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16. ABSTRACT

Rural communication engineering remains a mission critical skill that most engineers in the state have limited experience with. Lacking these skills, engineers and technicians have a difficult time designing and maintaining reliable and robust communication networks for rural Intelligent Transportation System (ITS) field equipment. As new technologies emerge, engineers and technicians will be required to understand the reality of what is possible versus the hype from a vendor.

In this phase of the project, one specialized course in Telecom Wireless Fundamentals was researched, developed and delivered by subject matter experts to train rural engineers and technicians. These two courses builds the professional capacity of rural ITS engineers and technicians to provide the skills necessary to successfully design, implement, and maintain reliable and robust communication systems in rural and remote areas.

Additional specialized training in other ITS areas by subject matter experts is recommended for the follow-on phase of this project.

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Final Report

Professional Capacity Building for Communications

Phase 3

by

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A report prepared for the

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LIST OF ABBREVIATIONS

1xRTT	One Times Radio Transmission Technology
ADN	Advanced Digital Network
ADSL	Asymmetric Digital Subscriber Line
AM	Amplitude Modulation
ARP	Address Resolution Protocol
BRI	Basic Rate Interface
Caltrans	California Department of Transportation
CAT-5	Category 5
CAT-6	Category 6
CCTV	Closed Circuit Television
CDMA	Code Division Multiple Access
CHAP	Challenge-Handshake Authentication Protocol
CSU/DSU	Channel Service Unit/Data Service Unit
CMS	Changeable Message Sign
CO	Central Office
DCE	Data Communications Equipment
DDNS	Dynamic Domain Name System
DHCP	Dynamic Host Configuration Protocol
DS1	Digital Signal at Level 1 (1.544 Mb/s)
DSL	Digital Subscriber Line
DTE	Data Terminal Equipment
EDGE	Enhanced Data rates for GSM Evolution (or Global Evolution)
EIA/RS	Electronics Industries Association/Recommended Standard
EMS	Extinguishable Message Signs
ERP	Effective (or Equivalent) Radiated Power
EV-DO	Evolution, Data Only or Evolution, Data Optimized
FCC	Federal Communications Commission
FHWA	Federal Highway Administration
FTP	File Transfer Protocol
G	Generation (e.g., 3G is 3rd Generation)
GHz	Gigahertz
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
HAR	Highway Advisory Radio
HDSL	High bit rate Digital Subscriber Line
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
Hz	Hertz
ICMP	Internet Control Message Protocol
IEEE	Institute of Electrical and Electronics Engineers
IOS	Internetwork Operating System
IP	Internet Protocol
IPSec	Internet Protocol Security
ISDN	Integrated Services Digital Network

LIST OF ABBREVIATIONS - CONTINUED

ITS	Intelligent Transportation Systems
ITSA	Intelligent Transportation Society of America
K	Kilobits per Second (e.g., 56k data rate), also kb/s
LAN	Local Area Network
LTE	Long Term Evolution
MAC	Media Access Control
Mb/s	Megabits per Second
MHz	Megahertz
MPLS	Multiprotocol Label Switching
MSU	Montana State University
NF	Noise Figure/Factor
OSI	Open Systems Interconnection
OSPF	Open Shortest Path First
OTDR	Optical Time Domain Reflectometer
PCS	Personal Communications System
PoE	Power over Ethernet
POTS	Plain Old Telephone Service (wireline telco services)
PPP	Point-to-Point Protocol
PPPoE	Point-to-Point Protocol over Ethernet
PRI	Primary Rate Interface
PTAP	Project Technical Advisory Panel
RF	Radio Frequency
RFB	Request for Bids
RIP	Routing Information Protocol
RSSI	Received Signal Strength Indication
RSTP	Rapid Spanning Tree Protocol
RWIS	Road Weather Information Systems
SLIP	Serial Line Internet Protocol
SME	Subject Matter Expert
S/N	Signal-to-Noise ratio
SNMP	Simple Network Management Protocol
SONET	Synchronous Optical Networking
SSH	Secure Shell
SSL	Secure Sockets Layer
TCP	Transmission Control Protocol
TDR	Time Domain Reflectometer
TKIP	Temporal Key Integrity Protocol
TMC	Transportation Management Center
TMS	Traffic Management System
UDP	User Datagram Protocol
VDSL	Very high bit rate Digital Subscriber Line
VPN	Virtual Private Network

LIST OF ABBREVIATIONS - CONTINUED

WAN	Wide Area Network
WEP	Wired Equivalent Privacy
WiMAX	Worldwide Interoperability for Microwave access
WPA	WiFi Protected Access
WTI	Western Transportation Institute
xDSL	Digital Subscriber Line (of any type such as ADSL, HDSL, or VDSL)

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EXECUTIVE SUMMARY

Under contract with the California Department of Transportation (Caltrans), the Western Transportation Institute at Montana State University researched and revised a comprehensive training curriculum for transportation communication systems that will build the professional capacity of rural intelligent transportation system (ITS) engineers and technicians. The project included the facilitation of one training course. The principal deliverables of this project were the revised Curriculum Scope and Sequence (5), an updated list of training providers (6), final materials from the training course, an evaluation of the training course, a needs assessment, gap analysis, and final report.

The curriculum consists of five major subjects: Plant Wireless, Telco Wireless, Plant Wired, Telco Wired, and Internet Protocol (IP) Fundamentals. Each subject includes subtopics with specific learning objectives. Upon review, while the subject areas remained the same, some changes were made to the subtopics to reflect current and upcoming technologies used by Caltrans ITS engineers. In the process of facilitating the training course, several revisions were also made to the specific learning objectives.

This phase of the project focused on Telco Wireless technologies. A formal limited solicitation process was conducted to secure an appropriate training provider and deliver a course in Telco Wireless Core and Cellular / PCS Basics, GSM Data 3G and Next Generations, CDMA Data 3G and Next Generations, and LTE, 4G and Next Generations. A subject matter expert delivered 40 hours of training over five days with a significant focus on later generation Telco Wireless technologies. Course evaluations and Project Technical Advisory Panel (PTAP) observations indicated that the course was a success.

Considerable effort was put into researching and developing a list of potential training providers (formerly referred to as a Subject Matter Experts list) in order to ensure that the limited solicitation request for bids (RFB) reached the largest possible pool of qualified training providers, and ultimately to secure an excellent instructor considered an expert in the field. As companies and instructors come and go, this is a dynamic document and future work will necessarily include updating this list.

Finally, since the original needs assessment and gap analysis were conducted in Phase 1, they were updated and repeated within Phase 3's project scope. The Professional Capacity Building for Communications 2015 needs assessment survey was an online survey designed and facilitated using SurveyMonkey. The target population and sample consisted of engineers and technicians working on ITS projects throughout Caltrans, particularly in rural areas. The survey collected demographic characteristics such as job title and years in position, as well as information on the level and kind of technical training already received. Participants were asked about their experience with the different communication technologies related to ITS, what topics they would like training on, and to what extent the training should address these topics. The subsequent gap analysis matched needs to course offerings so that training priorities could be set based on interest, applicability and experience of the ITS engineers.

INTRODUCTION

"A skilled workforce is a critical element in a transportation agency's ability to successfully develop, deliver, operate, and maintain regional and local transportation systems" (1). However, significant challenges face transportation agencies around the country including difficulty finding qualified staff, increasing turnover, retention of experienced staff with developed skills and leadership capabilities, and attracting new entrants to the transportation workforce.

At the same time, the demand on America's transportation system is growing quickly. Americans have come to expect a certain level of service from the transportation system and an effective, efficient, and safe transportation system is critical to economic growth and quality of life (2). A recovering economy, a population over 300 million, suburban sprawl, an increasing number of vehicle miles traveled, and an aging population are all putting the pressure on local, state, and federal transportation agencies. This pressure comes with growing expectations and an acute need to be more efficient with limited resources on all fronts.

Rapidly changing and evolving technology requiring employees to have new and dynamic skill sets adds to the mix of challenges involving the transportation workforce. The Federal Highway Administration's (FHWA) Office of Professional and Corporate Development (OPCD) asserted in 2010, "Technology innovation is the essence of efficiency and it is only through the application of technology by a skilled workforce that transportation can hope to close the gap between growing demand and available resources" (3). Furthermore, as many Intelligent Transportation Systems (ITS) engineers would concur, technical information becomes obsolete so quickly that many transportation professionals find it challenging to stay abreast of the latest technologies available on the market. Implementing ITS in rural and remote areas provides a clear and pertinent example of advancing technology and the critical need for a skilled workforce with the same advancing skill sets.

Rural ITS deployments are becoming increasingly complex in order to adequately address the challenges that rural transportation presents. A greater number and variety of field devices are being utilized to improve the safety and operations of rural travel. Communication between devices such as Highway Advisory Radio (HAR), Road Weather Information Systems (RWIS), Changeable Message Signs (CMS), Closed-Circuit Television (CCTV), Extinguishable Message Signs (EMS), roadway sensors, and the Transportation Management Center (TMC) that collects and responds to the information is a key factor in the successful implementation of such field devices. However, many rural ITS engineers lack the critical skills for designing and maintaining reliable and robust communications networks for rural ITS field equipment. "As new technologies emerge, engineers and technicians will be required to understand the reality of what is possible versus the glossy specification sheets from vendors" (4).

Rapidly changing technology, intense competition for skilled workers, high expectations, limited resources, an increasing demand on the transportation system, and an overall smaller labor pool, all contribute to the necessity for enhanced workforce development. Specifically, the area of rural ITS communication systems is compromised because of the lack of professional capacity.

To realize the full benefits of rural ITS, engineers as well as technicians must not only be aware of what technologies are available, but especially how to best select, implement, and maintain those technologies. Due to challenges presented by rural ITS communications, there is a clear need for an educational curriculum that addresses rural ITS communications engineering across the

board with a hands-on approach. At the least, this curriculum should be designed to address underlying rural ITS engineering and design principles, available technologies, and practical applications for those technologies. To best present the curriculum the literature suggests it should be taught by subject matter experts who can bring their own experiences and best practices into the classroom.

Phase 1 (Caltrans Contract Number 65A0271) of this project identified subject areas and specific topics that Caltrans ITS engineers identified as training needs in ITS telecommunications. Based on this assessment of need, a pilot course on RF (Radio Frequency) System Design was delivered in the first phase of the project. Again, based on the results of the needs assessment and guidance from the Project Technical Advisory Panel (PTAP), Phase 2 (Caltrans Contract Number 65A0403) of the project facilitated successful courses on Optical Fiber and IP Fundamentals.

Further review of the needs assessment and gap analysis conducted in Phase 1 of the project, along with input from the PTAP, substantiated the need to continue investigation and development of additional ITS communications training for Caltrans ITS engineers in a third phase of the project. The subject of Telco Wireless was chosen as the training focus for this phase and a course on Telecom Wireless Fundamentals was delivered.

Since the original needs assessment and gap analysis were conducted in Phase 1, they were updated and repeated within Phase 3's project scope. The curriculum scope and sequence was also revised based on the development of the Telco Wireless course and the results of the needs assessment.

Over the course of this project, several deliverables were completed to address the proposed tasks. The training course and evaluation summaries, as well as the results of the needs assessment and gap analysis are included in this final report document. For the sake of clarity, the revised Curriculum Scope and Sequence (5) and the updated Identified Training Providers List (6) have been left as stand-alone documents. Critical elements of these documents are included in this final report.

It should be noted that in order to conduct the gap analysis by comparing the needs of Caltrans ITS engineers with the availability of training opportunities and qualified instructors, a list of identified training providers was compiled. In previous documentation, this compilation of potential vendors has been referred to as a Subject Matter Expert list. However, without more in depth assessment of a vendor's capabilities (i.e., through the limited solicitation process or with similar rigor), it is difficult to judge whether a vendor is indeed a subject matter expert as defined by the PTAP. Thus, this list has been titled *Identified Training Providers, Professional Capacity Building for Communications (Phase 3)* (6).

BACKGROUND/HISTORY

To maintain the viability of the American transportation system as it is challenged by a smaller labor pool, higher and more intense demands, and limited resources, workforce development must be promptly and pro-actively addressed (7). However, the Framework for Workforce Planning, Development, Management and Evaluation as developed by the Transportation Workforce Development sector of the FHWA OPCD recognized in 2010 that a new generation of employees is emerging. This generation of workers brings a different set of priorities to the workplace. They "…grew up in the electronic age, [are] more comfortable with change, have greater expectations for job satisfaction, and are more willing to challenge and to be challenged" (2). Their success in meeting the current challenges of the transportation industry "will depend to a great extent on the ability of employers to introduce the emerging workforce to new and innovative approaches in workforce planning and development" (2). The Project Technical Advisory Panel (PTAP) suggested that with the loss of experience and skills due to staff retirements combined with the demand for new skills, agencies are refining core competency definitions and re-evaluating which should be maintained in-house.

Improving the safety and operations of transportation in often rugged and remote areas is a focal point for rural ITS installations. Designing and maintaining a reliable communications infrastructure to retrieve data from these sites is a challenge even for the most experienced engineer. As Caltrans states in their original description for this project (4):

> *"Understanding what communication technologies exist and how the underlying principles work will allow an engineer to design a communications network that will work reliably when needed most—during an incident. Often, because an engineer does not have the underlying knowledge of a communication technology, a less than reliable network is designed, often with undesirable results based on claims from a vendor or unrealistic expectations from technologies that were not designed to perform the task at hand".*

This lack of skill is partially the function of information existing in a multitude of formats from many different sources, with no one comprehensive and easily accessible resource.

Indeed, one overview for a college course offered in 1996 stated, "Ubiquitous access to information, anywhere, anyplace, and anytime, will characterize whole new kinds of information systems in the 21st Century" (8). Particularly in relationship to wireless communications and mobile information systems, the professor said, "There exists no well-defined body of knowledge that a student must learn to become proficient" (8). While this course was offered some years ago, these statements are still applicable today.

To address the challenges of rural ITS communications and the need for related professional capacity building, the project team proposed to develop a comprehensive training curriculum and deliver training for rural ITS communications. The remainder of this document describes the third phase of this project and its results.

METHODOLOGY

This project consisted of four tasks: *Project Management, Course Selection, Course Delivery,* and *Evaluation.* This section includes a summary of the methodologies used for each task. More detailed descriptions and plans can be found in the individual sections of the report and related deliverable documents which are referenced below.

Project management involved regular communication (in person, electronically, and by telephone) between members of the project team, the Caltrans project manager, and the Project Technical Advisory Panel (PTAP), as well as subject matter experts and course instructors. Project meetings were held as necessary to discuss the status of the project and address any issues or questions. Quarterly progress and financial reports were submitted by the project team to the Caltrans project manager. This final report represents the completion of the project management task.

Task 2 *Course Selection* included selecting a training topic, developing a formal Request for Bids, and selecting an appropriate instructor (Subject Matter Expert) / vendor to deliver the training course. At the start of Phase 3, four possible options for training course content were presented:

1. Repeat a previous course (e.g., Plant Wireless RF Engineering).
2. Try again for the Plant Wired Core / Plant Wiring Basics, Serial Connectivity, xDSL course, which was cancelled prior to delivery.
3. Next level (i.e., intermediate) training for Optical Fiber, IP Fundamentals, or RF Engineering.
4. New subject and topic(s).

The PTAP indicated that the fiber course couldn't readily be expanded to a next level, the IP Fundamentals would be appropriate only for those students that took the first course and were currently doing a large amount of network management which would likely be only a few students, and the same challenge in finding a suitable instructor exists for the Plant Wired topics. After discussion and guidance from the PTAP, the subject of Telco Wireless was chosen as the training focus for Phase 3.

The project team conducted a thorough search for training providers and available training opportunities that covered the stated learning objectives for the subject of Telco Wireless as outlined in the Curriculum Scope and Sequence (Revised) (9) from project Phase 2. A limited solicitation and detailed Scope of Work were developed and approved. A Request for Bids (RFB) was posted and distributed, and bids were accepted. The responses were evaluated based on an approved scoring rubric and a training provider was selected and contracted.

The PTAP and the project team worked with the contracted training provider to customize existing course materials to meet the needs and expectations of the project. The project team coordinated logistics and facilitated delivery of the course. *Telecom Wireless Fundamentals*, a five-day course in Telco Wireless, was delivered March 9-13, 2015, at the Ron LeCroix Training Center in Woodland, California. The course was taught by Scott Baxter from TONEX.

Students completed evaluation forms and members of the project team and PTAP attended all or part of the course. Evaluations and PTAP feedback were compiled and analyzed by the project team.

Since the original needs assessment survey and the gap analysis (10) were conducted in Phase 1 of the project, they were updated and repeated at the end of this phase (Phase 3). The Professional Capacity Building for Communications 2015 survey was an online survey designed and facilitated using the SurveyMonkey tool. The Caltrans project manager identified the target population and sample, which consisted of engineers and technicians working on ITS projects throughout Caltrans, particularly in rural areas. They included students from the previous courses delivered within this project, members of the Rural Program Steering Committee (PSC) and Rural Technical Advisory Panel (TAP) groups, and Caltrans District Points of Contact (POCs). The survey collected demographic characteristics such as job title and years in position, as well as information on the level and kind of technical training already received. Participants were asked several questions about each subject area and topic, including level of experience, importance of training, whether training was desired, and how often the technology was used on the job. Finally, training objectives for a sample course in each technology were evaluated for level of detail.

The gap analysis consisted of three related parts: needs, available opportunities, and a comparison. The needs were determined through the needs assessment survey described above. Available training opportunities were identified in conjunction with the search for subject matter experts. The identified subject matter experts were assessed on whether they offered a training opportunity that addressed each topic and to what depth the topic was covered. The gap analysis then compared the recognized needs with the available training opportunities to identify gaps in communications training for ITS engineers.

Finally, the project team identified next steps using the results from the project tasks, and input and feedback from the PTAP.

CURRICULUM SCOPE AND SEQUENCE

1.1. Curriculum Scope and Sequence Revision

A comprehensive literature review and a needs assessment with Caltrans ITS engineers was conducted as part of Phase 1 of this project (11) (10). Five major subjects were identified as important knowledge and skill areas for successful rural ITS implementations. These subject areas are: Plant Wireless, Telco Wireless, Plant Wired, Telco Wired, and IP Fundamentals. The curriculum scope and sequence is based upon these five subject areas and includes descriptions, prerequisites, duration, method of presentation, and specific learning objectives. The target audience includes field engineers and technicians who apply ITS technologies in rural areas to improve transportation safety and operations.

During this phase, the project team consulted with the PTAP, considered comments from students in the training courses, and reviewed the needs assessment survey and the subsequent gap analysis to update and revise the curriculum scope and sequence (5). While the main subject areas remained the same, some changes were made to the topics to be addressed in each subject area. The topic of Multiprotocol Label Switching (MPLS) was added to the Telco Wired subject area. The topic of WiMAX was removed from the Plant and Telco Wireless subject areas. A number of revisions were also made to the specific learning objectives for several of the subject areas. It should be noted that these modifications were made prior to the needs assessment conducted at the end of this phase; therefore changes identified in the latest survey may or may not be reflected in this revision and will require further review and discussion.

The project team felt it would be useful to have the scope and sequence available as a separate document. Therefore, to eliminate redundancy, the revised curriculum can be found in the document titled *Professional Capacity Building for Communications Curriculum Scope and Sequence (Phase 3 Revised)* (5). For quick reference, the subject areas and associated topics are outlined below:

A. Plant Wireless
   a. Plant Wireless Core and RF System Design
   b. 802.11 (WiFi) and Related
   c. Microwave
   d. Short Haul Radio

B. Telco Wireless
   a. Telco Wireless Core and Cellular/PCS Basics
   b. GSM Data, 3G and Next Generations
   c. CDMA Data, 3G and Next Generations
   d. LTE (Long Term Evolution), 4G and Next Generations

C. Plant Wired
   a. Plant Wired Core/Plant Wiring Basics
   b. Serial Connectivity
   c. xDSL
   d. Optical Fiber

D. Telco Wired
   a. Telco Wired Core
   b. POTS
   c. Analog Data Circuits
   d. ISDN

   e. xDSL
   f. DS1/T1
   g. Fractional DS1/T1
   h. Frame Relay
   i. MPLS

E. IP Fundamentals
   a. Understanding IP Networks/IP Networking Core
   b. Local Area Networks (LANs)
   c. Wide Area Networks (WANs)
   d. Network Security
   e. Vendor Specific Equipment Training (e.g., Cisco, Juniper, other)

1.2. Identified Training Providers

As noted in the introduction, in previous documentation this compilation of potential training providers has been referred to as a Subject Matter Expert list. Without more in depth assessment of a vendor's capabilities (i.e., through the RFB process or with similar rigor), it is difficult to judge whether a vendor is indeed a subject matter expert as defined by the PTAP. Thus, this list has been titled *Identified Training Providers, Professional Capacity Building for Communications (Phase 3).* Because of its length and detail, the list is provided as a stand-alone document (6). Caltrans and the members of the PTAP neither endorse nor disqualify any vendors on this list.

One of the core tenets for this project was to develop training that would be presented by experts in their field. As such, Phase 1 identified several potential vendors that could provide training in the ITS communications topics listed above. Phase 2 expanded the list with a particular focus on training offerings in plant wired and IP Fundamentals topics. During Phase 3, the list was again reviewed and revised focusing on Telco Wireless communications training providers.

The list of identified training providers is a dynamic document. It includes but is not limited to, vendors and training providers that appear to have some or all of the qualifications listed in the RFBs, including on-site course delivery, ability to customize content, hands-on exercises, and an established course(s) that addresses most of the expected learning objectives. The list was compiled through PTAP recommendations, word of mouth, recommendations from instructors, and an extensive web search.

The expertise of vendors that submitted a bid in response to an RFB was evaluated by the PTAP based on the approved limited solicitation scoring rubric. A provider was further vetted after a contract was signed and prior to course delivery. It should be noted that this list represents a best effort and that there may indeed be other possible providers not listed in the document. In turn, the procurement process is open and other qualified vendors are eligible to bid.

While the list of training providers focuses on vendors who provide training on the topics/subjects that were included in the RFBs, it also includes those who provide training on the remaining topics such as Telco Wired and Plant Wireless technologies. They were included to more thoroughly address the overall curriculum and provide a starting point for consideration of future courses. Additionally, some vendors may provide training in these topics, but did not appear to meet one or more RFB requirements. For example, they may not provide on-site training. However, in the interest of thorough documentation, the project team felt it was important to still include these providers in the list. Note that these vendors were not evaluated to the same extent as those receiving the RFB and submitting a bid. Therefore, further due diligence would be necessary to consider them for contracting.

The updated Identified Training Providers list contains general and individual contact information for the different organizations. The vendors that received the formal Request for Bids (RFB) for each of the released limited solicitations are marked along with those who actually submitted a bid.

TELCO WIRELESS COURSE DELIVERY

Phase 3 of this project focused on the subject of Telco Wireless communication technologies and its applicability to rural ITS installations.

This subject included the following topics: Telco Wireless Core and Cellular/PCS Basics; GSM Data, 3G and Next Generations; CDMA Data, 3G and Next Generations; LTE (Long Term Evolution), 4G and Next Generations; and Telco Owned WiMAX. As wireless systems evolve and newer technologies become more widely available, more interest is placed in the later generation technologies. The five-day training, *Telecom Wireless Fundamentals,* was delivered in March 2015. The technologies addressed included fixed deployments of field elements and communications with a TMC, maintenance yard, or other similar facility. This section describes the design, content, delivery and evaluation of the Telco Wireless course.

