies are all going to share data and information and make the changes that are necessary to benefit the traveler that's actually going throughout the corridor. So you can see at the bottom of this slide the stakeholders that are all coordinating what they're doing based on the same sets of information that they have access to because of the ICM. We're going to talk about one of them-

Carol Schweiger: This is the heart of the ICM that's actually being used in San Diego. So you can see that on the left is a red box with yellow lettering that says DSS Subsystem. That means Decision Support Subsystem, and anything that has yellow lettering means that this is a future capability that is right now in the process of being added to the San Diego system. You can also see on the right,a green box that is part of our ICM system that says IMTMS, and that stands for Intermodal Transportation Management System, and that's also a subsystem of the bigger ICM system. You can see it's in green, and the white lettering indicates that it's an existing or partially existing capability. That's what the white lettering is all about. And so going back to what is the red versus green, anything that's in green is-- I'm sorry, anything that's in red is considered a candidate system, so it kind of goes along with the yellow lettering, meaning it's going to be added in the future, and the green are the systems that are already in existence. So let's take this a step further, because there are several sort of modules within each of these subsystems that I want you to be able to think about.

Carol Schweiger: So overall, in the overall system, you're providing core functionality in these three blue boxes that we added under the overall system. So anything that's in blue, by the way, indicates core functionality and it draws upon all of the systems that you see below it. So we have these three major functional subsystems. And now let's break down each of the subsystems into their component pieces.

Carol Schweiger: So within the Decision Support subsystem, we have these various systems that are going to take-- that are going to be used within the subsystem. And again, they're in yellow lettering because they're being added as we speak, to be completed in the future. So we have a response plan, conferencing, event management, which we talked about a lot before, corridor management, and modeling. And again, the modeling might be used to predict what is going to happen in a corridor situation, could be a specific planned or unplanned event.

Carol Schweiger: So now I want to kind of put it together with some of the existing and future systems on the right-hand side in the IMTMS subsystem, and you can see-- I'm not going to read them all-- there are several with the white lettering that are already in existence, but there are some in yellow lettering that are actually being added. There is a full graphic that is in the Student Supplement that you can look at.

Carol Schweiger: So let's talk a little bit about how the ICM system in San Diego actually works. The ICM system really leverages the San Diego region's extensive ITS networks that are already in existence, and you could see that in the prior slide. So they're using those existing systems to help them with the corridor management, and we looked at what some of those were already. There's a 511 system that's in place. There's an advanced freeway traffic management system that's in place, and so we have those systems that are already in place. The ICM, again, is enabling the systems to talk to each other, which is one of the key components of ICM. It allows them to all use the same information to monitor the conditions in the corridor and the congestion. It helps them generate response plans to the problem in the corridor.

Carol Schweiger: And so now what I want to do is show you the actual standards that are being used within this corridor management system that actually makes the things that I just mentioned happen. So in San Diego, the three basic standards are the Intermodal Transportation Management System, which we showed you in the green box. It uses the Traffic Management Data Dictionary, or TMDD, version 2.1, for the data definitions, and that's very, very important here because that's a dictionary that a lot of traffic management or transportation management centers actually utilize, and we referred to it earlier. It also uses NTCIP 2306 for center-to-center communications, which we talked about before, and there is an IMTMS Systems Design Document that was developed when the ICM was being developed, and that's also being used in the IMTMS. There are also standards being used for the 511 system in San Diego, and there are three of them. We mentioned TMDD already. We mentioned the center-to-center message interfaces, and it's also utilizing another design document, which was done for 511 specifically, the interface between the IMTMS and the 511 system. So those are the standards being used for 511 dissemination of information. And finally, this is very transit-specific. It's called OrbCAD, which happens to be a brand name from the provider of San Diego's computer-aided dispatch and automatic vehicle location system, and there is an interface control document that was developed to make sure that the communication between that system and the regional system was standardized, so the interface is standardized, and that's the document that is being used for the standard.

Carol Schweiger: Let's talk a little bit about what and when the ICM system was put in place, what kinds of benefits did they actually experience when they did the evaluation of the system. So it allowed them to identify incidents and anything that was unusual in terms of congestion. It also allowed them to develop traffic management strategies that integrated all of the modal elements. So it integrated freeway, the arterial and the transit operational elements, and it allowed them to implement the strategies, either automatically through that IMTMS system we were looking at, or manually by the specific operators of the various systems. So it's really demonstrated the feasibility of using models, simulation models, and developing some of the scenarios ahead of when they actually happen so that they can implement a strategy very quickly.