1.3. Course Design

Wireless technology is becoming more economically feasible as it continues to rapidly advance. At the same time, demand for real-time communication between traffic management centers and remote sites is increasing. Consequently, leased wireless communications systems are being considered as a cost-effective, viable solution for rural ITS deployments. They are of particular interest to Caltrans because of their potential utility in remote areas where wireline communications are not available. An understanding of the design principles and practical application techniques involved with these technologies has become an important skill for Caltrans' rural ITS engineers and technicians. The *Telecom Wireless Fundamentals* course was designed with this in mind.

The project team conducted a thorough search for training providers and available training opportunities that covered the subject of Telco Wireless. Based on the results of this search, the project team identified potential contractors for this course. Caltrans and the members of the PTAP neither endorse nor disqualify any vendors on this list. (See Appendix A: List of Identified Training Providers – Telco Wireless.)

A LIMITED SOLICITATION AND DETAILED SCOPE OF WORK FOR THE COURSE IN TELCO WIRELESS WAS DEVELOPED AND APPROVED. A REQUEST FOR BIDS (RFB) WAS POSTED AND DISTRIBUTED, AND BIDS WERE ACCEPTED. (SEE

Appendix B: Request for Bids – Telco Wireless Training.) The responses were evaluated based on an approved scoring rubric and TONEX was chosen to develop the course materials.

With input and review by the PTAP, draft materials were developed by TONEX and the instructor Scott Baxter. Final course materials were approved and the course was delivered in mid-March 2015.

1.4. Content

The project team and the PTAP reviewed and updated the Telco Wireless learning objectives established in Phase 1 and revised in Phase 2 of the project. These objectives were included in the Request for Bids as required content for the course. It should be noted that the Curriculum Scope and Sequence (9) specified a relatively even amount of time spent addressing each of the relevant wireless technologies for a total of 13 full days of training. However, as mentioned above, the PTAP recommended a focus on later generation technologies, and 5 days of training was the limit logistically. Consequently, potential training providers were asked to submit a bid which focused primarily on later generation (i.e., 4G/LTE) technologies. It was expected that a contractor would enhance and customize an existing course based on the minimum objectives in the RFB and not develop a new course from scratch.

The approved outline for the Telco Wireless course follows.

Note: The text for Sections 1.4.1 through 1.4.8 is taken from the approved TONEX course outline, the final syllabus for the course, and/or the final RFB. Some formatting has been changed to fit the summary document requirements.

1.4.1. Course Title

Telecom Wireless Fundamentals

1.4.2. Course Description

A fundamental knowledge of the characteristics of leased wireless communication systems is important for determining how best to implement the technology to the benefit of rural transportation. In areas where Plain Old Telephone Service (POTS) or other alternatives are unavailable or cost-prohibitive, third and fourth generation (3G, 4G) GSM, CDMA, and LTE data communications between the Traffic Management System (TMS) and the TMC may be an appropriate, viable solution. As wireless systems evolve and newer technologies become more widely available, more interest is placed in the later generation technologies. After taking this course, rural ITS engineers and technicians will have the knowledge and skills necessary to design, implement, and maintain systems that interface to telco provided wireless communications.

1.4.3. Learning Objectives

After completing this course, the student will be able to:

- Define and explain terminology and general concepts for Telco wireless communication systems.
- Explain the evolution of Telco wireless technology from 1G to 4G LTE and beyond.
- Discuss the basic theory of RF technology.
- Discuss the concepts of wireless propagation and related theory, and review industry terms.
- Discuss the technical characteristics and basic operation of LTE communication systems.
- Discuss the technical characteristics and basic operation of GSM, GPRS and EDGE communication systems.
- Discuss the technical characteristics and basic operation of CDMA and CDMA2000 1xEV communication systems.
- Locate and classify cellular sites using the Federal Communications Commission (FCC) data base.
- Select and effectively utilize cellular/PCS data services.
- Determine when and where LTE, GSM, and CDMA communications technologies can be used effectively.
- Understand and thoroughly evaluate technical information on vendor equipment specification sheets.
- Ascertain tower and antenna requirements, and make an appropriate selection for the particular application (e.g., cellular modem at a fixed site for a CCTV).
- Specify and install proper antenna framework and cabling for the particular application.
- Determine the coverage area and signal strength at a specific location by conducting necessary field strength measurements.

- Compare, contrast and evaluate available modems and hardware and select the best alternative for specific applications.
- Successfully install and configure equipment considering such factors as modem type and data rate, and antenna requirements, gain and gain orientation for a fixed site.
- Deduce the required and optimal data rate with a working understanding of the data rate provided by various options such as LTE, General Packet Radio Service (GPRS), Enhanced Data rates for GSM or Global Evolution (EDGE), 1xRTT, and EV-DO, etc.
- Properly implement cellular/PCS (LTE, GSM, CDMA) equipment, taking into account the potential for system overload and the type of site receiver (dialup or fixed).
- Conduct thorough bandwidth and throughput testing and apply the results.
- Maintain and repair the system and equipment according to system provider, accepted standards, and/or Caltrans guidelines.
- Assess and compare the pros and cons of common alternatives.

1.4.4. Target Audience

The target audience includes field engineers and technicians who apply ITS technologies in rural areas to improve transportation safety and operations. Participants will generally be electrical engineers, electrical technicians or other engineers with ITS design and implementation responsibilities.

1.4.5. Participant Prerequisites

Basic (electrical) engineering skills or relevant experience.

1.4.6. Method of Presentation

Instructor-led classroom and hands-on laboratory activities.

A minimum of 25 percent of in class time was to be dedicated to realistic, hands-on problem solving and lab exercises, in addition to traditional classroom work.

1.4.7. Course Length

Five (5) days = 40 hours

1.4.8. Course Outline and Schedule

Workshop and Project Exercises

1. Working with techniques and methods to select and effectively utilize cellular/PCS data services.
2. Using field strength measurements, spectrum analyzer to determine the coverage area and signal strength at a specific location
3. Modeling tower and antenna requirements, and make an appropriate selection for the particular application (e.g., cellular modem at a fixed site for a CCTV).
4. Assess and compare the pros and cons of common alternatives.

5. Analysis of major radio access technologies: Narrowband, spread spectrum and broadband
6. Antenna installation and cabling techniques

Hands-on Labs

- Lab 1: Link Budget Calculations
- Lab 2: Working with Spectrum Analyzers to analyze and evaluate cellular/PCS voice and data services
- Lab 3: GSM, GPRS and EDGE communications applications
- Lab 4: CDMA, CDMA2000 1x and 1xEV-Do communications applications
- Lab 5: LTE communications applications
- Lab 6: Building antennas (students in groups of 5 will analyze, model and build a simple cellular antenna in the class)

Day 1: Overview of Radio Frequency (RF), Antennas and Propagation

- Introduction and Preliminaries
- Introduction to Radio Frequency
- Concepts behind Antennas
- RF Propagation Models and Theories
- Mathematical Preliminaries
- Electrostatics, Current, and Magnetostatics
- Propagation Models for Cellular and PCS
- RF Propagation Fundamentals
- Propagation models (e.g., Hata-Okumara and COST-231)
- Electromagnetic Wave Propagation: Common Effects
- Large-Scale Effects in Cellular Environments
- Small-Scale Effects in Cellular Environments
- Tests and Measurements
- Radio-Frequency Engineering
- Noise and System Issues Related to Nonlinearity
- Concepts behind Oscillators, Spectrum Analyzer and Related Issues
- Antennas Characterization
- Examples of Antennas
- Practical Issues: Connecting to Antennas, Tuning, Location and Site Survey
- Incorporating Fading Effects in the Link Budget

Hands-on

- Lab 1: Link Budget Calculations (TONEX will provide the software tools to all the students.)
- Workshop 1 and 2

Day 2: Agreements, Standards, Policies, and Regulations

- Agreements
- Standards

- Policies
- Regulations
- Mobile Spectrum Use, Management and Availability
- Mobile Standards Organizations
- Mobile Network Technologies, Architectures, Generations & Standards
- Mobile Applications & Services
- Mobile Terminals & Phones
- New Alternative Mobile Voice and Data Networks
- Analysis of the Mobile Market and Key Carriers, Network Operators & Resellers
- Examining The Future of Mobile Communications
- Federal Communications Commission (FCC)
- National Telecommunications and Information Administration (NTIA)
- Locate and classify cellular sites using the FCC data base
- How spectrum is allocated and licensed
- Analysis of licensed cellular, PCS service band plans & allocations
- Rules and regulations
- Planned and anticipated changes
- Analysis of new technologies for improving spectrum use and expand availability
- Broadband PCS
- Spectrum mapping
    - 700 MHz band
    - 824-894 MHz band
    - 880-960 MHz band
    - 1710-1755 MHz band
    - 1850-1990 MHz band
    - 1920-2170 MHz band
    - 2110-2155 MHz band

Hands-on

- Lab 2
- Workshop 3

Day 3: Telecom Wireless Access Technologies

- Introduction to Wireless Access Technologies
- Introduction to Wireless Network and Service Architectures
- Digital Communications for Wireless Access Systems
- The Cellular Concept
- Overview of Telco wireless access generations: 1G, 2G, 3G, 3.5G and 4G
- Overview of3G, 4G network architectures Examples of Air-Interface Standards: GSM, IS-95, UMTS/UTRAN, LTE
- Radio Network Basics
- FDMA, TDMA, CDMA and OFDMA
- GSM, GPRS and EDGE
- Spread Spectrum
- IS-95 CDMA
- 3G, 3.5G and 4G Technologies and Networks
- What is 3G?
- Why 3G?
- What is 4G?
- Why 4G?
- International Mobile Telecommunications-Advanced (IMT-Advanced)
- Relationship of IMT-2000 and IMT-Advanced
- Overview of 3G, 4G network architectures
- Third-Generation (3G) CDMA-Based Systems
- UTMS/UTRAN
- HSPA/HSPA+ and HRPD
- Emerging Technologies for Wireless Access
- 4G: LTE and LTE-Advanced
- What's Next?
- Architectures
- IP Networking
- Teletraffic Analysis
- GSM/GPRS/EDGE, CDMA/CDMA2000 1x, 1xEV-DO, LTE and IP: Ingredients of Convergence
- VoIP
- Toward an All-IP Core Network
- Making IP Work with Wireless
- Evolution from GSM to UMTS and LTE
- IP Multimedia Subsystem (IMS)

Hands-on

- Lab 3 and 4
- Workshop 4

Day 4: Networks Architecture and Key Services

- Cellular Carriers, Network Operators, Service Providers and Resellers
- GSM-based system architecture and key services
    - GSM-based GSM, GPRS and EDGE Technology and Features
    - GSM-EGPRS Networks Architecture and Key Services
    - GSM architecture and key services
    - System access
    - UMTS – R99
    - WCDMA
    - UTRAN
    - HSDPA/HSUPA
    - HSPA+
    - Data call setup
    - Mobility
    - Handoffs & handovers
    - Security and privacy
- CDMA-based system architecture and key services
    - CDMA2000 1x
    - 1xEV-DO
    - System architecture
    - Data call setup
    - Mobility
    - Handoffs & handovers
    - Security and privacy
- LTE-based system architecture and key services
    - LTE Technology and Features
    - LTE-Advanced Technology and Features
    - Architecture and key services
    - System access
    - Mobility
    - Handoffs & handovers
    - Security and privacy

<u>Hands-on</u>

- Lab 5
- Workshop 5

Day 5: Cellular RF Engineering, Planning and Testing

- Planning, design, engineering, optimization
- Importance of RF engineering
- Spectrum for network deployment
- WCDMA and HSPA Fundamentals
- UTRAN architecture
- HSPA
- Coverage and Link Budget Fundamentals
- Significance of link budget
- Capacity and Traffic Engineering
- Influence of AMR and high-speed data
- RF technology factors impacting capacity
- Deployment Considerations
- GSM vs. WCDMA
- 2G/2.5G and 3G-specific features for enhanced RF performance (e.g., handover and power control)
- 4G features for enhanced RF performance (e.g., handover and power control)
- Cell-site planning/sharing
- Call quality, coverage, data rates, and connectivity
- Assessing the factors that affect coverage and capacity
- Mobile and Cellular security and privacy strengths & weaknesses
- Radio access technology by major carrier mapping

Hands-on

- Lab 6
- Workshop 6

1.4.9. Equipment

Equipment Used:

- Spectrum Analyzer
- Antennas
- Link Budget Calculations Tools

Additionally, students were required to bring a laptop computer with Microsoft Excel, Adobe Reader, and a modern web browser installed. The instructor also utilized an app designed for Android phones called G-NetTrack. Students with Android smart phones were welcome but not required to pre-load the app and use it during class.

1.5. Logistics and Course Delivery

Telecom Wireless Fundamentals was held March 9-13, 2015, with five full days of training. The Ron Le Croix Training Center in Woodland, California, provided an appropriate location for the course. The training room was comfortable and of adequate size for the audience and the course activities. It was also in close proximity to lodging and dining options for those traveling from out of town.

The course was taught by Scott Baxter of TONEX. This contractor was chosen through a formal request for bids.

The student audience consisted of six Transportation Electrical Engineers, four ITS Engineers, one Electrical Engineer, two Transportation Engineers and one Electrical Engineering Technician. Students represented six Caltrans districts as well as Caltrans HQ. The course targeted rural ITS engineers and technicians, and students primarily came from Caltrans districts that work with rural transportation challenges on a regular basis. See Table 1 below for a list of students. Members of the project team and the PTAP also attended to facilitate and evaluate the course.

Table 1: Telco Wireless course students.

Name	District
Brian Finck	Caltrans District 1
Mike Beyer	Caltrans District 2
Keith Koeppen	Caltrans District 2
Jeremiah Pearce	Caltrans District 2
Michael Mullen	Caltrans District 3
Gurdeep Sidhu	Caltrans District 3
Steven Gee	Caltrans District 5
Samuel Campos	Caltrans District 6
Ihab Elzaanoun	Caltrans District 6
Dave Le	Caltrans District 10
Richard Montoya	Caltrans District 10
Patrick Leung	Caltrans Headquarters

Upon successful completion of the course, each student received a Certificate of Completion from TONEX.

1.6. Evaluation Strategies

To evaluate the course, the project team developed an evaluation form to be completed by the student participants at the conclusion of the training. On behalf of TONEX, the instructor also distributed an evaluation form for the overall course. Additionally, members of the PTAP and the project team attended all or part of the course to observe and evaluate the presentation methods and content.

1.6.1. Overall Course Evaluation

Students were asked to rate the instructor on a one-to-five scale, with one being poor and five being excellent, for his knowledge of the subject matter, ability to answer questions, presentation and delivery skills, preparedness, time management, and how well questions and discussion were encouraged and facilitated. Along with an overall rating of the instructor, the students were asked how likely it was that they would attend another course taught by this instructor. Space was provided for free-form comments.

Second, students rated the different characteristics of the course on a one-to-five scale. Students rated the content of the course as well as the subject matter, level of detail, instructional methodology, presentation structure and organization, and overall quality of the course. Relevancy and application to real situations, and whether the course met student needs and expectations were additional course characteristics appraised by the students. Finally, students were asked to assess the hands-on activities in the course. Space was again provided for free-form comments. To further evaluate the content of the course, students were asked whether they agreed that the correct objectives were targeted.

Course materials were evaluated on the same scale for quality, organization, usefulness, practicality, and potential value as future reference materials. In addition, students were asked to indicate how well the course materials corresponded with the course presentation. Students were given space to provide any relevant comments they might have.

To evaluate the logistics of the course, students were asked to indicate level of satisfaction with the location of the course and the facility/classroom. Course length, pace of course, and time of year the course was offered were also assessed by student satisfaction level. Students could provide comments if desired.

Whether the course would be recommended to others and likelihood of attending another course taught by TONEX were two additional questions on the evaluation form that were included to obtain an overall impression of the quality and value of the course. Students were also asked what they could apply to their job after taking the course as well as difficulties they foresaw in applying the course materials to their work.

Because this course was part of the larger curriculum development project, the evaluation form included an area for mentioning other subject areas in which students were interested in receiving training. Finally, the evaluation queried whether the student had participated in the needs assessment survey as part of the project and, if so, whether this course had met their needs and expectations for communications training in Telco Wireless Fundamentals and Usage.

THE COMPLETE EVALUATION FORM DEVELOPED BY THE PROJECT TEAM IS INCLUDED IN

Appendix C: Telco Wireless Course Evaluation Form.

1.6.2. Student Learning

A Level II evaluation of student learning was conducted via oral questioning, review questions, and discussion. The instructor was continuously cognizant of student progress throughout the course and adjusted the content and presentation as needed.

It should be noted that no formal pre-test or post-test measurements of student learning were developed. The project team worked under the assumption that adult learners voluntarily participating in this type of course will likely take the initiative to learn the material. Therefore, such an assessment would do little to enhance the overall project beyond the information collected by the evaluations discussed above.

1.7. Participant Evaluations

The evaluation forms described above were generally divided into questions about the instructor, the course, course materials, overall impression of the course, and logistics. This section provides a summary of the participant evaluations according to the categories above. The evaluations can be found in Appendix D: Participant Evaluations (WTI) – Telco Wireless Course and Appendix E: Participant Evaluations (TONEX) – Telco Wireless Course.

The majority of students rated the course instructor "Very Good" or "Excellent" in every
with an overall rating average of 4.7 on a 5.0 scale (

Table 2, Figure 1). Most students agreed that the instructor's knowledge of the subject matter was excellent, and a large majority of the evaluations indicated he answered questions clearly and completely. One student commented, "Very thorough and easy to understand. Would take another course again." In turn, all students rated the instructor "Very Good" or "Excellent" for encouraging questions and facilitating discussion. This helped to keep students engaged and actively learning the course content as expected. However, student comments and just slightly lower ratings for class organization and time management suggest that the instructor may have "jumped around" the content in a manner which made the course difficult to follow or confusing at times. Regardless, the majority of students indicated they would likely take another course taught by this instructor (

Table 3, Figure 2).

Table 2: Number of students who rated the instructor at each level.

Instructor	*Number of students who rated the item at each level*					
	5	4	3	2	1	
	Excellent	Very Good	Good	Fair	Poor	Average Rating
Knowledge of subject matter	11	1	0	0	0	4.9
Presentation skills and delivery	7	4	0	0	0	4.6
Ability to answer questions	10	2	0	0	0	4.8
How well prepared was the instructor?	8	3	1	0	0	4.6
How well did the instructor encourage questions and facilitate discussion?	9	3	0	0	0	4.8
How well did the instructor organize and manage the course to stay on task?	5	4	2	1	0	4.1
Overall rating of instructor	8	2	0	0	0	4.7

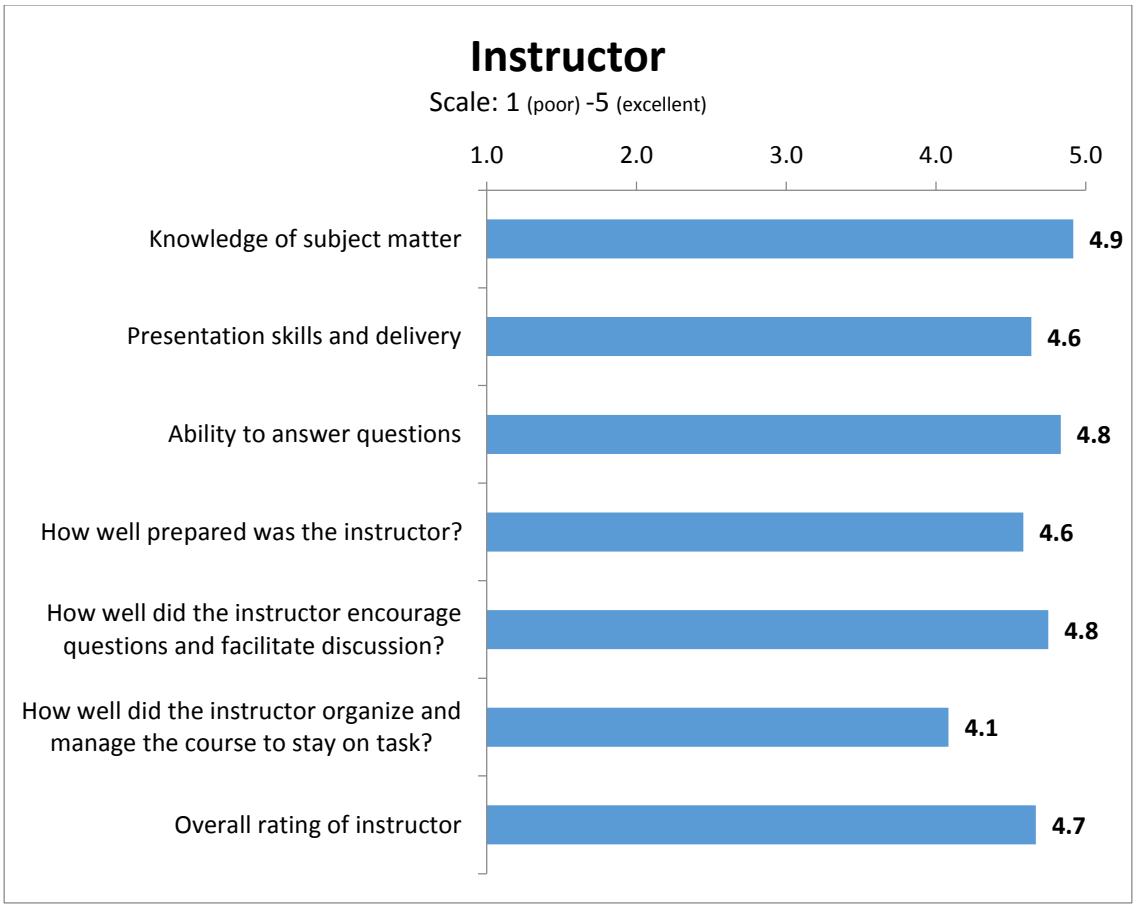
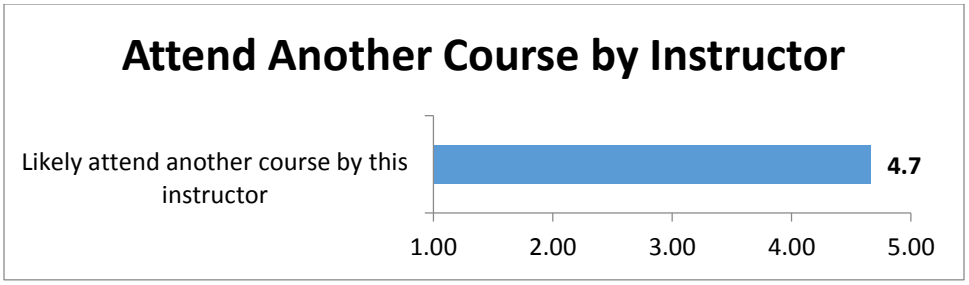


Figure 1: Average instructor ratings.

Table 3: Number of students who would likely attend another course taught by this instructor.

Likely attend another course by this instructor	*Number of students who rated the item at each level*					
	5	4	3	2	1	
	Very Likely		Neutral		Not At All Likely	Average Rating
Attend another course by instructor	9	2	1	0	0	4.67

Figure 2: How likely students would attend another course taught by this instructor.



In general, the ratings for the course presentation and content were “Very Good” or higher (Table 4, Figure 3). Students seemed satisfied with the subject matter, the level of detail in which topics were addressed, and the instructional methodology. Additionally, students generally felt that the course met their needs, and was relevant and applicable to their jobs and real situations. Most students also agreed that the course objectives were achieved and that the course met their expectations for professional capacity building in the Telco Wireless subject. Similarly, the majority of students agreed or strongly agreed that the course targeted the correct objectives (

Table 5, Figure 4). "The instructor covered both the practical and theoretical aspects well." One student stated that he was "far more well prepared to deploy this technology in our district." On the other hand, some students suggested that portions of the class were not relevant to their needs, or that others were covered in too much detail. One stated, "It seemed like some things were skipped."

Table 4: Number of students rating the course and content at each level.

Course	*Number of students who rated the item at each level*					
	5	4	3	2	1	
	Excellent	Very Good	Good	Fair	Poor	Average Rating
Content overall	7	3	2	0	0	4.42
Subject matter	6	4	2	0	0	4.33
Level of detail	7	2	3	0	0	4.33
Instructional methodology	4	6	2	0	0	4.17
How easy was the course to understand?	2	7	2	1	0	3.83
How relevant was the course to your job?	5	6	1	0	0	4.33
Hands-on activities	2	2	4	3	1	3.08
Application to real situations	4	5	3	0	0	4.08
Presentation structure and organization	4	6	1	1	0	4.08
How well were course objectives achieved?	4	6	1	1	0	4.08
How well did the course meet your expectations?	5	5	1	0	1	4.08
How well did the course meet your needs?	4	5	2	1	0	4.00
Overall quality of course	5	5	1	0	0	4.21

Figure 3: Average course ratings.

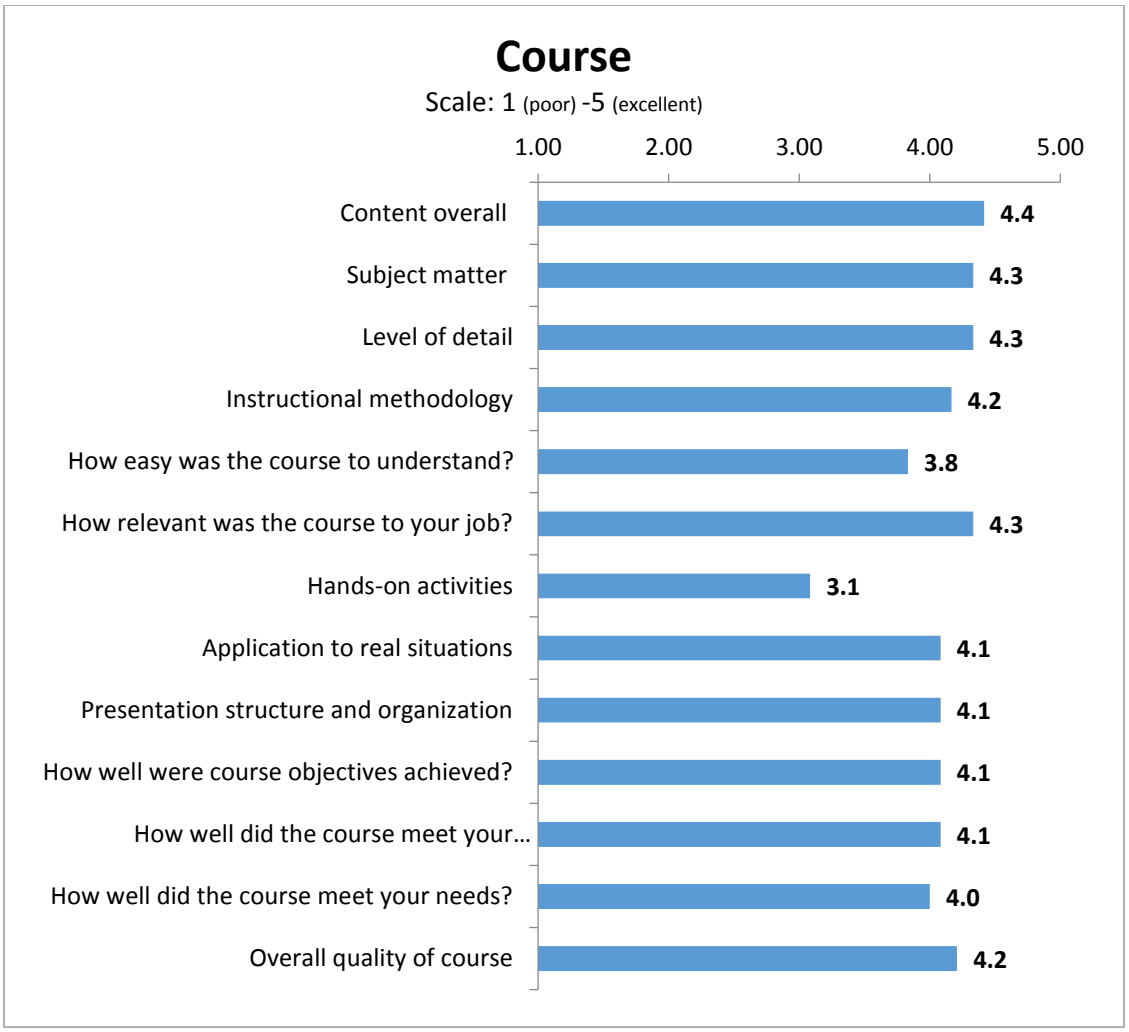

Course
Scale: 1 (poor) -5 (excellent)
1.00
2.00
3.00
4.00
5.00
Content overall
4.4
Subject matter
4.3
Level of detail
4.3
Instructional methodology
4.2
How easy was the course to understand?
3.8
How relevant was the course to your job?
4.3
Hands-on activities
3.1
Application to real situations
4.1
Presentation structure and organization
4.1
How well were course objectives achieved?
4.1
How well did the course meet your...
4.1
How well did the course meet your needs?
4.0
Overall quality of course
4.2

Table 5: Number of students agreeing with target objectives.

Agreement on target objectives	*Number of students who rated the item at each level*					
	5	4	3	2	1	
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Average Rating
Agree on target objectives	6	5	1	0	0	4.42

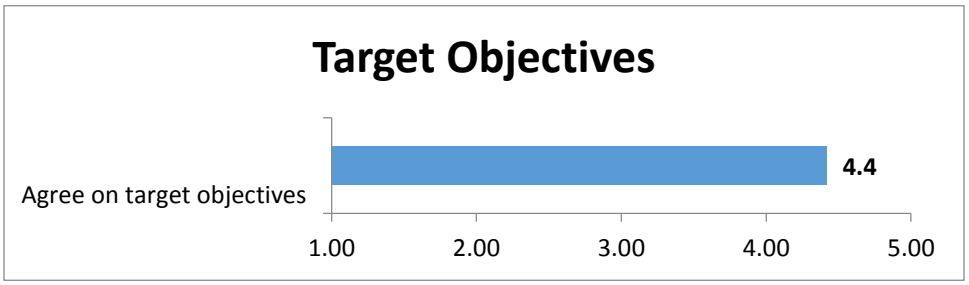


Figure 4: Level of agreement that the correct objectives were targeted.

Hands-on activities have been strongly emphasized throughout all phases of this project. While this particular subject may not have readily lent itself to hands-on activities as one student stated, the ratings and comments also suggested that the course was somewhat lacking in this aspect (Table 4, Figure 3). Another student indicated that the instructor did the hands-on activities and it "would have been nice for students to have to do the labs." He continued, "Perhaps material was too detailed on the provider side, and not enough on Caltrans specific applications. May be a good idea to try to get specific questions from students prior to course, and go into as much detail as possible." Similarly, another student said, "Even if there isn't great hands on material, set the students up with some real world scenarios and engage the class with problem solving." However, as noted previously, students were generally very satisfied with the instructor's ability to engage in discussion.

The course materials generally received favorable ratings, averaging "very good" across the different evaluation points (

Table 6, Figure 5). Students felt they were of overall high quality and generally useful and practical. For the most part, the materials were well-organized and followed the course presentation. However, one student said that the materials didn't seem sequential. It is unclear whether this comment stemmed from the instructor "jumping around" as alluded to above, or that the course outline/materials were not organized in such a way that the information could be readily applied in a real situation. Students appreciated that the instructor updated materials onsite, found references based on questions and discussion, and then provided the additional and updated materials to the students on a flash drive and via his course website. The majority of students indicated that the course materials would likely be a valuable reference after the course was completed. One participant did state that he finds it easier to read materials in a binder versus a spiral bound book such as what the Telco Wireless course materials were in.

Table 6: Number of students rating the materials at each level.

Materials	*Number of students who rated the item at each level*					
	5	4	3	2	1	
	Excellent	Very Good	Good	Fair	Poor	Average Rating
Overall quality	8	3	1	0	0	4.58
Organization, flow and structure of information	5	5	1	1	0	4.17
How well did the course materials follow the course presentation?	5	5	1	1	0	4.17
Usefulness, practicality of course materials	5	5	1	1	0	4.17
How easy were the materials to understand?	2	8	2	0	0	4.00
Potential value as future reference material	5	5	1	1	0	4.17

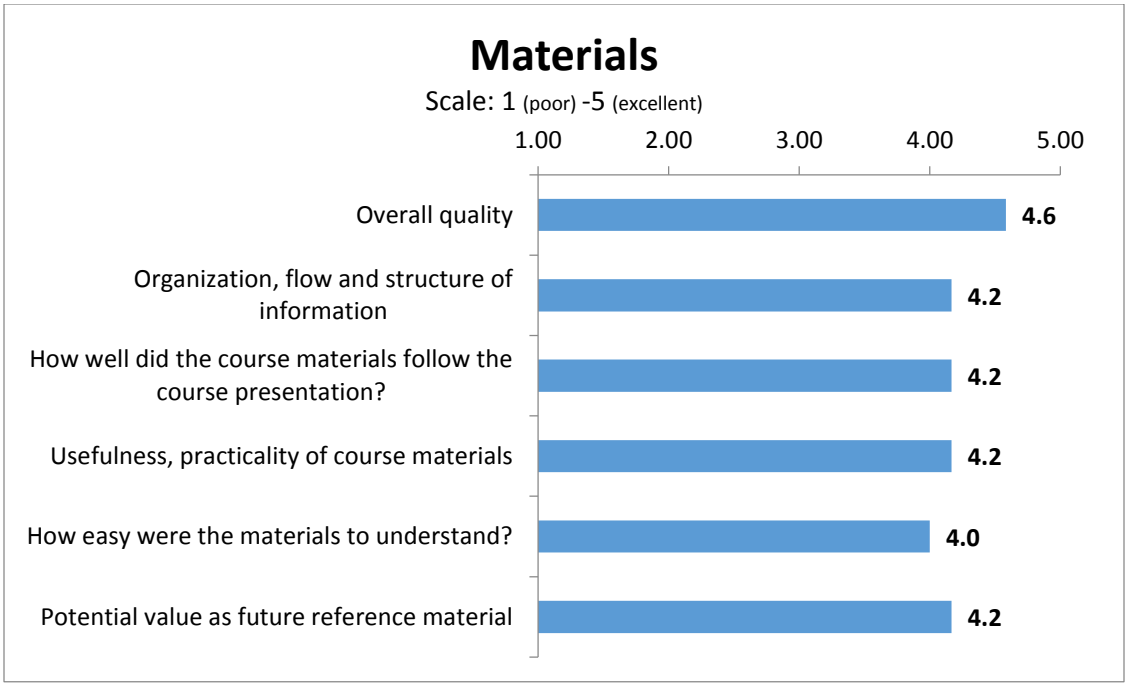


Figure 5: Average ratings for the course materials.

All aspects of course logistics, including location, classroom, course length, pace of course, and time of year the course was offered, were satisfactory for the majority of the students (Table 7, Figure 6). One student did say that the "U" shape configuration of the tables and chairs relative to the instructor/screen was uncomfortable. In line with the comments above regarding hands-on activities, one student said the course should be longer to allow for more hands-on labs, while another student said that while he was very satisfied with the overall length, he thought the course could have been organized differently to spend more time on hands-on activities. A couple of other comments about the length of the course are worth noting as they directly apply to student needs for training and the content and organization of the course. One student commented, "I think the course materials for the applications used by Caltrans could have been presented to us in two days without going in[to] details of each technology. After all, districts are at the receiving end of [the] technology, so system engineering is what gets designed and what [is] desired by most districts." He continued, "The structure of the course may have been done slightly different due to the diverse audience. 1) Wireless technology and its practical application and implementation; 2) Building blocks of these technologies without the technical depth presented since the clients (Districts) are at the receiving end of these technologies (users); and 3) I think the course could be presented over 3 days if the above items were taken into consideration."

Table 7: Number of students rating level of satisfaction for different aspects of the course.

Aspects	*Number of students who rated the item at each level*					
	5	4	3	2	1	
	Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied	Average Rating
Location	6	3	2	1	0	4.17
Facility/Classroom	5	5	1	1	0	4.17
Course length	6	2	3	1	0	4.08
Pace of course	5	6	0	0	0	4.45
Time of year course was offered	6	3	3	0	0	4.25

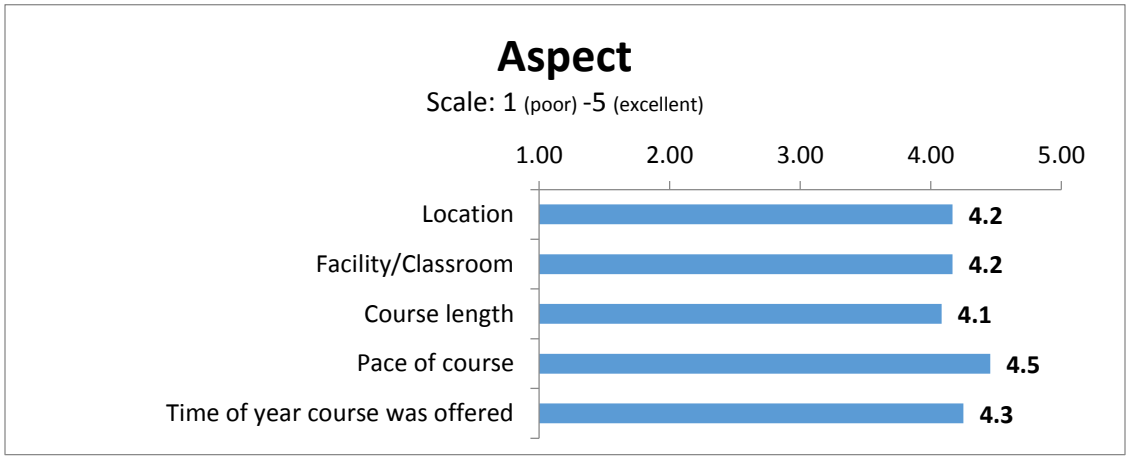


Figure 6: Level of satisfaction with different aspects of course logistics.

Students listed numerous areas in which they had acquired knowledge or skills which could be directly applied to their jobs. Antenna placement and evaluation of installation sites, analysis of antenna types, examining various technologies in relation to different carriers, and a general understanding of 3G/4G principles were all listed as being applicable to participants' jobs. Four students said that the signal strength and quality tools presented in the course—such as www.sensorly.com and G-NetTrack—would be useful in the workplace. One participant wrote that he would be able to apply techniques for evaluating LTE sites and deploying LTE modems, and that the "Tools presented in this training will help me in deployment of these [LTE] modems and [making] informed decisions on type of antenna needed to boost poor signal locations." Another student indicated that his district is currently in the process of changing all of their cellular modems in a move towards LTE technology, and that the course presented him with considerations for design and implementation.

When asked what topics or skills from the course they may have difficulty applying in their jobs, few students listed anything. However, one student did say he would have difficulty using the spectrum analyzer to analyze potential field sites. While using equipment such as the spectrum analyzer was to be an important laboratory exercise, this comment is not unexpected considering other comments regarding a lack of hands-on activities in the course.

Students either did not take the original needs assessment survey or were unsure whether they had. However, the evaluations suggest that the course met student expectations and presented content that was relevant to their needs. Students commented that the course applied to them and that they learned useful information about all wireless technologies, including advantages and disadvantages of different cellular technologies. One student commented that yes the course met his needs and expectations, explaining that "We do need this information to expand our system, provide alternate communications paths and provide services we currently cannot." Another student summarized, "The course met my needs for the type of applications used in my district and exceeded in other areas of coverage." On the other hand, a student noted that while the class was "very rich in content" and overall a good class, he was expecting more focus on the user/application side of systems versus the provider side. Another student said the course really didn't meet their needs and expectations – "…some of it did, but not 5 days' worth."

Another key objective for all three phases of this project was to have the courses taught by subject matter experts with industry experience. When asked whether this course met their needs and expectations for training on Telco Wireless topics, one student said, "Yes, the instructor was very experienced in the industry and answered a lot of questions we had."

Students suggested a number of different topics in which they desired training. These included telco specific technologies and related such as DSL, MPLS, metro Ethernet and telco provided network extension. Non-wireless communications, RFID and Bluetooth between vehicles and at a base station, licensed and unlicensed wireless radio, and short range communications were also listed as training interests. A couple students mentioned communications security as a potential training topic. Modem configurations and video compression/encoding schemes were some specific skill sets for which students would like training.

When considering options for future professional capacity building, it is worth noting that several students showed interest in IP networking and fiber optics, subjects already covered in previous phases of this project. It is unclear whether this simply indicates that the commenter did not participate in those earlier courses, or that a student was possibly interested in more advanced

training on those topics. Also worth considering, one student did suggest courses that concentrated on specific intelligent transportation systems covering every aspect of the given system, from the field to the central office or TMC.

In summary, eleven out of the twelve students in the course were likely to or would definitely recommend this course to a peer, and all were likely to participate in another training course as part of the professional capacity building project (Table 8, Figure 7).

Table 8: Number of students likely to recommend course to others.

Recommend to others	*Number of students who rated the item at each level*					
	5	4	3	2	1	
	Definitely	Likely	Neutral	Maybe	No	Average Rating
Recommend to others	8	3	1	0	0	4.58

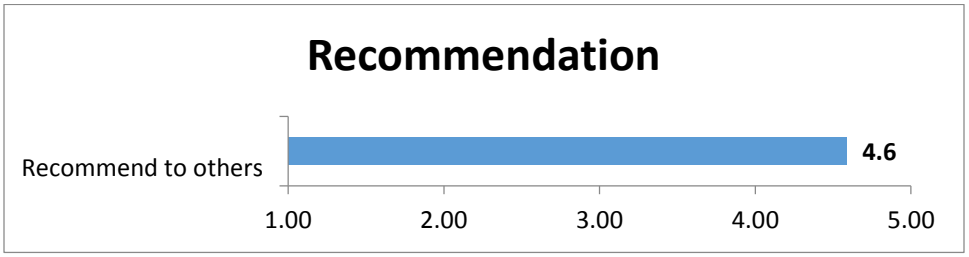


Figure 7: How likely students were to recommend this course to others.

1.8. PTAP Evaluations

While participant evaluations were important and provided beneficial feedback, it was very valuable to have members of the PTAP and project team attend all or parts of the class in a review capacity. PTAP members were also able to gather some additional feedback and reactions directly from the student participants.

Overall, the PTAP felt the course was well-received and worthwhile for the student participants. After the course concluded, PTAP members have received positive feedback about the course and the instructor. The PTAP indicated that "the students thought it was a good course."

- In a nutshell, the overall goal of the course was to provide students with the necessary knowledge and skills needed to be able to choose and implement Telco Wireless technologies that are most appropriate for a given application. This includes some background information, how a system works, transmission, availability, type of service, the ability to ask intelligent questions of vendors, etc. The PTAP felt the syllabus "nailed it" in regard to the content that should be presented in this course.
- The course presented a tremendous amount of material on an aggressive timeline. Similar to all of the previous courses delivered during this project, this "fire hose" effect is preferable – presenting a wealth of information possibly beyond what the students could master in the allotted time, but then be able to go back to the comprehensive materials for specifics. One person indicated that despite the robust topic and "fire hose" presentation,

the course was relatively easy to follow as presented. Another PTAP member confirmed that the depth of material was what it should be, stating the course was intended to be an engineering level class.

- The instructor was very knowledgeable and experienced in Telco Wireless technologies and applications. The PTAP recognized his efforts to make himself available for questions/discussion and then to ensure a thorough and accurate response. He was flexible and responded to student feedback as the course progressed. With that said, the PTAP felt and student comments alluded to, that too much time was spent on the introductory sections. Consequently, the Day 1 material was not completely covered until halfway through Day 2 which threw off the tight timeline for the course. The PTAP steered the remaining content presentation toward topics of most interest. However, the result may have come across as "jumping around" or not in a logical sequence. Similarly, one person noted that the anecdotes shared by the instructor were well-received but also threw off the presentation timing.
- Given the discussion above, the instructor and the PTAP agreed that the course could have been organized differently to have a more logical track as well as better match students' needs, interests, and expectations. The instructor noted that the subject of Telco Wireless is large and "stirred up", making it difficult to see a cohesive flow. He added that each topic needs to be addressed adequately on an individual basis in addition to part of the larger subject area.
- The PTAP and the instructor agreed with the students that the course may have fell short in the amount and quality of hands-on activities. However, there was some question as to what could have been included given the subject, fixed outline, and already crowded timeline. Everyone agreed that some reorganization of the syllabus might help address this deficiency.
- On that same note, if students have some pre-requisite skills and knowledge in transmission technology for example, it is possible the rest of the syllabus could be addressed in four days. With that said, the additional day's worth of time could then be spent on hands-on activities, field trips, case studies, or other practical applications.
- Two specific examples related to hands on activities involved the Android application that was used during the course and activities with the spectrum analyzer. Students were/are using the Android software outside of class time and recognize its capability. Someone commented that there was certainly some "self-interest" at play. As mentioned in the previous section, using a spectrum analyzer was to be an important laboratory exercise. At least one student expressed that they would have difficulty using the spectrum analyzer to evaluate signal strength and frequency for field sites/actual applications. The PTAP stated that there should have been more interest in the spectrum analyzer on the part of the students, but that it appeared the class was "content to watch the screen while one student ran the equipment." Perhaps given more time dedicated to such activities, each student could have spent time learning about and using this equipment.
- The instructor completely agreed with the overall intent and the need for the course and the project. He said this course is not something you would find in an academic setting explaining it was vocational beyond the technician level. He also encouraged the PTAP to

make the course as accessible as possible, repeating it several times for different audiences with similar needs.

- As mentioned above, the course materials were complete and professional. The instructor made changes as needed right on site and then ensured that all of the students and the PTAP had access to the updated materials. He also included any relevant resources that were discussed during class or during breaks. However, the printed materials would have benefited from some delineations that matched the syllabus (e.g., Day 1, Day 2, etc.; or topic headings). A structured table of contents would also make the materials more useful as a future reference.
- The PTAP and instructor agreed that the location and facility were adequate and comfortable. The presence of the maintenance yard's radio room offered some opportunity for spontaneous discussion particularly relevant to the topics being presented in the course.
- It should be noted that at the request of a PTAP member, the instructor prepared for and spent one evening after the regular class time with interested students discussing topics related to medium frequency ground wave propagation.