Carol Schweiger: So in terms of the second system, which is the Dallas ICM system, that we talked about earlier, let's talk a little bit about the basic components. So the vision for this ICM system was to manage the operations of the US-75 corridor. Again, it's a multimodal corridor. It has various elements that I'm going to talk about in a minute. But the overall vision for this system is to increase the throughput of the corridor, improve the travel time reliability, improve the incident management response, and to enable travelers to make changes among modes if they need to. So this particular corridor covers US-75. We're talking about these particular lanes of travel carry over 330 thousand vehicles a day, and then there are another 20 to 30 thousand vehicles on the frontage roads near US-75, in that corridor. There are concurrent flow HOV lanes that are in that corridor, and there's also light rail lines or streetcar lines in Dallas that are in that corridor as well.

Carol Schweiger: So here what I want to show you is kind of the heart of the Dallas ICM system, and this is actually a portion of a diagram that's shown in your Student Supplement that shows all of the elements, but here I kind of wanted to zoom in on the three major subsystems that are shown in this particular chart. One of the components is the SmartNET and SmartFusion. So 1.2 is SmartFusion, on the right-hand side of the diagram, and SmartNET is 1.3, which is at the bottom left-hand part of the diagram. And so here those systems gather data from a variety of sources and deliver that information to a variety of destinations. So you can see there's a lot of interchange between those two, 1.2 and 1.3, and the actual Decision Support System which is shown in 1.1. So again, in the Student Supplement, you'll see a larger version of this particular diagram. So that's the heart of the ICM system.

Carol Schweiger: I wanted to point out a couple of transit-specific elements of the ICM system. One is showing you a train or streetcar times, location and capacity. So this particular map shows you, for a particular station-- it's called Market Center Station-- what the real-time arrivals and departures are for northbound streetcar trains and southbound trains. So it provides you with information where you might decide that that's a better mode of transportation than driving in a car alone.

Carol Schweiger: There's another element of the ICM, which is providing you with parking lot information, and here we're looking at some parking lot information at Parker Station, which says that there's a certain amount of capacity that's still available. So you might decide that, that transit station, you could actually easily drive to that, and indeed there is parking available. So you might decide to utilize that parking lot.

Carol Schweiger: And then there are bus times and locations, very similar to the streetcar times and locations that were shown on the previous slide. So those are some of the elements.

Carol Schweiger: Now let's get into what standards are actually used in the Dallas system. So the first one we actually spoke about earlier and it was also used in the San Diego system, and that's TMDD. So the SmartNET portion of the diagram that I showed you earlier utilizes TMDD version 1 as its data dictionary, and also the regional center-to-center system in Dallas is based on that TMDD as well. Then another standard that's used by both SmartNET and the region center-to-center system, again, is the message sets for external TMC to TMC communication. That's another standard. And finally, on the transit side of things, the Dallas Area Rapid Transit, which is the transit authority in Dallas that operates the light rail and bus systems, they have a portal and they're utilizing TCIP for exchange of some of the data elements that they need to use to operate within the corridor. So those are the three standards.

Carol Schweiger: And in Dallas there was actually calculations of what-- using a simulation of what the overall benefits would be of using the ICM system. So here you can look at the numbers-- I won't read them to you-- about reduced congestion and travel time reliability. But I think the overall most important one is that there's a benefit-to-cost ratio of 20 to 1. So clearly implementing this ICM system is really, really critical to moving through that corridor in a much better way during the times that that corridor, the US-75 corridor, is congested.

Carol Schweiger: Let's move to another example in California, which is the I-80 corridor, which is in the Bay Area specifically, and here I have listed on the slide some of the basic vision components of the ICM system. Here, on this particular segment of I-80, there are over 20 thousand vehicle hours of delays. So there's quite a bit of congestion in that corridor. There's a very inconsistent level of service on that corridor. It goes anywhere from C to F-- so again indicating very congested. There are variable speeds in the corridor. You could be at a stop-and-go mode all the way up to 65 miles an hour. There are a lot of incidents. There are over two thousand incidents in this corridor on an annual basis. And finally, the travel time is very unreliable. It can be anywhere from 20 to 60 minutes, which is extremely variable.

Carol Schweiger: So physically, what does the corridor cover? It covers not only a major corridor for cars and transit but also for freight, and that's because it's very close to the Port of Oakland. So you have a lot of freight movement here. It's connected to two major airports. There are major employment centers here, and it crosses multiple jurisdictions.