1.9. Recommendations

Based on the planning, results, and evaluation of this course, the project team makes the following recommendations:

- The time of year the course was held seemed appropriate and worked well for this training and project phase. The late September timeframe has also worked well for previous classes. A summer course may also be a feasible choice, possibly in conjunction with the Western States Rural Transportation Technology Implementers Forum, which is a meeting attended by many in the target audience.
- The full week length of the course was appropriate and necessary for this topic and course presentation. Shifting the start time on the first day of the course to a little later in the morning is helpful to accommodate those traveling from longer distances.
- The location of the training course was also a good choice. It was comfortable, spacious, and had all of the necessary equipment and services. Lodging options were in very close proximity as were a variety of dining choices.
- It is recommended that the project team and PTAP continue to clearly communicate course expectations, including attendance, skill level, and relevancy to those choosing which students should participate in a particular training course.
- It is critical to maintain the high standards set forth in this project regarding the content and delivery of these courses – that high quality technical content be delivered in a challenging environment by an expert in the field. The curriculum and presentation should not be "dumbed down" but instead students should be "brought up" to a higher level of expertise. Students should come out of a course challenged but with a solid understanding of the material and the different options available for solving a communications problem. Furthermore, the instructor must have practical, hands-on experience in the field for a length of time necessary to be considered an expert, in addition to being a quality instructor.

- The contractor was selected from a number of bids through a formal limited solicitation process. This process allowed the project team to set clear expectations and standards for the instructor, content, materials, delivery, and logistics, and have the leverage to hold the contractor accountable through the duration of the contracted services agreement (CSA). It is highly recommended that a similar process and Request for Bids be used for future training opportunities.
- The Scope of Work for the CSA should include a timeline and deadlines for various steps in course development and delivery (i.e., due dates for draft materials, final materials, equipment list, evaluations, etc.) This establishes accountability, but also provides the opportunity to review, evaluate, and approve content, materials, presentation, and activities to ensure the course and its delivery will meet the needs of the students and expectations for the project.
- The one hour "dry run" presentation, which included a description of a hands-on activity, was helpful to confirm the pedagogy of the upcoming course.
- As mentioned in previous sections, the instructor's knowledge of the subject matter was critical for successful delivery of this course. It is recommended that potential course instructors be thoroughly vetted by the PTAP/project team/selection committee to determine levels of knowledge and experience.
- It is further recommended that instructors be included in course curriculum development from the beginning and throughout the preparation. Clear expectations for relevancy and laboratory exercises must be expressed and understood by all involved in the development process. Solid confirmation of actual hands-on activities to be conducted during the course should be received from the instructor by the PTAP and project team.
- Based on the evaluations, it is recommended that the PTAP ~~consider~~ revise and reorganize the course syllabus to allow time for more discussion of practical applications and hands-on activities. One idea is to have students submit before the class begins some examples of real situations they are faced with in their district.
- Based on the evaluations, it is recommended that the PTAP give further consideration to the level and type of pre-requisite skills/knowledge that students should have before taking this course.
- It is recommended that direct means for communication with the instructor throughout the process be provided to the PTAP. (We note this because the PTAP was not given direct access to an instructor in the course offered in Phase 1, and there were resulting challenges.)
- It is recommended that some further consideration be given to administering an assessment of learning. Student perception of the effectiveness of the course and instructor may not match the expectations of the PTAP, and high evaluation marks may not equate to the course meeting its intended objectives. Thus, course evaluations alone may not give a sufficient indication of course effectiveness.
- Having project team and PTAP members attend the course was valuable and should be continued in some capacity for future training classes.

- Course materials and equipment should be shipped directly to the training location. It is preferable to have the course materials and equipment set up at least one business day prior to the start of the course. Network connectivity should also be tested in advance and backup arrangements made if needed.
- Class size should be no larger than 10 to 12 students to ensure quality of student and teacher interactions. An effective means of utilizing a waiting list should be in place.
- It is recommended that the PTAP consider different options for course presentation. One idea may be to conduct two or three days of training with a trainer such as Mr. Baxter and then do a practical field experience with nearby ITS installations or case studies, or some combination thereof. The field experience may be led by a Caltrans engineer or other subject matter expert.
- It is further recommended that the PTAP explore the possibility of engaging Caltrans engineers to develop and present professional capacity building courses in ITS communications. We note that this would likely require a sabbatical program for Caltrans engineers.

NEEDS ASSESSMENT AND GAP ANALYSIS

This section compares and summarizes the needs and expectations of Caltrans' rural ITS engineers and technicians as assessed through the Professional Capacity Building for Communications (2015) survey and the available training opportunities identified during development of the subject matter expert list.

1.10. Needs Assessment

1.10.1. Survey Design

THE PROFESSIONAL CAPACITY BUILDING FOR COMMUNICATIONS DESIGNED AND FACILITATED USING SURVEYMONKEY AND BASED CONDUCTED IN PHASE 1 OF THE PROJECT. A COPY OF THE SURVEY IS INCLUDED IN

Appendix F: Needs Assessment Survey. The Caltrans project manager identified the target population and sample. The sample consisted of engineers and technicians working on ITS projects throughout Caltrans and particularly in rural areas. Participation was voluntary. Demographic information was collected to help characterize the target audience for the potential training coursework. Questions included job title, years in position, and the location and name of the Caltrans district/department for whom the respondent worked. Respondents were also asked about the technical training already received related to their job and/or career, including but not limited to degrees, certifications, and professional training classes. Name and contact information was collected only for the purposes of this study and for course development and delivery.

The survey was divided into categories according to subject areas, namely Plant Wireless, Telco Wireless, Plant Wired, Telco Wired, and IP Fundamentals. Each category had brief descriptions and included a list of specific topics with the option for respondents to include additional topics

they deemed important. Refer to Section 1.1 Curriculum Scope and Sequence to review the subject areas and associated topics.

Respondents were asked about their level of experience with each of the above topics. Choices were substantial experience, some experience, no experience, and not familiar with topic. Next, the survey asked the importance of training for each of the specific topics. Respondents could designate very important, important, not important, or not familiar with topic. A simple yes or no answer helped establish whether training was desired for each of the specific technologies. In regard to frequency of use, the survey respondents could designate daily, weekly, monthly, yearly, sometime in the future, sometime in the past, or do not use this technology. Finally, training objectives for a sample course in each technology were evaluated for level of detail (not enough detail, just enough detail, too much detail, or not familiar with this topic).

1.10.2. Data Collection and Analysis

The survey remained open for approximately five weeks (September-October, 2015) and responses were collected using SurveyMonkey. A total of 15 individuals started the survey and 12 completed it for an 80 percent completion rate. It should be noted that 14 responses were collected for the demographic information and the questions related to the Plant Wireless subject area; 12 people responded to the rest of the questions. The data was analyzed using Microsoft Excel and SurveyMonkey.

Survey responses were categorized by questions, subject area, and topic. The number of responses for each question option were totaled and expressed as a simple percent of the number of responses for the question.

To assess the needs of Caltrans personnel for training in different ITS communications technologies, the data was then aggregated and organized into a summary table and presented graphically with simple column (bar) charts. For level of experience, the percentage of respondents with substantial experience in each technology was listed in the summary table. The percentage desiring training was also listed. The percentage of respondents who thought training was very important and important were aggregated together so the number in the summary table was a sum of those two choices. For frequency of use, the percentage of respondents answering daily, weekly, and monthly were totaled for a percentage of respondents that use a certain technology at least monthly.

The percentage of respondents evaluating the level of detail in the sample topic lists as ‘not enough,’ ‘just enough,’ ‘too much,’ and ‘not familiar’ were left as a stand-alone table.

As mentioned earlier, the subject areas and topics at hand have already been identified as important by Caltrans and substantiated by the literature review. The needs assessment survey provided a closer look at the specific needs of Caltrans ITS engineers. More pressing needs were identified based on the percentage results and the representative charts.

1.10.3. Demographics

Survey respondents were asked which district or department they worked in, job title, number of years in the current position, and technical training they have completed related to their career/job. For number of years in current position, responses ranged from 1 year to 20+ years. The average

time in current position was 10.7 years. To help characterize the sample, a list of job titles is shown below.

- Chief, Office of ITS Engineering and Support
- District Traffic Electrical - TMC Chief
- ITS Engineer (3)
- Senior Electrical Engineer - TMC Support
- Senior Transportation Engineer, Electrical (Specialist)
- Senior Electrical Engineer
- State Electrical Maintenance Coordinator
- Supervisor Transportation Engineer Electrical
- Trans. Engr. - Electrical Range C
- Transportation Electrical Engineer (3)

Survey respondents worked in five of the 12 Caltrans districts and three departments at Caltrans Headquarters. The most respondents were from Caltrans District 2 (four). Figure 8 shows the distribution of responses regarding where the survey respondents were employed.

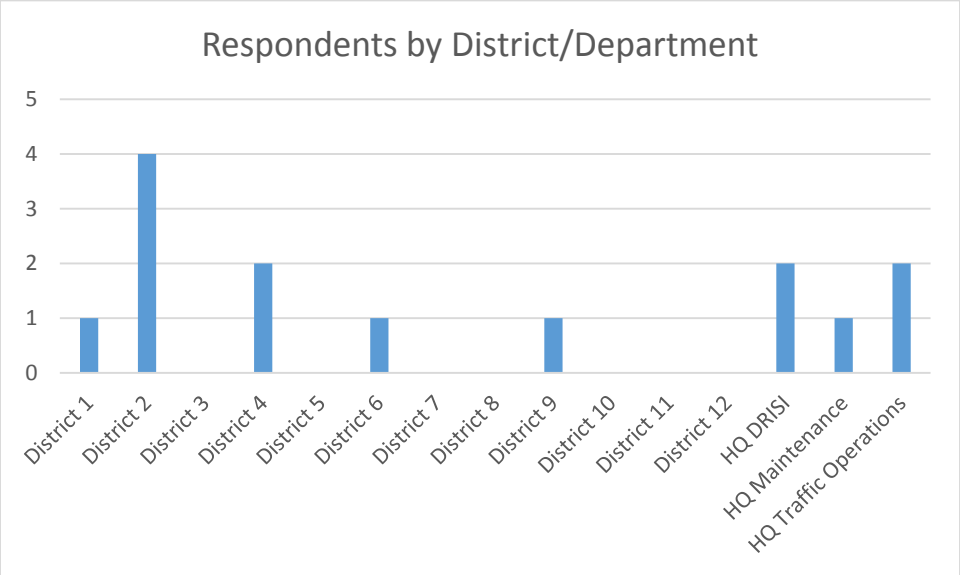


Figure 8: Number of survey respondents per district or department.

Regarding technical training related to current jobs/careers, seven of the 14 respondents who answered the question listed a bachelor's degree in electrical engineering. One listed an associate's degree in electronics technology. Other degrees listed included civil engineering and physics. Fundamentals of Engineering, or EIT (Engineer-In-Training) certification, was listed by two respondents and seven listed Professional Engineer (PE) status in California. Two respondents listed one or more professional certifications in lieu of or in addition to an academic degree. Certifications included: project management, Cisco Certified Network Associate (CCNA), Comp TIA Security, Comp TIA A+, and Microsoft Professional Certification. One respondent listed on-the-job training and another included self-study. Six responses included mention of the four PCB courses that have been delivered through this project (RF Engineering, Optical Fiber, IP Networking Fundamentals, Telco Wireless Fundamentals). One respondent listed the Western States Rural Transportation Technology Implementers Forum and "numerous research symposiums." Other training classes/topics listed for technical training received by the survey respondents included the following:

- Basic Network Systems Training
- Electrical Safety Training
- Grounding Training
- CMS workshop
- Traffic Operations Academy
- HCM Training
- PE Academy
- TMC Training
- Emergency Operations Center (EOC) Training
- In-house training classes
- Various vendor trainings

It should be noted that two respondents put either an "X" or "N/A" in response to this question. One only listed "Project Management Certificate." Considering job titles and number of years in position, these respondents likely have some relevant training experience and/or academic degrees in addition to on-the-job training.

1.10.4. Level of Experience

The survey asked respondents to gauge their level of experience with each of the topics in the different subject areas. The choices were substantial, some, none, and not familiar with the topic. For the purposes of the gap analysis, the project team first examined the percentages of respondents with substantial experience in each technology as organized by subject area. More in depth analysis will be conducted if the PTAP so directs.

In the Plant Wireless subject area, 29 percent of respondents indicated substantial experience with microwave technologies. Just over 20 percent of respondents indicated substantial experience with Plant Wireless Core / RF Systems Design, while 14 percent and 7 percent said they had substantial experience with 802.11 (WiFi) and related and short haul radio technologies respectively. None

reported substantial experience with Privately-owned WiMax. The higher percentages of survey respondents that lack substantial experience in these technologies suggest a need for training in this subject area. See Figure 9.

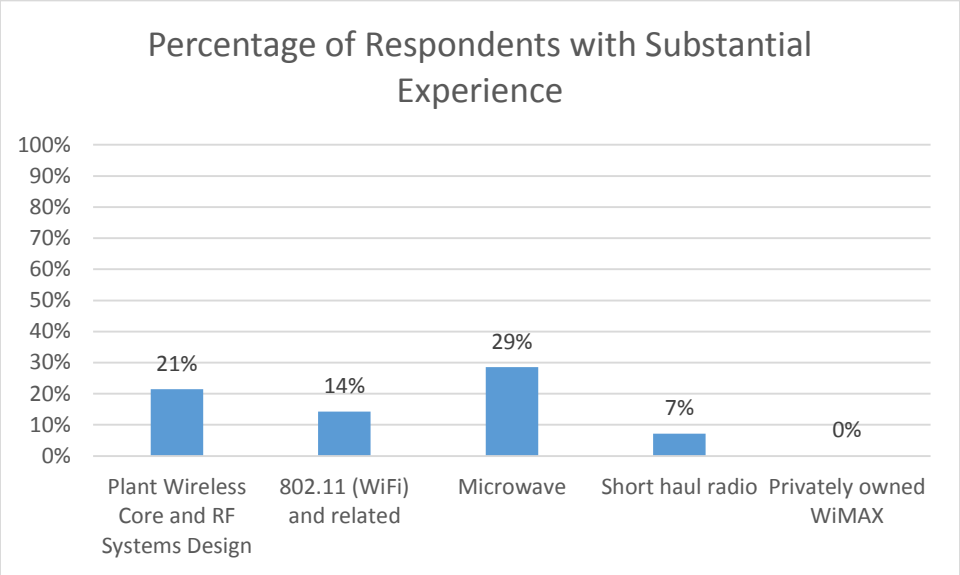


Figure 9: Percentage of respondents with substantial experience in Plant Wireless technologies.

In the Telco Wireless subject area, 17 percent of respondents reported having substantial experience with Telco Wireless core and cellular/PCS basics and only 8 percent listed similar experience with LTE, 4G and next generation technologies. None indicated a high level of experience with GSM, CDMA (3G and next generations), or Telco owned WiMAX technologies. In this case, it is worth noting that besides the three with substantial experience, the majority of survey respondents did report having some experience with all of the Telco Wireless technologies except WiMax – for that topic, 10 individuals said they had no experience and 2 said they were unfamiliar with the topic. The very low percentages of respondents with substantial experience in these Telco Wireless technologies implies that training may be needed to address this evident lack of professional capacity. Refer to Figure 10.

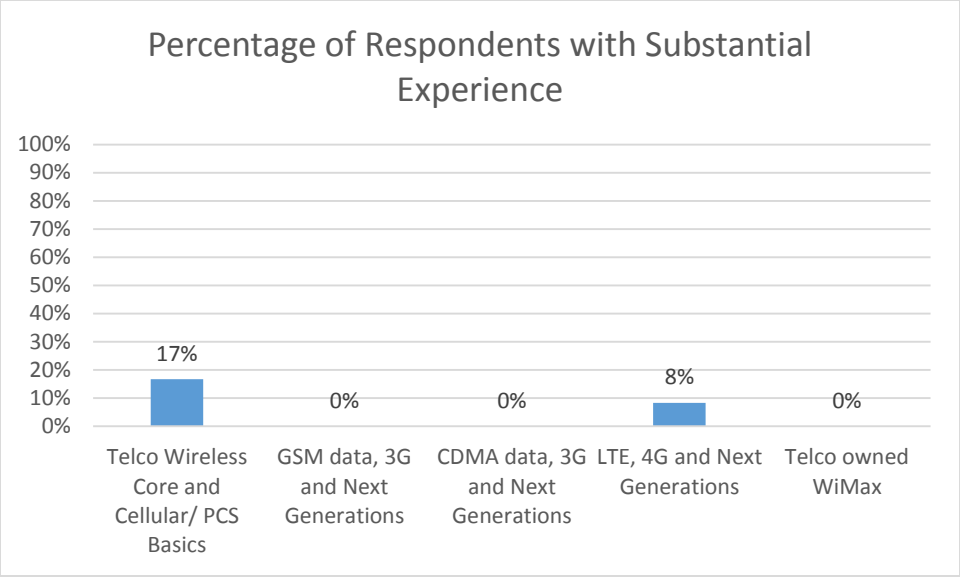


Figure 10: Percentage of respondents with substantial experience in Telco Wireless technologies.

Of those with substantial experience in Plant Wired technologies, 42 percent reported that level of experience in both Plant Wired core / plant wiring basics and serial connectivity. Only 8 percent noted substantial experience with xDSL technology, but 17 percent said they had a high level of experience with optical fiber. Even though compared to the other subject areas, more individuals indicated a higher level of experience in Plant Wired technologies, those with substantial experience was still less than 50 percent. This still suggests a potential need for training in these topic areas, albeit possibly somewhat less than that of other topics. See Figure 11.

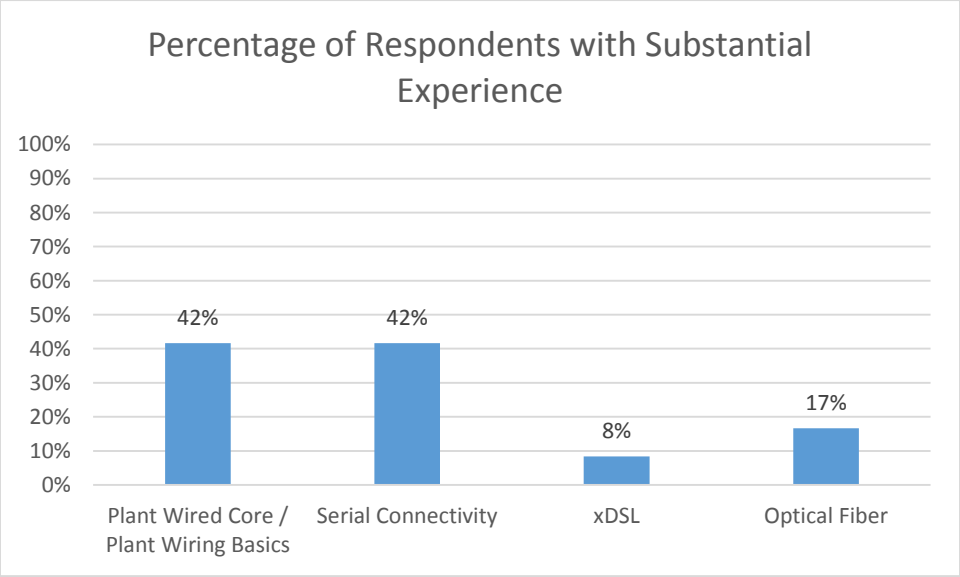


Figure 11: Percentage of respondents with substantial experience in Plant Wired technologies.

In the Telco Wired subject area, half of the respondents had the most experience with POTS (Plain Old Telephone Service), followed by 42 percent with substantial experience in ISDN technologies. A quarter or less of the respondents noted a high level of experience with the rest of the Telco

Wired technologies, with none saying they had substantial experience in frame relay technology. Similar to Plant Wired technologies, though experience levels may be somewhat higher with Telco Wired technologies compared to that of other subjects, those with considerable experience was still 50 percent or less, suggesting a potential need for training in these topics. Refer to Figure 12.

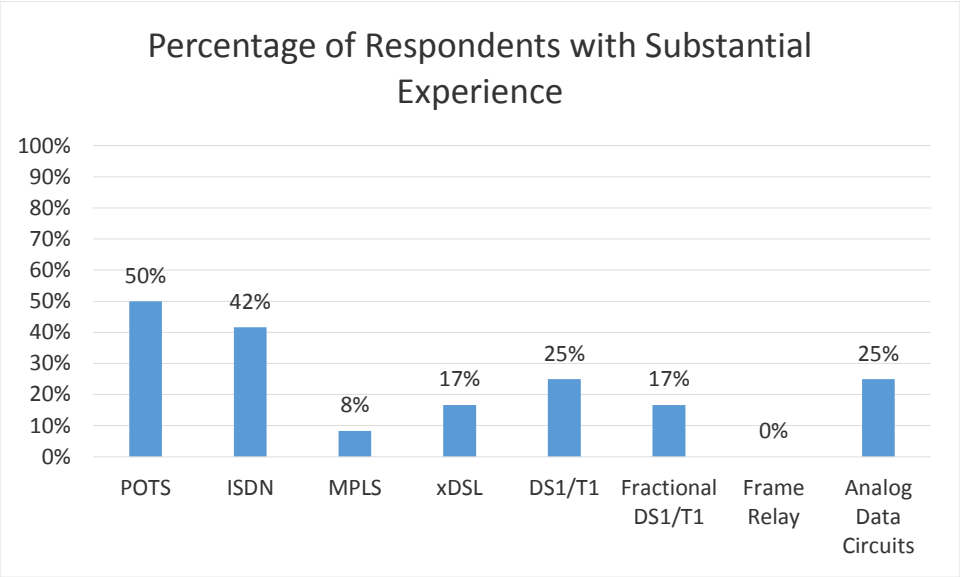


Figure 12: Percentage of respondents with substantial experience in Telco Wired technologies.

Experience levels for IP Fundamentals topics were relatively consistent with 33 percent reporting extensive experience with three of the four topics. Individuals had the least experience with network security (17 percent). Given only one third of survey respondents noted substantial experience in IP Fundamentals topics, a need for professional capacity building in this subject can be inferred. See Figure 13.

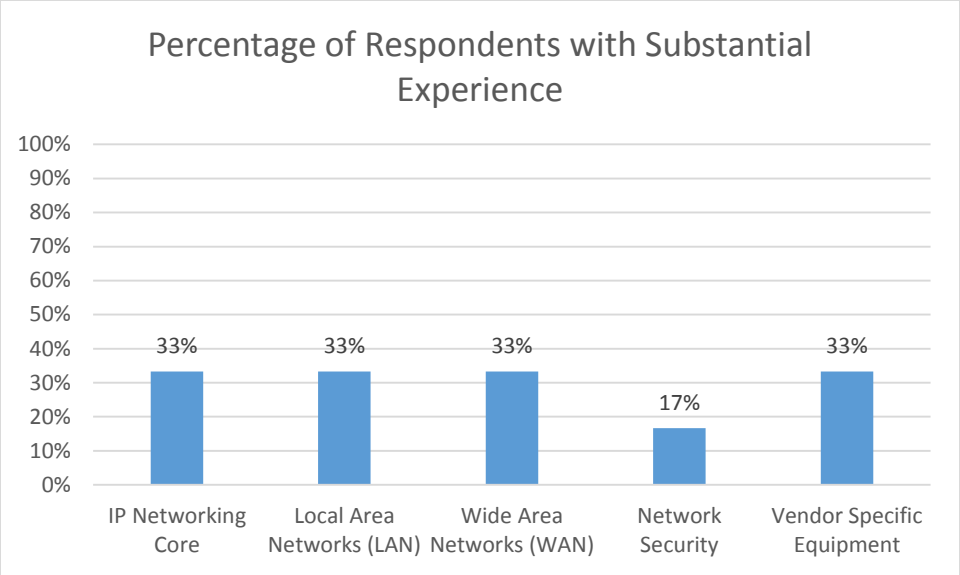


Figure 13: Percentage of respondents with substantial experience in IP Fundamentals technologies.

Over all the subject areas and topics, respondents possessed the most experience with POTS technology, followed by ISDN, serial connectivity, and plant wired core / plant wiring basics. The sample generally had less experience in Telco Wireless technologies which included Telco Wireless Core and cellular/PCS basics, GSM and CSMA (3G and next generations), LTE (4G and next generations, and Telco owned WiMax. It should be noted that when the percentages of those with substantial experience are averaged across a subject area, 30 percent or less of the sample had substantial experience in any of the communications subject areas. An average of 14 percent had extensive experience in the Plant Wireless technologies and only 5 percent had significant experience in Telco Wireless technologies. This relative lack of experience related to specific ITS communications technologies provides compelling evidence that training is needed in these areas to build the professional capacity of Caltrans ITS engineers. It is of particular interest given the class that was delivered in this phase of the project covered Telco Wireless technologies. However, it is unclear whether this is simply a function of the sample make-up or a factor to consider relative to specific content of the training course.

1.10.5. Importance of Training

The survey then asked participants to rate the importance of training for each of the communications technologies. Possible answers were very important, important, not important, and not familiar with topic. Similar to the previous question, the project team most closely examined the subset of data that included the responses for very important and important. The percentages of participants that marked either response were aggregated to result in a single value (important) which was used for the preliminary needs assessment.

For Plant Wireless technologies, 100 percent of survey respondents said that training in Plant Wireless core and RF systems design, 802.11 (WiFi) and related, and microwave technologies were important. Training in short haul radio was marked important by 93 percent of the sample and 64 percent said the privately owned WiMax training was important. An overwhelming majority of survey respondents demonstrated significant support for training needs in Plant Wireless communications technologies by indicating training was important or very important for these topics in relation to their jobs and professional capacity. Refer to Figure 14.

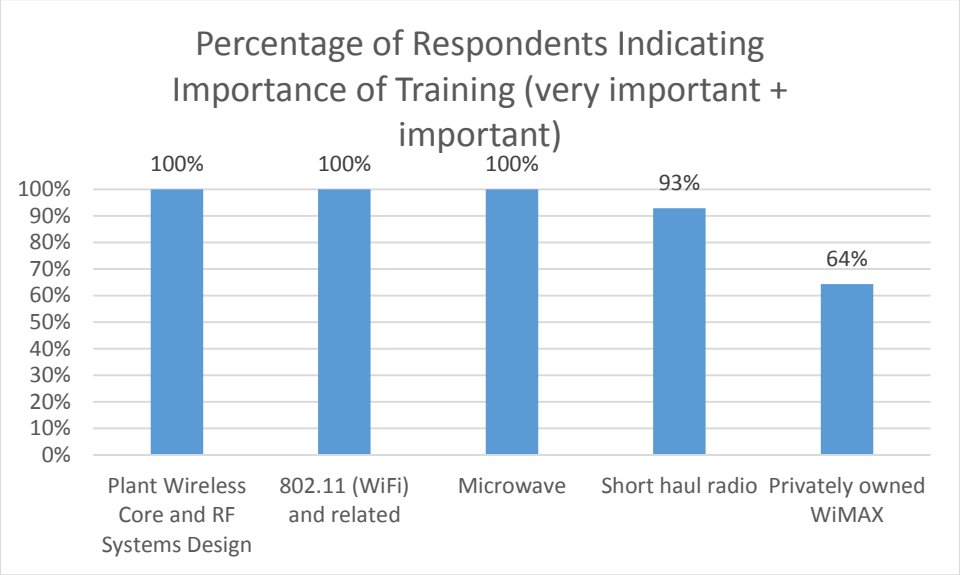


Figure 14: Percentage of respondents indicating importance of training (very important + important) for Plant Wireless communication technologies.

Among Telco Wireless communication technologies, 92 percent of survey participants designated training in LTE, 4G and next generation technology as very important or important. In regard to Telco Wireless core and cellular/PCS basics, GSM and CDMA (3G and next generations), 83 percent said training was important for these topics. A notably lower percentage marked Telco owned WiMax as important (Figure 15). While the percentages considering training important for Telco Wireless technologies were just slightly lower than those for Plant Wireless technologies, a significant number still indicated training was important for Telco Wireless topics, implying a notable need in this area.

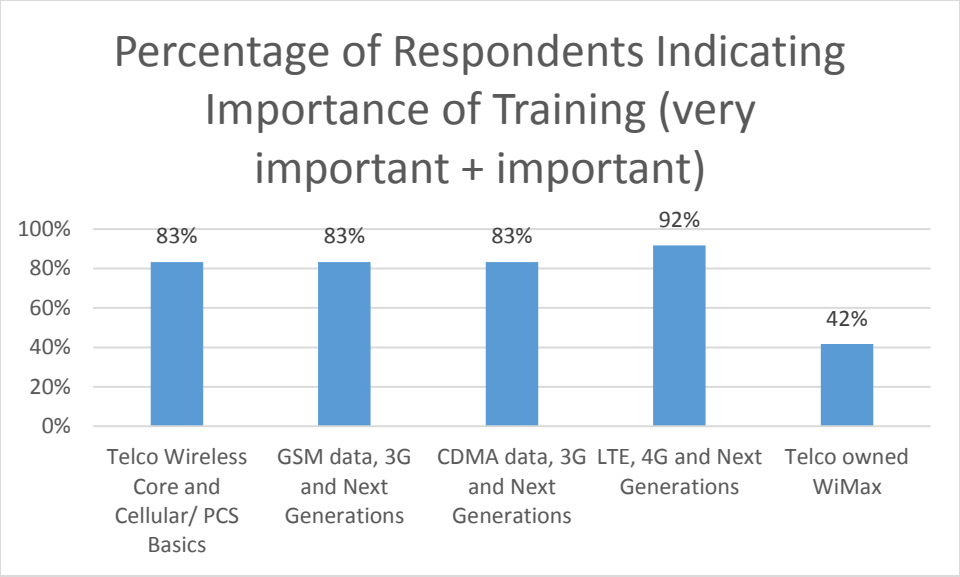


Figure 15: Percentage of respondents indicating importance of training (very important + important) for Telco Wireless communication technologies.

Training importance was consistently high across the Plant Wired subject area, with 100 percent indicating training in serial connectivity and optical fiber was important, and 92 percent saying that Plant Wired core / plant wiring basics and xDSL training were important. These results reveal that Caltrans engineers consider knowledge of these technologies crucial to their jobs and lend strong support for the need for training in Plant Wired ITS communications. See Figure 16.

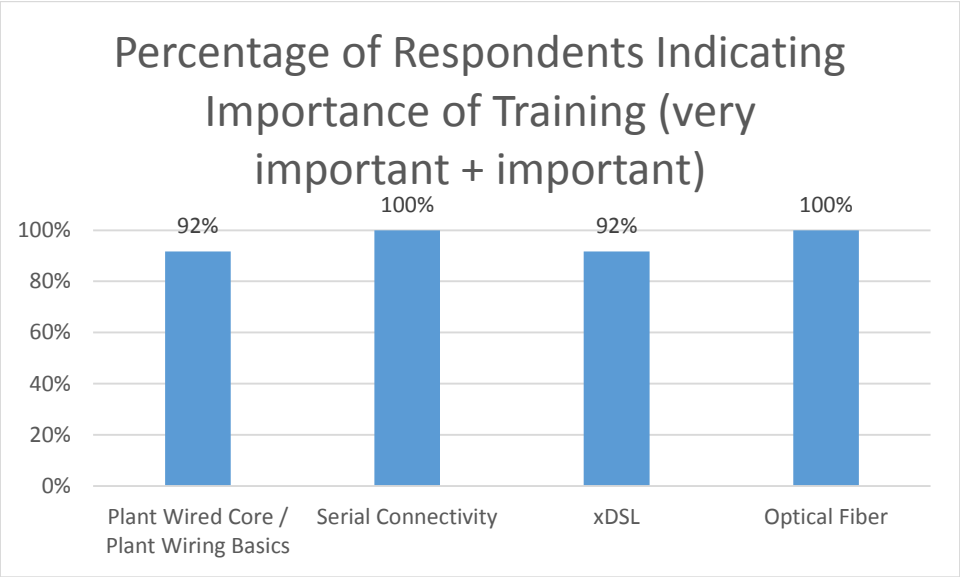


Figure 16: Percentage of respondents indicating importance of training (very important + important) for Plant Wired communication technologies.

The importance of training in Telco Wired topics was again consistent across the subject area. All of the survey sample said that DS1/T1 training was important while 92 percent said the xDSL training was important. For the other six topics, 83 percent marked training as very important or important. These results clearly support a need for training in these topics. See Figure 17.

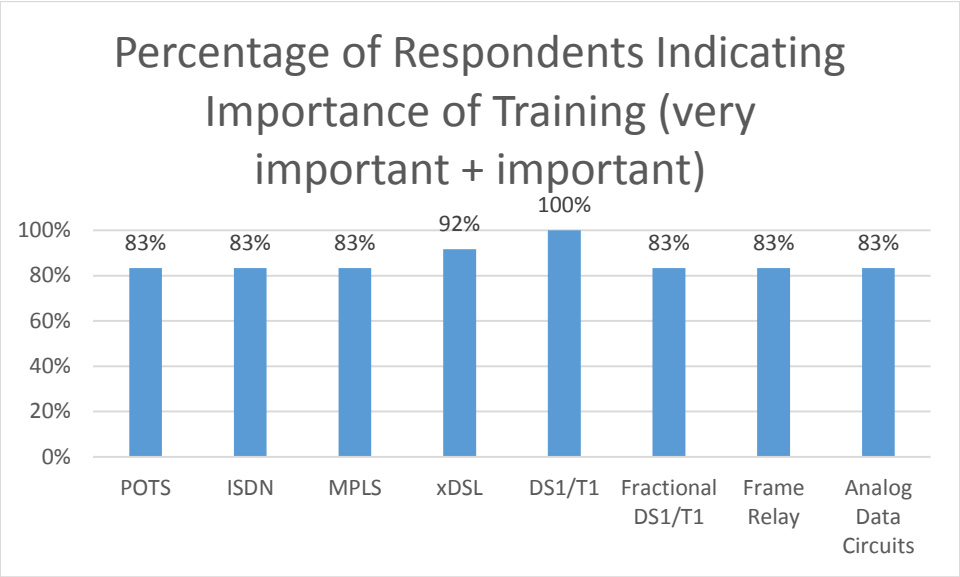


Figure 17: Percentage of respondents indicating importance of training (very important + important) for Telco Wired communication technologies.

For topics related to IP Fundamentals, 92 percent of the sample said training was very important or important for four of the five topics. Training on vendor specific training was considered important by 83 percent of the sample. These results lend strong credence to the need for professional capacity building related to these topic areas. Refer to Figure 18.

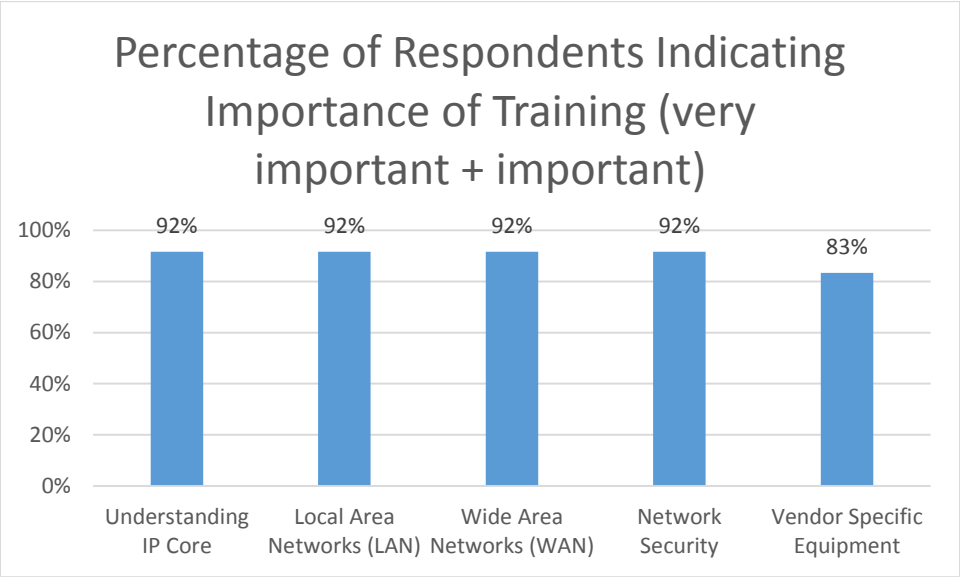


Figure 18: Percentage of respondents indicating importance of training (very important + important) for IP Fundamentals communication technologies.

Comparing the importance of training across subject areas, 83 percent or more of the sample indicated that training was important for all of the listed topics with the exception of privately owned WiMax (64 percent) and Telco owned WiMax (42 percent). Generally, training in Plant Wired communication technologies was considered most important with an average of 96 percent of the sample saying training was important. Plant wireless topics, IP Fundamentals, and Telco Wired topics were close behind with an average of 91 percent, 90 percent, and 86 percent of the sample respectively indicating that training was important or very important for these subjects. If the topic of privately owned WiMax is removed from the Plant Wireless subject area, an average of 98 percent of the sample said that training was important for the remaining topics. Comparatively, training for Telco Wireless technologies was less important although over three quarters of the sample still marked it important or very important. It is clear that the majority of the sample considers training in these communication technologies valuable to their work, which in turn suggests a notable need for training in these areas.

1.10.6. Desire for Training

To gauge the level of interest in training for the specified communication technologies, survey participants were simply asked whether or not they desired training in a certain technology. Answer choices were either yes or no.

With three exceptions, 83 percent or more of the sample indicated they were interested in training in all of the topics in every subject area. Of most interest (92 percent or more marking yes for training interest) were 802.11 (WiFi) and related, serial connectivity, optical fiber, POTS, xDSL, understanding IP core, local area networks (LAN), wide area networks (WAN), and network security. Training in Telco Wireless topics was of slightly less interest overall, but on average

over three quarters of the sample still desired training in this subject area. In the Plant Wired subject area, 75 percent of the respondents thought training in Frame Relay would be valuable. According to the respondents, privately owned WiMax and Telco owned WiMax were of least interest for training with 71 percent and 50 percent respectively marking that they would like training on those topics.

These results clearly show that a need exists for training in ITS communications across the board. Refer to Figure 19, Figure 20, Figure 21, Figure 22, and Figure 23 for more details.

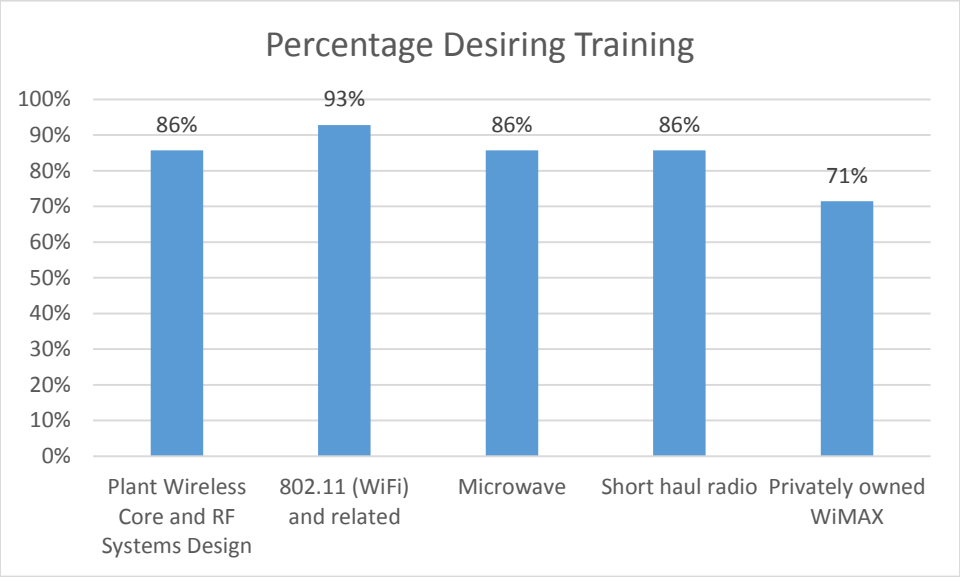


Figure 19: Percentage of respondents desiring training in Plant Wireless communication topics.

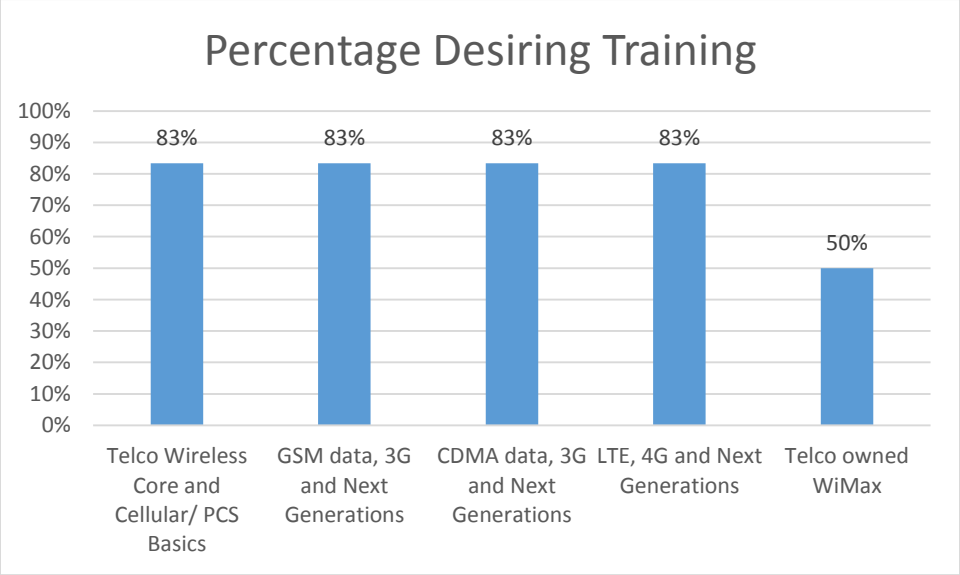


Figure 20: Percentage of respondents desiring training in Telco Wireless communication topics.

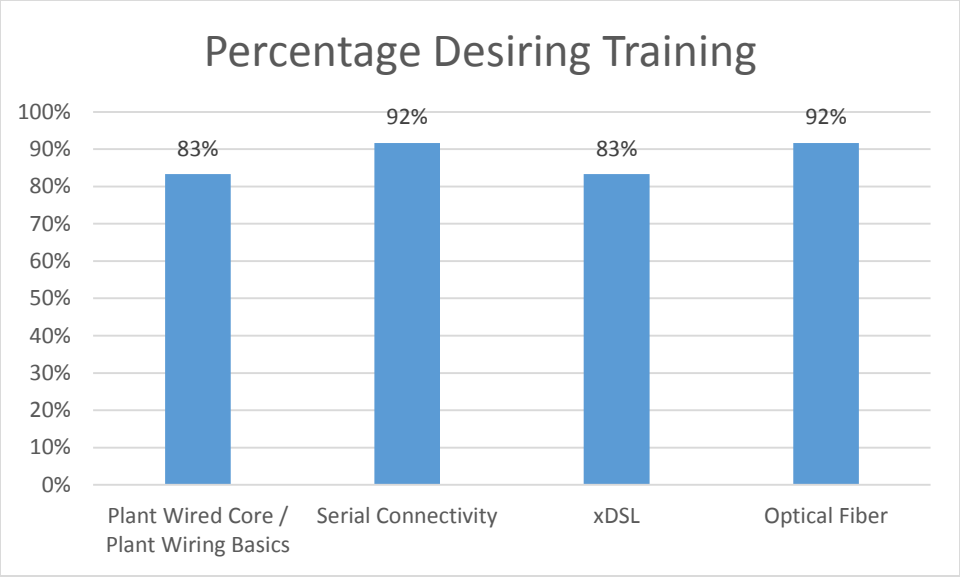


Figure 21: Percentage of respondents desiring training in Plant Wired communication topics.

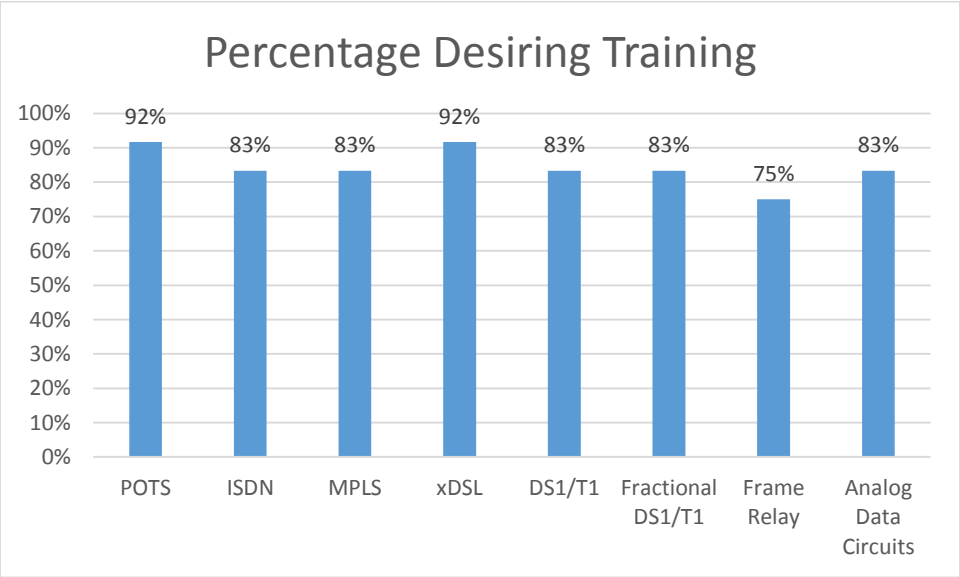


Figure 22: Percentage of respondents desiring training in Telco Wired communication topics.