Carol Schweiger: So what were some of the concepts that were deployed in this particular project? You can see here on the slide. And in the transit management area-- I wanted to kind of call that out separately-- transit signal priority is being deployed on San Pablo, that portion of the corridor, from crossing arterials and they're using ramp metering as well so that the vehicles can bypass places of delay. So that gives them preferential treatment. And they're also integrating-- you can see on the slide-- with park-and-ride and some transit traveler information.

Carol Schweiger: So from a diagram perspective, here's what the ICM looks like and how it's integrated with various other systems. So without going into a great deal of description on the diagram, there's a virtual private network, or a VPN, that allows communication among the smart corridor systems, which is what this I-80 corridor is called-- it's called a smart corridor-- and a variety of systems and entities within the corridor. So you can see that there's connection with all of the cities in the corridor. There's a connection with emergency management services in some of the corridors, like the Richmond Police Department or the El Cerrito Police Department, for example, and there's connection with the signal systems as well. So that gives you an overall picture.

Carol Schweiger: As of a little more than a year ago, the construction was completed on the ICM project, and they were in a process of installing signs. So these are the signs that actually have arrows on them, which indicate whether there's a priority lane of travel. There's signage within this big sign of the actual speed limit, which can be changed. It's a variable speed limit based on the conditions in the corridor, and so you also have a dynamic message sign element that can tell you, for example, there's congestion ahead, or there's a park-and-ride lot at the next exit. So that's the status of the I-80 project.

Carol Schweiger: And we've got one more project to talk about, which now we go to the East Coast, and this is in the New York and New Jersey area, and this particular vision for this ICM is listed here. Really the whole idea was to utilize existing assets to effectively manage this corridor, which is very, very congested, but they also looked at expanding the corridor in that capital improvement part of things.

Carol Schweiger: And so let's take a look at the corridor itself, and you can see it's in the New York and New Jersey area. It's centrally located. There's a population of about 20 million people in this corridor. It connects the New Jersey Turnpike, which is part of I-95, to the Van Wyck Expressway, which is I-678, and it also traverses Midtown Manhattan. There are numerous residential, commercial and industrial usage within this corridor. There are two key transportation facilities: the Lincoln Tunnel, which you can see, which connects New Jersey and Manhattan, and the Queens Midtown Tunnel, which connects Manhattan and Queens. There's an extensive highway network there and all kinds of other secondary roads. So it's kind of a complicated corridor.

Carol Schweiger: So we talked about them using existing technology and standards, and here is the existing technology and standards that have already been used, but they are leveraging those for the specific integrated corridor management program.

Carol Schweiger: And then there are other intelligent transportation system programs and modal programs that are taking place within that corridor, and the new ICM is actually utilizing parts of those ongoing programs as well. I want to point out the select bus service, which some of you may be familiar with. It's a program in New York City that provides limited stop services on select bus routes where you can actually pay your fare off-board. That's part of this overall ICM picture.

Carol Schweiger: So we've come to our final quiz of the module.

Carol Schweiger: And the question here is: Which one of these standards is not used in the Dallas ICM system? So remember, we reviewed the standards that were being used.

So which one of these is not being used? Answer A is message sets for external TMC to TMC communication. B is transit communication interface protocol, or TCIP. C is 511 dissemination interface. And D is the traffic management data dictionary, or TMDD.

Carol Schweiger: Now let's talk about the correct answer. The correct answer is C. The 511 dissemination interface is not being used in the Dallas example. So that's the only one that's not being used, and let's look at the other answers. Answer A is incorrect. That is being used in the Dallas system. SmartNET and the center-to-center system in Dallas are utilizing that standard. Transit Communication Interface Protocol is being used by DART-- remember I mentioned that. And finally, the TMDD is indeed being used in a couple of places within the Dallas system.

Carol Schweiger: So that concludes our three learning objectives. And so just quickly to review, what have we really looked at in these three modules, is we've defined integrated corridor management and the concepts that it uses to operate. We've identified and described the standards that are typically used within integrated corridor management, and we've also learned a little bit about the four actual deployments that I discussed in the last learning objective.

Carol Schweiger: So in conclusion, I'd like to thank you very much for completing this particular module, and I would strongly recommend and urge you to use the feedback link to provide us with your thoughts about the module so that we can potentially use those in the future to improve it. And again, I thank you very much for taking this module.

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