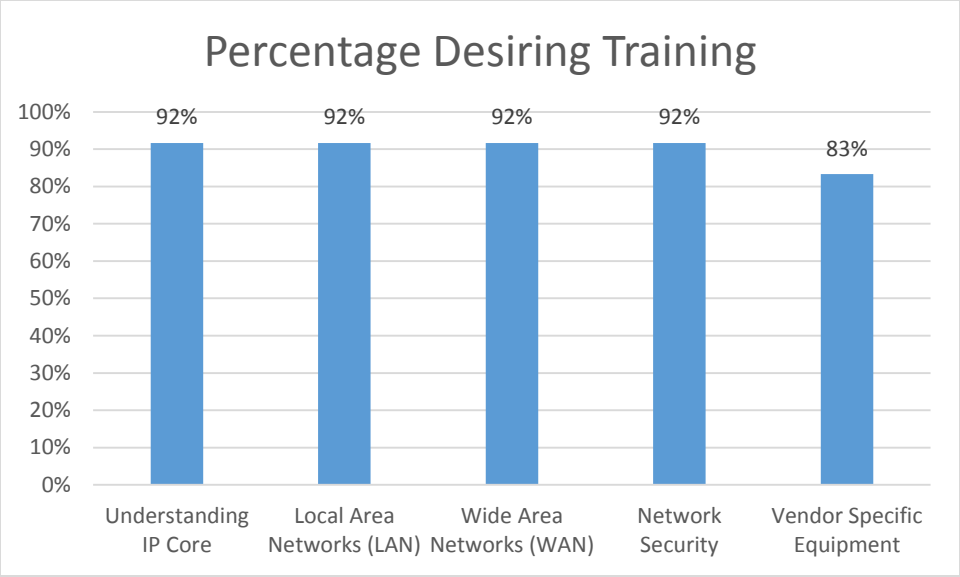


Figure 23: Percentage of respondents desiring training in IP Fundamentals communication topics.

1.10.7. Frequency of Use

Survey participants were asked how often they use the listed technologies as applied to ITS communications. Choices were daily, weekly, monthly, yearly, sometime in the future, sometime in the past, or do not use this technology. To best assess the needs of the sample, the project team aggregated the values for daily, weekly, and monthly to establish a percentage of respondents who use the given technology at least monthly. More in depth analysis will be conducted if the curriculum review committee so directs.

Half of the survey respondents use microwave technologies on at least a monthly basis, while a little over one third (36 percent) regularly use Plant Wireless core, RF systems, and 802.11 (WiFi) (Figure 24). Only 7 percent use short haul radio and privately owned WiMax technologies monthly. About one third do anticipate using these latter two technologies in the future, however 57 percent said they do not use WiMax technology.

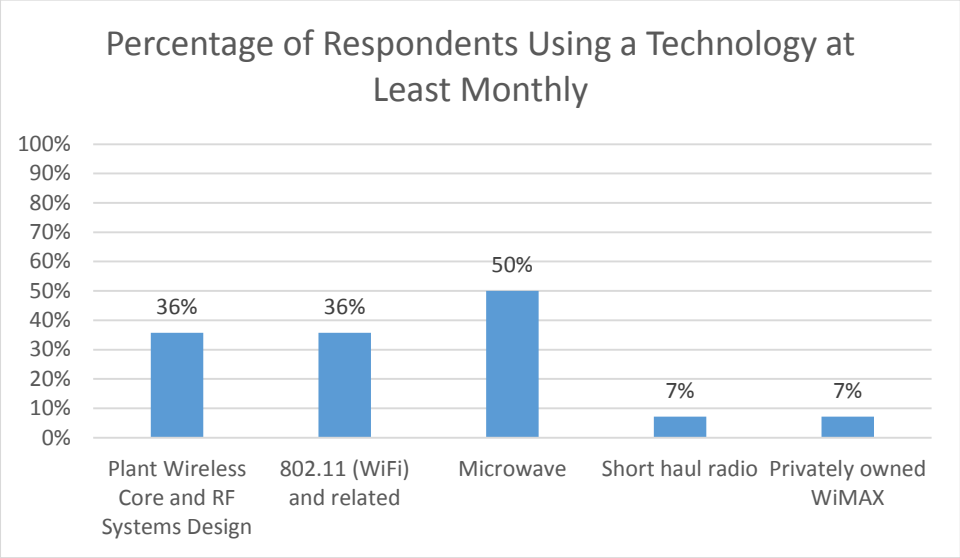


Figure 24: Percentage of respondents using a Plant Wireless communication technology at least monthly.

About half of the survey respondents use all of the Telco Wireless technologies except Telco owned WiMax on at least a monthly basis. While one third indicated that they might use WiMax in the future, the rest of the sample said they do not use this technology at all (Figure 25).

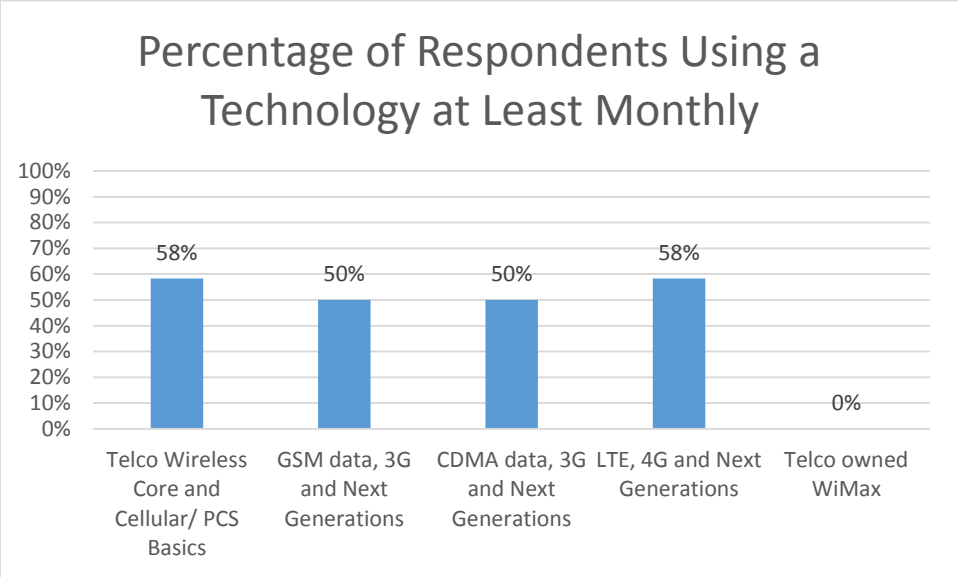


Figure 25: Percentage of respondents using a Telco Wireless communication technology at least monthly.

For Plant Wired technologies, 83 percent of the sample used serial connectivity at least once a month whereas 50 percent or more used the other three technologies for ITS communication applications monthly (Figure 26).

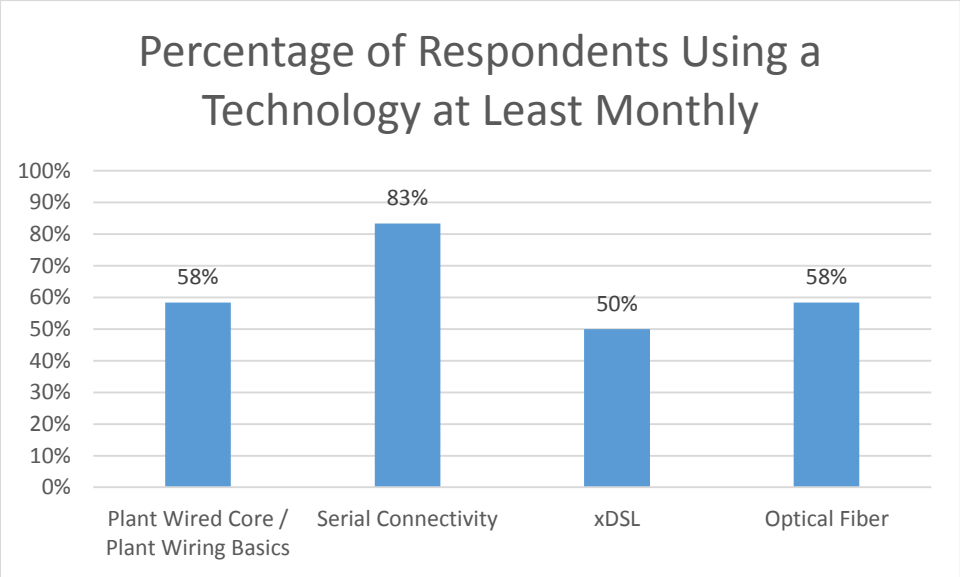


Figure 26: Percentage of respondents using a Plant Wired communication technology at least monthly.

POTS technology was used at least monthly by 67 percent of the sample as compared to only 8 percent who used frame relay technology at least monthly (Figure 27). One third of the respondents do not use either frame relay or MPLS technologies. Of those technologies used less frequently now, there was some indication that they have been used in the past.

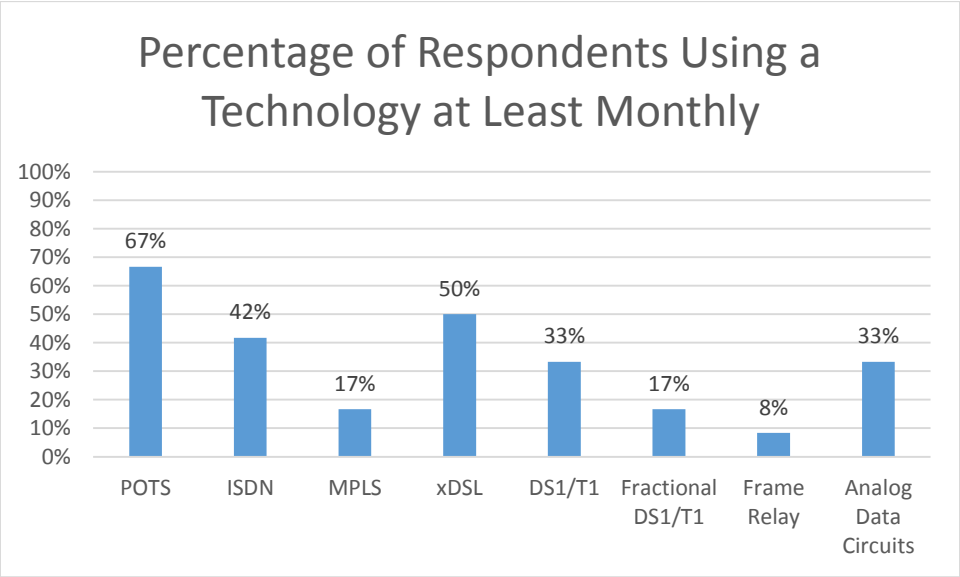


Figure 27: Percentage of respondents using a Telco Wired communication technology at least monthly.

Generally, IP Fundamentals technologies were used more frequently with 75 percent using local area networks, network security technologies, and vendor specific equipment at least once a month. Wide area networks and the topic described as understanding IP core are used regularly by 67 percent of the sample. See Figure 28.

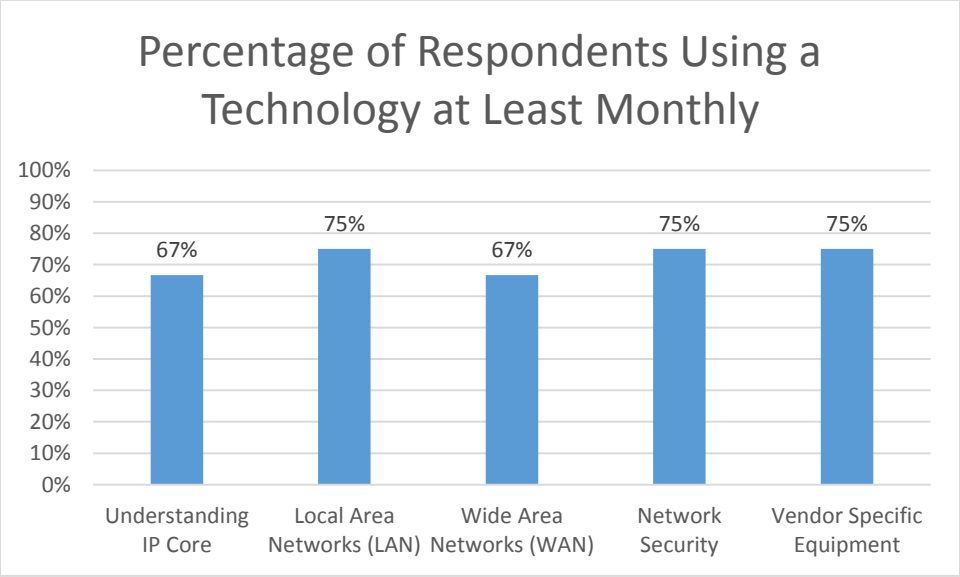


Figure 28: Percentage of respondents using an IP Fundamentals communication technology at least monthly.

Comparing frequency of use across the five subject areas, Plant Wireless communication technologies are used less frequently while the technologies defining IP Fundamentals are used more frequently. Additionally, three quarters or more of the sample used serial connectivity (83 percent), local area networks (75 percent), network security (75 percent), and vendor specific equipment (75 percent) on at least a monthly basis. Approximately 60 percent of all of the listed technologies are regularly used by at least half of the survey's respondents. In contrast, less than 20 percent of respondents use short haul radio (7 percent), privately owned WiMax (7 percent), Telco owned WiMax (0 percent), MPLS (17 percent), fractional DS1/T1 (17 percent), or frame relay (8 percent) at least monthly.

1.10.8. Training Objectives (Level of Detail)

DETAILED LEARNING OBJECTIVES FOR EACH OF THE TOPICS IN DEVELOPED AND REFINED OVER THE COURSE OF THIS PROJECT. ASSESSMENT SURVEY IN

Appendix F: Needs Assessment Survey and in the *Professional Capacity Building for Communications Curriculum Scope and Sequence (Revised)* (9). Survey participants were asked to rate the level of detail for a course with those objectives. Options were not enough detail, just enough detail, too much detail, and not familiar with the topic. The survey also asked respondents to list additional comments and training objectives they thought should be addressed.

The large majority of the sample thought the objectives listed for the Plant Wireless communication technologies provided just enough detail (Plant Wireless Core, RF Systems Design – 83 percent, 802.11 (WiFi) and related – 92 percent, Microwave – 83 percent, Short haul radio – 92 percent). Three quarters indicated an appropriate level of detail in the privately owned WiMax objectives, while the other 25 percent said they were unfamiliar with the topic. See Figure 29 for details.

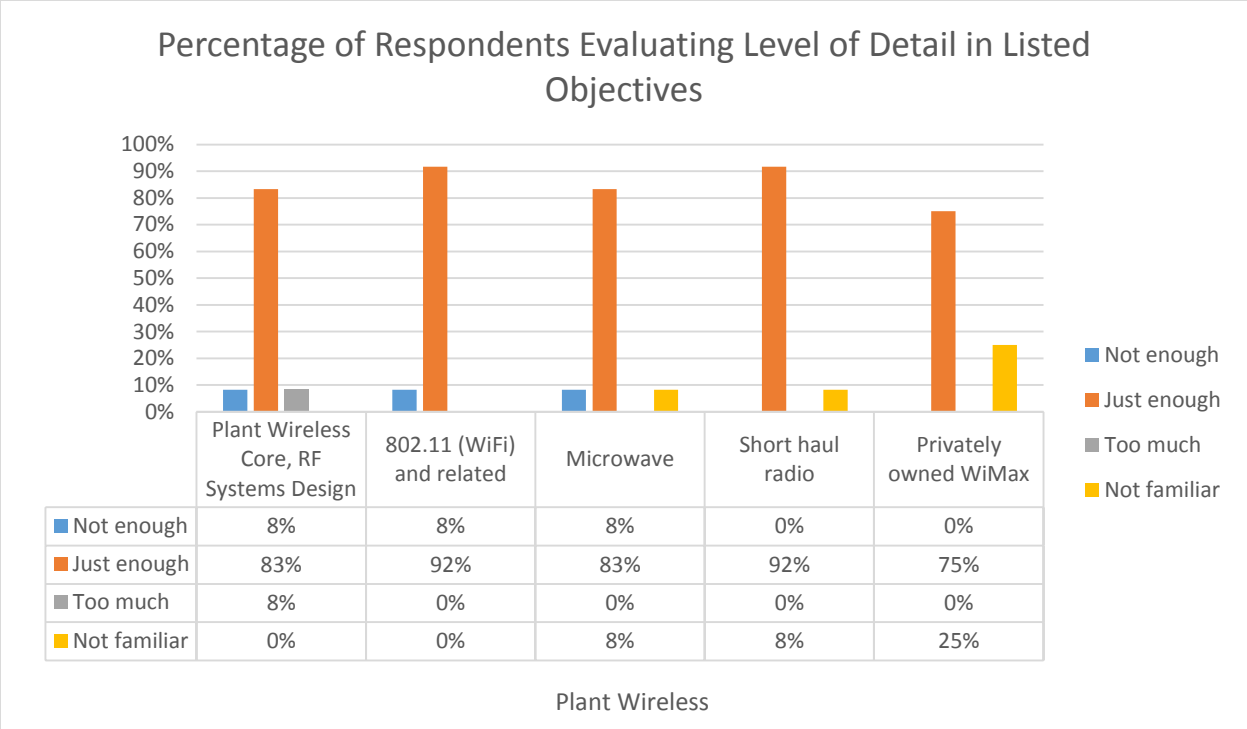
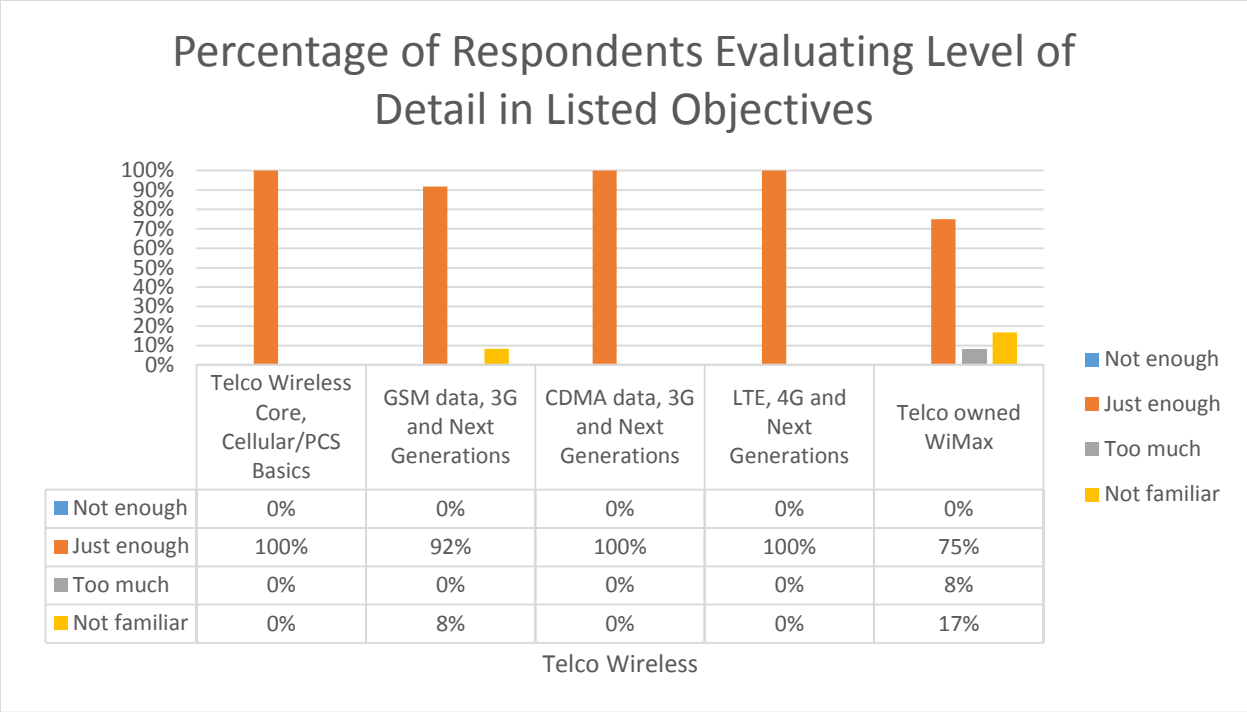


Figure 29: Percentage of respondents evaluating listed objectives for level of detail in a potential course in Plant Wireless ITS technologies.

Installation details, including racking of equipment and proper waveguide/cabling installation, were listed as important to include as core plant wireless training. One respondent said, "Proper installation of equipment is an important aspect of maintainability and reliable operation of the system." How to secure the channel against intrusion, eavesdropping, and denial of service attacks, as well as the pros and cons of the various security modes, would be useful to address generally and particularly for 802.11 (WiFi). Some attention to site survey techniques, including spectral analysis, would also be helpful to rural ITS engineers. In regard to 802.11 (WiFi) and related technologies, it was suggested to include discussion on "mixing modes of B/G/N/AC in a wifi system and the impact of the speed / bandwidth." Addressing system degradation (i.e., when using an antenna inside versus outside of a cabinet) was suggested for inclusion specific to short haul radio.

As with the Plant Wireless objectives, almost all of the sample were satisfied with the level of detail in the objectives for potential courses in four of the five Telco Wireless topics – 100 percent for Telco Wireless core and Cellular/PCS basics, CDMA data 3G and next generations, and LTE 4G and next generations; 92 percent for GSM data 3G and next generations. Also similar, 75 percent of the sample said that the objectives for Telco owned WiMax provided just enough detail, but 8 percent thought not enough detail was provided while 17 percent were unfamiliar with the topic. Refer to Figure 30.

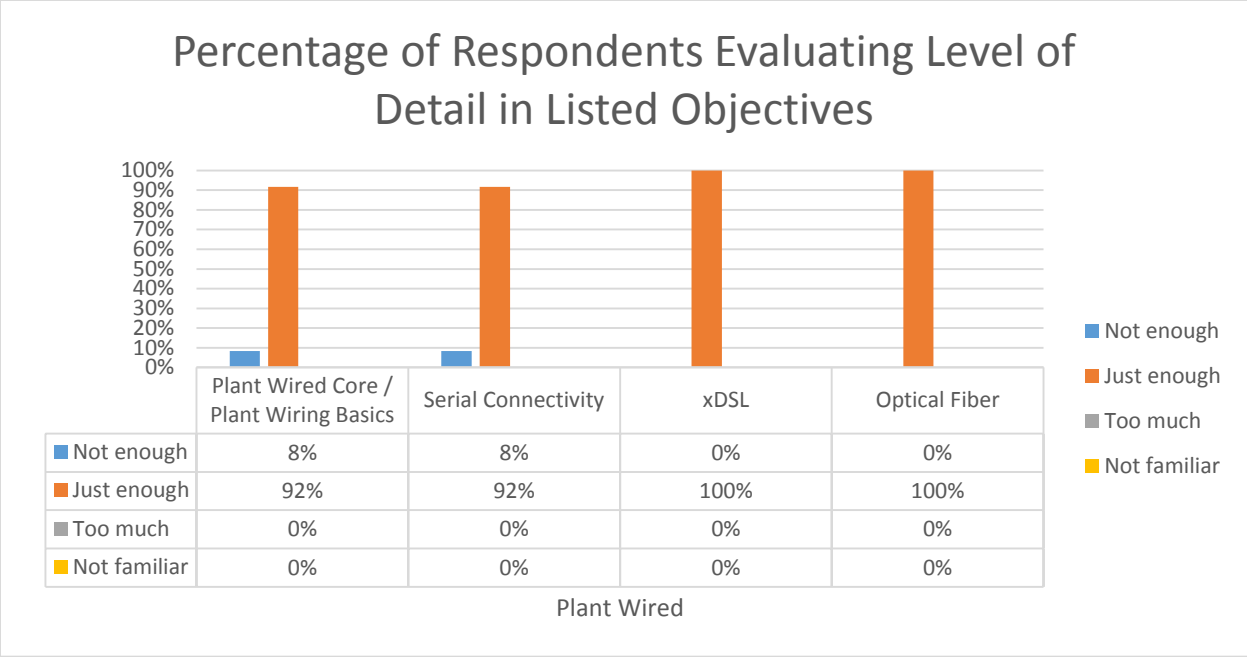


	Telco Wireless Core, Cellular/PCS Basics	GSM data, 3G and Next Generations	CDMA data, 3G and Next Generations	LTE, 4G and Next Generations	Telco owned WiMax
Not enough	0%	0%	0%	0%	0%
Just enough	100%	92%	100%	100%	75%
Too much	0%	0%	0%	0%	8%
Not familiar	0%	8%	0%	0%	17%

Figure 30: Percentage of respondents evaluating listed objectives for level of detail in a potential course in Telco Wireless ITS technologies.

As with Plant Wireless technologies, core training for all of the Telco Wireless technologies should include proper installation methods, including racking of equipment and proper waveguide/cabling installation. Discussion on various cost considerations for video transmission would be helpful to include. One respondent mentioned that the PCB *Telecom Wireless Fundamentals* course delivered during this phase of the project covered the Telco Wireless topics well.

Almost all of the sample also thought the objectives for the Plant Wired topics provided adequate detail, with just 8 percent indicating that the objectives for Plant Wired core / plant wiring basics and serial connectivity lacked sufficient detail. See Figure 31.

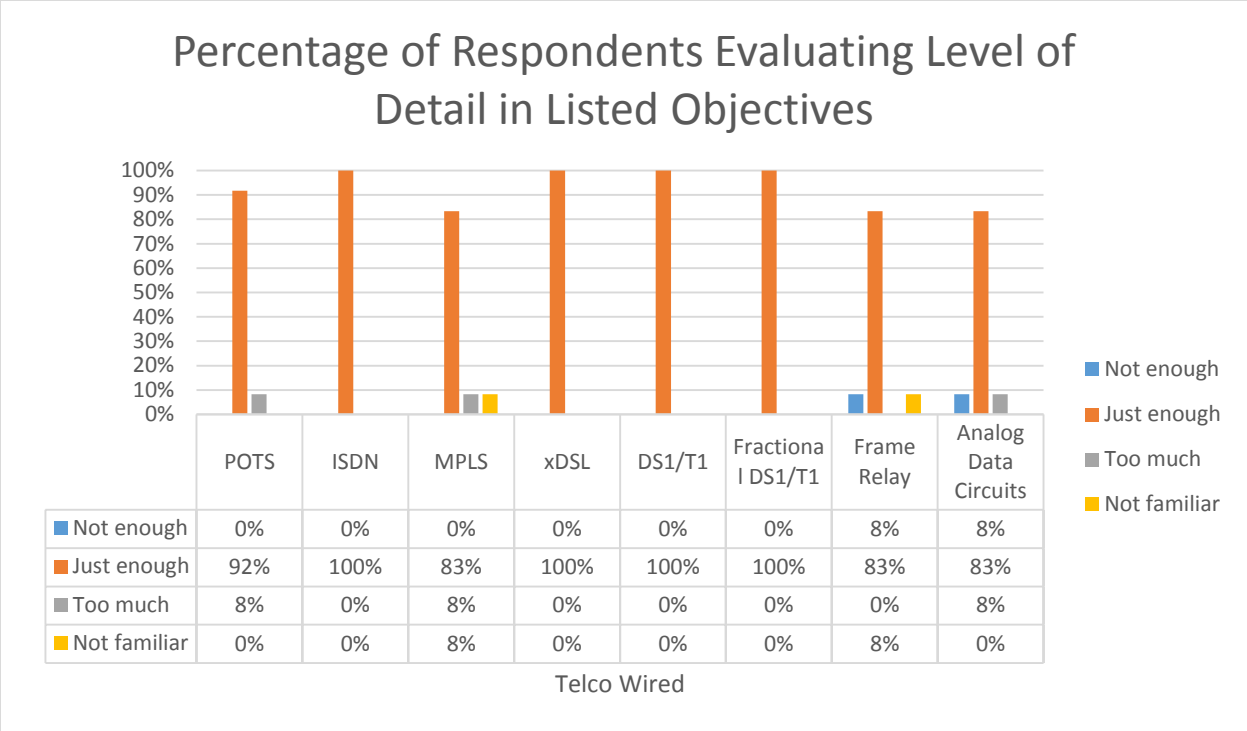


	Plant Wired Core / Plant Wiring Basics	Serial Connectivity	xDSL	Optical Fiber
Not enough	8%	8%	0%	0%
Just enough	92%	92%	100%	100%
Too much	0%	0%	0%	0%
Not familiar	0%	0%	0%	0%

Figure 31: Percentage of respondents evaluating listed objectives for level of detail in a potential course in Plant Wired ITS technologies.

Again, it was mentioned that "good installation workmanship is critical for robust and reliable operations and maintenance of the system." It was suggested that significant time (a day or more) be spent on how to layout/design and restructure equipment rooms as part of Plant Wired core and plant wiring basics. Some examination and review of Telco trends (e.g., phase out of technologies such as ISDN, T1, etc.) was also suggested for inclusion. Com port redirection software, USB to serial and terminal servers were objectives recommended for inclusion in a potential serial connectivity course. Discussion on system security was suggested to augment potential courses in serial connectivity, xDSL, and optical fiber. One respondent did note that the optical fiber course delivered in Phase 2 of the PCB project was excellent.

Generally, the objectives listed for the Telco Wired communication technologies appeared to offer an appropriate level of detail with the large majority indicating that the objectives provided just enough detail to cover each topic adequately. In fact, 83 percent or more of respondents said the objectives for all of the topics were sufficiently detailed. Refer to Figure 32 for more details.

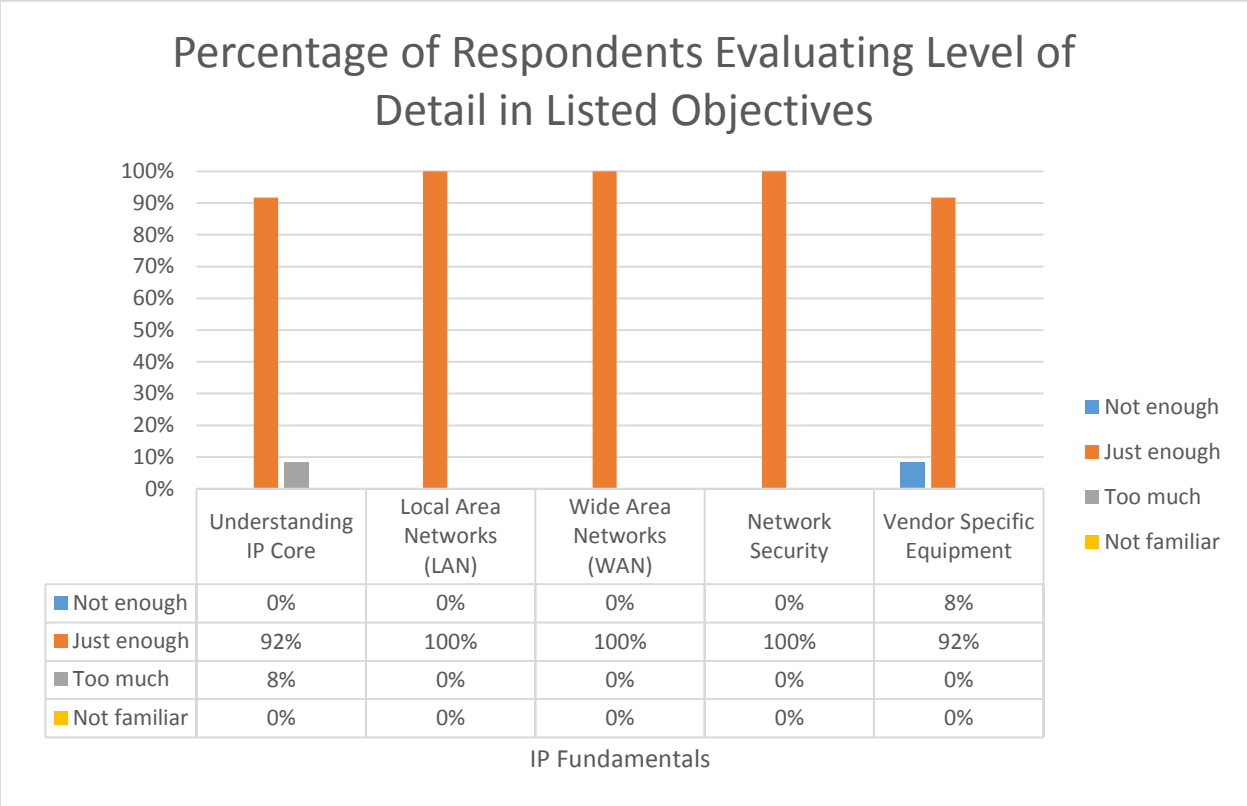


	POTS	ISDN	MPLS	xDSL	DS1/T1	Fractional DS1/T1	Frame Relay	Analog Data Circuits
Not enough	0%	0%	0%	0%	0%	0%	8%	8%
Just enough	92%	100%	83%	100%	100%	100%	83%	83%
Too much	8%	0%	8%	0%	0%	0%	0%	8%
Not familiar	0%	0%	8%	0%	0%	0%	8%	0%

Figure 32: Percentage of respondents evaluating listed objectives for level of detail in a potential course in Telco Wired ITS technologies.

Discussion about security issues with xDSL systems, particularly the security ramifications for xDSL circuits that are public versus those that are vLAN, would be useful to include in a potential Telco xDSL course. Addressing framing, timing, and clock derivation, etc., were suggestions to enhance the objectives of potential training in DS1/T1, fractional DS1/T1, and frame relay technologies. Although analog data circuit technology has become somewhat deprecated, participants suggested it was still useful to know about it, and suggested adding objectives dealing with transmission and transmission impairments, test levels, and use of half-duplex/full-duplex and the pros and cons of each. In regard to MPLS technology, one person commented that it seemed more the responsibility of the Telco provider.

Most of the survey sample also agreed that the listed objectives for IP Fundamentals training provided just enough detail (Figure 33). Just 8 percent indicated that understanding IP core objectives were too detailed while 8 percent said that not enough detail was included in the objectives dealing with vendor specific equipment.



	Understanding IP Core	Local Area Networks (LAN)	Wide Area Networks (WAN)	Network Security	Vendor Specific Equipment
Not enough	0%	0%	0%	0%	8%
Just enough	92%	100%	100%	100%	92%
Too much	8%	0%	0%	0%	0%
Not familiar	0%	0%	0%	0%	0%

Figure 33: Percentage of respondents evaluating listed objectives for level of detail in a potential course in IP Fundamentals ITS technologies.

To thoroughly cover wide area networks (WANs), it was noted that router functionality should be addressed in great detail (i.e., ARP, packet forwarding, ACL's, etc.). Specific to network security, it was suggested that it would be helpful to examine potential vulnerabilities in a system, how an attacker could access the network, and what tools they might use to do so. One person stated, "Network management has become a large part of the ITS infrastructure and support skill sets." He/she suggested incorporating a training track towards CCNA certification.

As with the optical fiber and the Telco Wireless courses delivered through the PCB project, it was mentioned that the IP Fundamentals course conducted in Phase 2 was excellent. One person did say that he/she may want to talk to their CISO about what would be important to know relative to network security.

1.10.9. Summary

In general, the need for professional capacity building in rural ITS communication technologies, most notably the specific technologies addressed in the survey, is evident in the results of this needs assessment. The high percentages desiring training and those considering training important, coupled with the lower numbers of individuals with substantial experience, lend credence to this observation. Additionally, a majority of all of the listed topics are used on a fairly regular basis indicating that ITS engineers are utilizing the technologies and therefore adequate training is needed. Even with the technologies with relatively lower percentages interested in training and considering it important, the percentages still represented a large majority of the

sample. It should be noted that 75 percent or more of the sample desired training in all of the listed topics with the exception of WiMax (see discussion below.) Training in all of the topics (except WiMax) was deemed important by 83 percent or more of the sample.

Considering the results of the needs assessment survey for training in specific topics, the sample of Caltrans ITS engineers demonstrated a significant need for professional capacity building in serial connectivity. A somewhat lesser need is apparent for 802.11 (WiFi) and related technologies and POTS.

Of the sample, 92 percent desired training in serial connectivity technology, while 100 percent thought such training was important or very important. Just less than half (42 percent) reported having substantial experience in this topic, but 83 percent indicated they use the technology at least once a month.

As with serial connectivity, the entire sample noted that training in 802.11 (WiFi) and related technologies was important while 93 percent were interested in training on the topic. Only 14 percent indicated significant experience with the topic and a little over one third said they use the technology on a regular basis. A need for training in POTS technology is demonstrated by a very high percentage desiring training (92 percent) and considering it important (83 percent). Furthermore, 67 percent of the sample said they use POTS technology regularly and only half reported having substantial experience with POTS relative to ITS communications.

On the other hand, the survey results suggest that training in WiMax technology, both private and Telco owned, is of much less need. While there was some indication that respondents might use Telco owned WiMax in the future, none said they used the technology at least once a month. Only 7 percent reported using privately owned WiMax monthly. Compared to the other communication topics, percentages of respondents desiring training were notably lower (privately owned WiMax – 71 percent, Telco owned WiMax – 50 percent). Similarly lower percentages considered training in WiMax as important or very important (privately owned WiMax – 64 percent, Telco owned WiMax – 42 percent). None reported having substantial experience with either type of WiMax technology. In fact, one survey respondent commented that the technology is outdated and not used in this capacity (for ITS communications). These numbers and related comments imply that these topics could be removed from the ITS communications curriculum at this time. When this project was first conceived and developed, WiMax was an up and coming technology that industry was embracing. However, that is not the case now and the current demand for the technology is minimal or non-existent.

Beyond the specific technologies mentioned above, it may be helpful to examine needs on a subject area level. Training in Telco Wireless topics (excluding WiMax) was of significant importance to a large majority of the sample (85 percent) and roughly the same number were interested in receiving Telco Wireless training (83 percent). Over half use the technologies on a fairly regular basis, but just over 6 percent reported substantial experience with Telco Wireless technologies (excluding WiMax). Training in the subject of Telco Wireless technology as applied to ITS communications appears to be a significant need for Caltrans ITS engineers and technicians.

A need for overall training in IP Fundamentals is also apparent. Across all of the listed topics, an average of 90 percent of the sample described IP Fundamentals training as very important or important. IP Fundamentals training was also highly desired (90 percent). Just over 70 percent (72 percent) of the sample use IP technologies for ITS applications on a monthly basis, but only 30 percent indicated substantial experience with the listed topics.

Similar cases can be made for training need in the other three subjects – Plant Wired, Telco Wired, Plant Wireless. ITS engineers are interested in communications training and deem it important to their jobs. Generally, many of the technologies are used on a fairly regular basis, but many engineers/technicians do not have substantial experience with them.

Finally, the level of detail in the overall proposed curriculum appears to be appropriate to adequately build the professional capacity of Caltrans ITS engineers and technicians. As discussed in the previous section, a number of comments were received relative to augmenting and refining individual objectives. In addition, one respondent said the curriculum was "very well thought out" overall, but reiterated that more emphasis should be placed on security in every aspect of ITS communications systems. Another commented, "It may be better to differentiate the training that is needed for repair/maintenance, system implementation, system design, or system administration. We would want everyone to have a basic overall understanding, but do not need to train/educate on specifics that are not needed for a particular job."

Several respondents also complimented the training courses already delivered through this project. One respondent added that he/she would benefit from additional training and that his/her district will soon have a new TE-Electrical who will likely need a fair amount of training.

1.11. Comparison to Previous Needs Assessment Survey

In comparison to the results of the needs assessment conducted in Phase 1, the results of this survey were generally similar. Overall, the need for professional capacity building in rural ITS communication technologies, most notably the specific technologies addressed in the surveys, is evident across the board. The high number of individuals interested in training and those considering it important, along with the lower numbers of individuals with substantial experience in the listed technologies, continues to support this observation.

In the previous survey, a greater need for training in four topics in three different subject areas was apparent. That sample demonstrated a significant need for professional capacity building for Plant Wireless technologies including RF system basics and microwave, Plant Wired xDSL technology, and network security under IP Fundamentals.

Responses for Plant Wired xDSL were similar between surveys. However, when compared to the other recognized needs in the recent survey, respondents indicated they used the technology less frequently and were somewhat less interested in training. Results for RF Engineering and microwave technologies indicated similar desire for training and importance of such training. However, reported experience levels have increased for these technologies since the first survey and fewer individuals indicated regular use of RF technologies at this time. Training in network security is still important and highly desired; usage has increased and more individuals reported having substantial experience with such technologies. As mentioned previously, IP Fundamentals training is still a recognized need and network security was specifically noted in the recent survey.

While training in serial connectivity was identified as a somewhat higher priority need in the recent survey, followed by POTS and 802.11 and related technologies, a need for training in all of the topics is still apparent. Like xDSL as discussed above, responses from the recent survey for serial connectivity training were similar to those of the original survey, but when compared to responses for the other topics in the recent survey, it emerges as an important training need. Training in 802.11 technology is considered somewhat more important at this time, although usage levels have

decreased slightly. More individuals desired training in POTS, although they considered it slightly less important and have more experience with the topic.

There were also some variations in particular responses between the original survey and the recent survey as listed below:

- Level of Experience: Reported experience levels are higher for Plant Wireless Core / RF Systems Design, microwave, Plant Wired core / plant wiring basics, ISDN, DS1/T1, fractional DS1/T1, and all of the IP Fundamentals topics. Respondents reported having somewhat less experience at this time in GSM and CDMA data technologies. This is not necessarily surprising considering the shift to later generation LTE and 4G technologies.
- Importance of Training: More survey respondents said training was important in 802.11 (WiFi) and related technologies, and DS1/T1. Interest in POTS training was slightly lower, but still relatively high overall. For all the other topics, results were the same or similar and indicated that training was important.
- Desire for Training: The percentage desiring training in POTS technology went up considerably, while percentages desiring training in ISDN, Telco Wired xDSL, and analog data circuits also increased. Those desiring training in Telco Wireless core decreased somewhat as did those desiring training in privately owned WiMax technology. Training desire for Telco owned WiMax decreased considerably. These results also lend support to removing WiMax from the overall training curriculum. When this project was first conceived, WiMax was of significant interest to industry. However, since then, demand has decreased considerably.
- Frequency of Use: Plant Wireless technologies are generally used less frequently at this time, with usage levels for Plant Wireless Core and RF systems design decreasing the most in this subject area. Telco Wireless technologies are used slightly more frequently, but ISDN, DS1/T1, and frame relay (Telco Wired) technologies are used somewhat less often. While IP core technologies are used less regularly than previously, more respondents reported using network security and vendor specific equipment on at least a monthly basis. More respondents also reported using optical fiber technology on a regular basis.

See *Needs Assessment Summary and Gap Analysis for Professional Capacity Building for Communications Systems (10)* for detailed responses and summaries on the first survey.

1.12. Available Training Opportunities

Over the course of this project (Phases 1, 2, and 3), a number of different organizations were found to provide training in communications technologies. Several provide training applicable to Caltrans and rural ITS implementations while others provide training relevant to the broader communications industry. As discussed in Section 1.2, these training providers are listed in the Identified Training Providers list (6). It should be noted that this list is a dynamic document. There may be additional training opportunities not documented by the project team or training offerings may have changed since the document was last updated. The PTAP can direct the project team to further investigate particular training opportunities if necessary.

Most of the topics listed in each of the five subject areas are addressed by at least one identified training provider at a level of detail ranging from moderate to significant. However, full training courses in analog data circuits, plant wiring basics, and serial connectivity are limited to non-

existent. These topics appear to be covered to varying degrees as parts of training in related topics and/or broader course offerings.

Moreover, formal requests for bids (RFB) have been released for four training courses in addition to the pilot course conducted in Phase 1. The RFBs and training requests were directed to those vendors that appeared to meet the qualifications listed in the solicitation, one qualification being that the provider already had an established course(s) that addressed most of the expected learning objectives. Training courses in RF Systems Engineering, Optical Fiber, IP Fundamentals (IP networking core, LANs, WANs), and Telecom Wireless Fundamentals, have been delivered through this process. However, a course in Plant Wired Core / Plant Wiring Basics, serial connectivity, and xDSL was cancelled due to problems with the selected contractor.

The main objective of this project is to have subject matter experts provide onsite, practical, nuts and bolts training to rural ITS engineers and technicians. Qualifications set out in the RFBs include on-site course delivery, ability to customize content, hands-on exercises, and as mentioned above, an established course that comes close to covering all of the listed learning objectives. With that said, it should be noted that even though a provider may cover a topic, that coverage may or may not be in the form that matches the intent of this project. The IEEE WCET certification program is one example. It is naturally focused on wireless communications and has a host of resources to help prepare for the certification exam. Plant Wireless, Telco Wireless, and IP Fundamentals topics are included in these resources. However, this type of training would likely not be conducted in the manner envisioned and applied in this project.

1.13. Gaps

Gaps in communications training would be evident if no training opportunity appeared to be available that adequately addressed identified needs of Caltrans rural ITS engineers. A gap could also exist if no course instructor could be identified with the expertise and experience of a subject matter expert as expected by Caltrans.

According to the results of the needs assessment survey, training for all of the listed topics with the exception of WiMax could potentially be interpreted as needs. Indeed, one survey respondent said, “There still seems to be a significant knowledge gap on how communication technologies work, how they should be applied, security of the communication system and basic robust, reliable installation of the technology.”

As discussed in Section 1.10, some could be considered a higher priority for training, namely serial connectivity, 802.11 (WiFi) and related, and Plain Old Telephone Service (POTS). The latter two are covered by one or more providers in adequate detail as outlined in the curriculum scope and sequence. Training in serial connectivity is provided at varying levels of detail by different organizations, but the topic is not covered to a significant extent in a dedicated course. With that said, however, the curriculum specifies one day for training on this topic. Given that many training providers do offer customization of courses, it is likely that training on serial connectivity could be adequately provided as part of another training course. This may also be a topic for which training could be developed in house by a Caltrans engineer. Therefore, for serial connectivity a small gap between needs and training opportunities could be considered to exist.

As noted in the previous section, training opportunities for plant wiring basics and analog data circuits are also somewhat limited. Both could be considered important training topics. In regard to plant wiring basics, this quote from the needs assessment survey summarizes the need: “There

seems to be a complete disregard to how equipment is installed in a TMC/ roadside cabinet. Most equipment installations are marginal at best, and sometimes downright scary. These installations include wiring / equipment that is core to the application / communication of the system." Given the recognized need and limited training opportunities, a smaller gap could also be identified for these technologies.

Specifically in regard to plant wired technologies, during Phase 2 of this project a course that addressed plant wiring basics, serial connectivity, and xDSL went through a limited solicitation process, bids were received, and a provider selected based on the approved scoring rubric. However, the contract was canceled during course development when it became apparent that the vendor would not meet the expectations for a subject matter expert delivering practical, technically detailed training. Given the rigorous nature of the entire limited solicitation process, this experience also suggests that a gap does exist between needs, existing training opportunities, and the availability of qualified instructors for plant wiring basics and serial connectivity.

It should be noted that the ultimate goal of this project is to meet the needs of Caltrans personnel in regard to rural ITS communications training. One way to do this could be simply utilizing existing training opportunities. In these cases, a gap doesn't exist. However, the task for the project team then becomes how best to incorporate existing training opportunities within the overall course scope and sequence.

Additionally, few training providers are geared toward transportation technology applications, let alone rural transportation communications. In fact, very few vendors offer training that is directly applicable to transportation and those opportunities don't necessarily have a rural component. However, as mentioned previously, many providers do allow flexibility in course content and will tailor their training to meet specific learning objectives established by the client.

1.14. Conclusions

The subjects and topics addressed in this curriculum are complex and require study and experience over many years. The PCB courses are meant to provide basic training and familiarization of the identified technologies; significant study and effort over time is necessary for mastery of these complex subjects. It is important for Caltrans to consider building the professional capacity of staff members over time, not just with one time classes.

The needs assessment and gap analysis clearly show the need for comprehensive communications training geared towards ITS. This training should have a distinctly rural focus with wider applicability to urban transportation as well.

Generally, a high percentage of the survey respondents indicated interest in training for all topics and this may be in part attributable to the prospective students' overall desire to learn. As such, content decisions must also account for organizational need and applicability.

The subjects and topics in the proposed curriculum appear to reflect the state of the practice in regard to ITS communications. However, the results of the needs assessment do indicate that both privately owned and Telco owned WiMax can be removed from the list of topics. Furthermore, the level of detail in the overall curriculum is appropriate to sufficiently build the professional capacity of Caltrans ITS engineers and technicians.

Finally, the courses delivered through this project have been favorably received and appear to have met the needs and expectations for ITS communications training.

NEXT STEPS

This project is a positive step towards providing critical professional capacity building by way of advanced, technical training to Caltrans ITS engineers and technicians. In Phase 3, the comprehensive curriculum was revised and another successful training course was delivered. The results of this project show enough potential for Caltrans to move towards another phase.

Based on the experience gained in completing this phase of the project and with significant input from the PTAP, the project team suggests the following next steps:

- Further detailed development of the curriculum in future project phases should proceed similar to what has been done in Phases 1, 2, and 3, but incorporating as appropriate any changes suggested by the results of the needs assessment conducted in Phase 3. One aspect that may merit consideration is further specification of the target audience (i.e., repair/maintenance, system implementation, system design, system administration, etc.). Regardless, the expectation is to continue to deliver high quality technical content in a challenging environment.
- Four training courses have been delivered to date through this project. Competent instructors and subject matter experts have already been identified and content is well established. Consideration should be given to how best to utilize what has already been done and not "reinvent the wheel."
- Carefully evaluate how best to approach securing subject matter experts who can deliver quality training that is hands-on and applicable to rural ITS engineering. Although outside the scope of project phases thus far, further consideration should be given to sabbatical programs for the development of curricula by expert Caltrans personnel. This may be a more feasible option for developing one or two day trainings on a specific topic (e.g., Plant Wired core / plant wiring basics – 2 days, serial connectivity – 1 day, analog data circuits – 1 day).
- The PTAP should again consider whether to repeat a previously offered course; try again to secure a subject matter expert and deliver a course in Plant Wired core / plant wiring basics, serial connectivity, xDSL; offer an intermediate level training in IP fundamentals or RF Engineering; or develop a course in a new subject/topic (e.g., machine-to-machine network security).
- Delivering hands-on and practical, relevant training is of crucial importance to this project. While alternative delivery mechanisms have been considered, the experiences of the PTAP and delivery of the courses indicate that onsite delivery by industry recognized experts is the most effective and preferable to such methods as web-based, independent study, or condensed versions.
- While not pursued within the scope of this project, the possibility of offering professional development credits or more direct preparation for certification exams are concepts to bear in mind for future professional capacity building. Coordination with college/university programs or other technical training programs is another option to investigate in order to insure quality professional training programs.
- This project has been developed based on the needs of Caltrans ITS engineers and technicians. The project team is unaware of any similar efforts at other state departments

of transportation (DOT) although interest in the project has been expressed by other DOTs through the Western States Rural Transportation Consortium. The potential exists for adaptation, adoption, and delivery of ITS communications professional capacity building curricula in other states and on a national level. While some informal discussions with FHWA personnel have occurred in the past, future research should investigate opportunities to sustain the program as well as probe prospective "sponsor" organizations (e.g., FHWA, IEEE, ITSA).

APPENDIX A: LIST OF IDENTIFIED TRAINING PROVIDERS – TELCO WIRELESS

The following list contains dynamic content. It includes identified vendors and training providers that appear to have the qualifications listed in the Telco Wireless RFB, including on-site course delivery, ability to customize content, hands-on exercises, and an established course(s) that addresses most of the expected learning objectives. The list was compiled through PTAP recommendations, word of mouth, recommendations from instructors, and an extensive web search. The expertise of vendors that submitted a bid was evaluated by the PTAP based on the approved limited solicitation scoring rubric. A provider was further vetted after a contract was signed and prior to course delivery. This list represents a best effort and there may indeed be other possible providers not listed here. In turn, the procurement process is open and other qualified vendors are eligible to bid.

The vendors listed below who did not submit a bid were not evaluated to the same extent as those that did submit a bid. Therefore, further due diligence would be necessary to consider them for contracting. Caltrans and the members of the PTAP neither endorse nor disqualify any vendors on this list.

This is a partial list which includes only those training providers who received the RFB for the Telco Wireless course. Bids were ultimately received from CellStream, Systems and Network Training, TONEX, and Telecommunications Research Associates. TONEX was ultimately selected to deliver the course.

1.15. 3G Wireless Software/Daniel Wireless

Name:	3G Wireless Software/Daniel Wireless
Website:	http://www.danielwireless.com/
Address:	340 S. Lemon Ave #8593 Walnut, CA 91789
Email Address:	info@danielwireless.com
Telephone:	
Individual Contact:	Daniel Wong dwong@danielwireless.com Daniel Wireless LLC info@danielwireless.com danielwirelessllc@gmail.com

1.16. Alexander Resources

Name:	Alexander Resources
Website:	http://www.alexanderresources.com/index.html
Address:	2295 Towne Lake Parkway Suite 116-238 Woodstock, GA 30189
Email Address:	
Telephone:	(972) 818-8225
Individual Contact:	Carol Smyth (972) 818-8225 csmyth@alexanderresources.com Fax: (214) 432-6632

1.17. Besser Associates

Name:	Besser Associates
Website:	http://www.besserassociates.com/
Address:	480 San Antonio Road Suite 215 Mountain View, CA 94040
Email Address:	info@besserassociates.com
Telephone:	(650) 949-3300
Individual Contact:	Annie Wong Office: (650) 949-3300 ext. 100 Direct: (650) 318-5377 Email: awong@besserassociates.com

1.18. BTS Training

Name:	BTS Training
Website:	http://www.btstraining.com/
Address:	P.O. Box 46905 Kansas City, MO 64118-6905
Email Address:	
Telephone:	(877) 463-6232
Individual Contact:	Julie James (816) 584-8177 ext: 774 jjames@btstraining.com Christopher Kehoe (816) 584-8177 ext: 771 ckehoe@btstraining.com

1.19. CDMA Solutions

Name:	CDMA Solutions
Website:	http://www.cdma-solutions.com
Address:	
Email Address:	Sales@cdma-solutions.com
Telephone:	
Individual Contact:	

1.20. CellStream

Name:	CellStream
Website:	http://www.cellstream.com/
Address:	Plano, TX
Email Address:	
Telephone:	(866) 659-1014
Individual Contact:	Andrew Walding andyw@cellstream.com awalding@gmail.com

1.21. Dashcourses International

Name:	Dashcourses International
Website:	http://www.dashcourses.com/
Address:	7561 E. Gold Dust Ave. Scottsdale, Arizona 85258
Email Address:	info@dashcourses.com
Telephone:	(480) 391-0791
Individual Contact:	Marianne Cherney mcherney@dashcourses.com

1.22. ENO

Name:	ENO
Website:	http://www.eno.com/
Address:	6 St. Charles Ct Stafford, VA 22556. USA
Email Address:	salesinfo@eno.com
Telephone:	1 (888) 742-3214
Individual Contact:	Janey Sears salesinfo@eno.com Andrew Russell corporateinfo@eno.com Alternate contact: Jim Cummings (540) 720-9660 Fax: (540) 720-9664

1.23. Eogogics

Name:	Eogogics
Website:	http://www.eogogics.com/
Address:	333 Maple Avenue East, No. 2005 Vienna, VA 22180
Email Address:	sales@eogogics.com
Telephone:	1 (888) 364-6442
Individual Contact:	KK Arora President Direct: (703) 539-5329 Main: (703) 281-3525 kk@eogogics.com

1.24. Leliwa

Name:	Leliwa
Website:	http://www.leliwa.com/en/
Address:	Orrspelsvägen 66 SE-167 66 Bromma Sweden
Email Address:	
Telephone:	+48 32-376-63-05
Individual Contact:	Mirosław Korus +48 (32) 376 63 05 Fax: +48 (32) 376 63 07 miroslaw.korus@leliwa.com Skype: leliwa_poland

1.25. Lever

Name:	Lever Technology Group
Website:	http://www.lever.co.uk/
Address:	Woodhead House Centre 27 Business Park, Woodhead Road Leeds, WF17 9TD England
Email Address:	info@lever.co.uk
Telephone:	44 (0) 113 398 3300
Individual Contact:	Bev Gilman bevg@lever.co.uk +44 (0) 113 398 3300 Fax: +44 (0) 1924 442829 Skype: beverley.gilman

1.26. Perpetual Solutions

Name:	Perpetual Solutions
Website:	http://www.perpetual-solutions.com/
Address:	27-37 St. Georges Road London, England SW19 4DS
Email Address:	
Telephone:	0 (207) 620-0033
Individual Contact:	Sam Hurrell Senior Account Manager + 44 (0) 207 620 0033 Ext: 2126542 Fax: + 44 (0) 207 620 0055 sam.hurrell@perpetual-solutions.com

1.27. Systems & Network Training

Name:	Systems & Network Training
Website:	http://www.soundtraining.net/
Address:	Robert Denholm House Bletchingley Road Nutfield Surrey RH1 4HW UK
Email Address:	info@snt.co.uk
Telephone:	+44 (0) 1737-821590
Individual Contact:	Sammy Davitt Account Manager sammy.davitt@snt.co.uk

1.28. Telecoms Academy

Name:	Telecoms Academy - School of Advanced Communications Technologies
Website:	http://www.telecomsacademy.com/
Address:	Mortimer House 37-41 Mortimer St London W1T3JH United Kingdom
Email Address:	training@telecomsacademy.com
Telephone:	+44 (0) 207-017-4144
Individual Contact:	Fergus Hanley Business Development Manager +44 (0)207 017 7431 fergus.hanley@informa.com Skype: fergus_hanley

1.29. TelXperts Academy

Name:	TelXperts
Website:	http://www.telxperts.com/
Address:	78 York Street London, W1H 1DP United Kingdom
Email Address:	info@TelXperts.com
Telephone:	+44 (0) 7812075951
Individual Contact:	Peter peter@telxperts.com Customer Service Representative info@telxperts.com

1.30. Teracom Training Institute Academy

Name:	Teracom Training Institute
Website:	https://www.teracomtraining.com/
Address:	PO Box 3376 Champlain NY 12919-3376
Email Address:	
Telephone:	1 (877) 412-2700
Individual Contact:	Eric Coll, M.Eng. Director eric@teracomtraining.com Patricia Barber Operations Manager patricia@teracomtraining.com

1.31. TONEX

Name:	Tonex
Website:	https://www.teracomtraining.com/
Address:	1400 Preston Rd., Suite 400 Plano, Texas 75093
Email Address:	
Telephone:	1 (972) 665-9786
Individual Contact:	Howard Gottlieb (214) 762-6673 Fax: (972) 692-6829 hgottlieb@tonex.com

1.32. Telecommunications Research Associates

Name:	Telecommunications Research Associates (TRA)
Website:	https://www.tra.com/
Address:	St. Mary's, KS
Email Address:	
Telephone:	(785) 437-2000
Individual Contact:	Steve Wages swages@tra.com 1 (800) 872-4736 ext 151

APPENDIX B: REQUEST FOR BIDS – TELCO WIRELESS TRAINING

REQUEST FOR WRITTEN BIDS

State of Montana **LIMITED SOLICITATION FORM** **AGENCY** **Montana State University - Bozeman**	Solicitation Number: 414030-1401 Solicitation Title: Professional Capacity Building for Communication Systems Course Delivery – Telco Wireless Fundamentals and Usage Training for Rural Intelligent Transportation Systems Engineers Agency Contact: Leann Koon 1-406-994-7643, leann.koon@coe.montana.edu

Limited Solicitation is an informal procurement method for purchases over $5,000 and up to $25,000. This process is authorized by section 18-4-305, MCA, and ARM 2.5.603.

Company Name: _____

Address: _____

_____

Phone Number: _____ Fax Number: _____

Federal Tax ID Number: _____

Responses to this solicitation will be accepted by MSU / Western Transportation Institute at P.O. Box 174250, Bozeman, MT 59717-4250 or electronically by email at leann.koon@coe.montana.edu until **2:00 pm (Bozeman time)** on November 14, 2014. The following documents are attached to this solicitation and will be applicable to the resultant contract: Requirements and Scope of Services; Deliverables, Due Dates, Payment; and Exhibit B Blank Contracted Services Agreement.

Instructions and Requirements/ Scope of Services are stated on pages 3-8.

Item Description	Qty	Price
Course materials		
Customization		
Training delivery		
Travel and Instructor Materials Instructor material and travel expenses, including transportation, lodging, per diem, and incidentals, must be included and designated as such (line items) in the bid. Training provider will be responsible for instructor travel arrangements.		
Total		

Vendor Signature: _____

Additional vendor information attached: Yes _____ No _____

CONTRACTED SERVICES AGREEMENT EXHIBIT B SHALL APPLY

MSU reserves the right to award a contract based on factors other than the lowest acceptable quote. MSU will review and evaluate the quotes based on price and the following factors. Vendors are required to submit the following information and responses with their bids:

Total evaluation points possible: 150

1. Section 3.1 Course Curriculum – 50 points
2. Section 3.2 Customization – Pass/Fail
2. Section 3.3 Instructor – 25 points
3. Section 3.4 Company Qualifications – 25 points
4. Section 3.5 References – Pass/Fail

COST BID– total points possible: 50

Lowest proposed price receives the maximum allotted points. All other proposals receive a percentage of the points available based on their relationship to the lowest. Example: Possible points for price are 50. Vendor A submits a price of $10,000. Vendor B submits a price of $12,000. Vendor A receives 50 points. Vendor B receives 42 points calculated as such: ($10,000/$12,000) = 83% times 50 = 42.

Scoring Criteria other than Price

Superior Response (95-100%): A superior response is an exceptional reply that completely and comprehensively meets all of the requirements of the RFB. In addition, the response may cover areas not originally addressed within the RFB and/or include additional information and recommendations that would prove both valuable and beneficial to the agency.

Good Response (75-94%): A good response clearly meets all the requirements of the RFB and demonstrates in an unambiguous and concise manner a thorough knowledge and understanding of the project, with no deficiencies noted.

Fair Response (60-74%): A fair response minimally meets most requirements set forth in the RFB. The Vendor demonstrates some ability to comply with guidelines and requirements of the project, but knowledge of the subject matter is limited.

Failed Response (59% or less): A failed response does not meet the requirements set forth in the RFB. The Vendor has not demonstrated sufficient knowledge of the subject matter.

EXHIBIT A
REQUIREMENTS AND SCOPE OF SERVICES

Professional Capacity Building for Communications Systems
Phase 2

Telco Wireless Fundamentals and Usage Training for Rural Intelligent Transportation Systems Engineers

1. BACKGROUND AND REQUIREMENTS
MSU is seeking to purchase the delivery of a course in Telco Wireless Fundamentals and Usage Training for Rural Intelligent Transportation Systems Engineers, and the services to present such course. The course will be delivered over five days, will be customized to meet the needs of California Department of Transportation (Caltrans) engineers, and must include hands-on lab activities. It is assumed that this course will be a customization of an existing offering from a reputable training provider and delivered by an experienced instructor who has hands-on design and implementation experience in the technologies to be presented.

Rural Intelligent Transportation Systems (ITS) deployments are becoming increasingly complex with a greater number and variety of field devices utilized to improve the safety and operations of rural travel. Design of communication networks between devices such as Highway Advisory Radio (HAR), Road Weather Information Systems (RWIS), Changeable Message Signs (CMS), Closed Circuit Television (CCTV) cameras, Extinguishable Message Signs (EMS), roadway sensors, and the Transportation Management Center (TMC) is a critical skill in successful implementation of rural ITS projects. With any advancing technology, there is a need for a skilled workforce with an advancing skill set, which in turn requires ongoing training in new technologies. To realize the full benefits of rural ITS on the transportation system, engineers as well as technicians must not only be aware of what technologies are available, but especially how to best select, implement, and maintain those technologies.

To adequately address the diverse aspects of rural ITS communications, the project and the developed curriculum have been divided into different subject areas with associated topics. **Telco Wireless Fundamentals and Usage** is one subject area and is the focus of this solicitation. The technologies to be addressed include fixed deployments of field elements and communications with a TMC, maintenance yard, or other similar facility.

This solicitation document defines the scope and sequence for **one course** that provides training for **Telco Wireless** technologies.

The requirement is that the training course will dedicate a minimum of 25 percent of in class time to realistic, hands-on problem solving and lab exercises, in addition to traditional classroom work.

The target audience includes field engineers and technicians who apply ITS technologies in rural areas to improve transportation safety and operations. Participants will generally be electrical engineers, electrical technicians or other engineers with ITS design and implementation responsibilities.

A Project Technical Advisory Panel (PTAP) will work closely with the Contractor training provider to customize and facilitate the training course. The PTAP will consist of Caltrans ITS engineers and members of the Western Transportation Institute (WTI) project team.

The Course must be able to accommodate 12 students.

2. COURSE SCOPE

2.1 Description

The Telco Wireless Fundamentals and Usage subject area, as applied to Rural ITS, is composed of topics related to systems that are leased from telecommunication service providers. After taking this course, rural ITS engineers and technicians will have the knowledge and skills necessary to design, implement, and maintain systems that interface to telco provided wireless communications. These technologies are of increasing interest to Caltrans because of their potential utility in remote areas where wireline communications are not available.

2.2 Participant Prerequisites

Basic (electrical) engineering skills or relevant experience. Participants will generally be electrical engineers, electrical technicians or other engineers with ITS design and implementation responsibilities.

2.3 Duration

- Five (5) days = 40 hours

2.4 Method of Presentation

Instructor-led classroom and hands-on laboratory activities

A minimum of 25 percent of in class time will be dedicated to realistic, hands-on problem solving and lab exercises, in addition to traditional classroom work.

2.5 Learning Objectives

Note: It is expected that the contractor will enhance and customize an existing course and not develop a new course from scratch based on these objectives. The procured course must, at a minimum, include the following objectives for cellular/PCS basics, 3G and 4G Data Communications.

2.5.1 Telco Wireless Fundamentals, 3G and 4G Data Communications

A fundamental knowledge of the characteristics of leased wireless communication systems is important for determining how best to implement the technology to the benefit of rural transportation. In areas where Plain Old Telephone Service (POTS), or other alternatives, are unavailable or cost-prohibitive, third and fourth generation (3G, 4G) GSM, CDMA, and LTE data communications between the Traffic Management System (TMS) and the TMC may be an appropriate, viable solution. As wireless systems evolve

and newer technologies become more widely available, more interest is placed in the later generation technologies.

After completing this course, the student will be able to:

- Define and explain terminology and general concepts for telco wireless communication systems.
- Explain the evolution of telco wireless technology from 1G to 4G LTE and beyond.
- Discuss the concepts of wireless propagation and related theory, and review industry terms.
- Discuss the technical characteristics and basic operation of LTE communication systems.
- Discuss the technical characteristics and basic operation of GSM communication systems.
- Discuss the technical characteristics and basic operation of CDMA communication systems.
- Locate and classify cellular sites using the Federal Communications Commission (FCC) data base.
- Select and effectively utilize cellular/PCS data services.
- Determine when and where LTE, GSM, and CDMA communications technologies can be used effectively.
- Understand and thoroughly evaluate technical information on vendor equipment specification sheets.
- Ascertain tower and antenna requirements, and make an appropriate selection for the particular application (e.g., cellular modem at a fixed site for a CCTV).
- Specify and install proper antenna framework and cabling for the particular application.
- Determine the coverage area and signal strength at a specific location by conducting necessary field strength measurements.
- Compare, contrast and evaluate available modems and hardware and select the best alternative for specific applications.
- Successfully install and configure equipment considering such factors as modem type and data rate, and antenna requirements, gain and gain orientation for a fixed site.
- Deduce the required and optimal data rate with a working understanding of the data rate provided by various options such as LTE, General Packet Radio Service (GPRS), Enhanced Data rates for GSM or Global Evolution (EDGE), 1xRTT, and EV-DO, etc.
- Properly implement cellular/PCS (LTE, GSM, CDMA) equipment, taking into account the potential for system overload and the type of site receiver (dialup or fixed).

- Conduct thorough bandwidth and throughput testing and apply the results.
- Maintain and repair the system and equipment according to system provider, accepted standards, and/or Caltrans guidelines.
- Assess and compare the pros and cons of common alternatives.

2.6 Course Materials

The vendor will provide a description of procedure for how and when content and materials for courses are revised, updated and customized. Also include an explanation of how and when new courses are developed and old courses are removed from the catalog.

Student materials, instructor guide, and lab manual shall be in full color and appropriately bound.

Contractor will prepare and ship student materials for 12 students plus two additional copies, for a total of 14.

The PTAP (Caltrans) and the project team (WTI) shall each retain one official copy of student materials, instructor guide, lab manual, and assessment tools for the project records.

3. REQUIRED QUALIFICATIONS

3.1 Curriculum (50 points)

This course on telco wireless technologies shall address the topics including but not limited to, those listed in section 2.5 Learning Objectives (*Telco Wireless Communications, 3G and 4G Data Communications*). The course will consist of at least 25 percent hands-on, relevant and realistic laboratory activities/exercises.

The Vendor will provide the following with the bid submission:

- Course description, learning objectives, method of presentation, course length, amount and type of hands-on and laboratory activities, course size, and description of student materials.
- A previously developed training module or chapter on a related topic with all materials that demonstrates depth of material and presentation style. Include a revision history for the training module or chapter.
- List of equipment provided by the contractor that will be used to conduct the course and a description of intended use.
- List and description of specific hands-on and laboratory activities. Such activities might include:
    - Optimizing field site design for reliability.
    - Signal measurements and what they mean.
    - Troubleshooting and how to interface with a telco wireless provider when solving system problems.
    - Setting up field element network communications and transmitting data.
    - Potential pitfalls or challenges to using telco wireless technologies for ITS applications.

- Identification of field elements that can best be connected using telco wireless technologies.
- Identification of the best wireless technology for asynchronous versus burst versus continuous data flow.

3.2 Customization (Pass/Fail)

The training course will be relevant and applicable to the target audience as demonstrated with content and materials that address rural Intelligent Transportation Systems (ITS) topics and problems. The contractor will indicate to what extent customization is done for pre-existing course outlines and if applicable, provide a concise explanation of how course customization would be accomplished.

3.3 Instructor(s) (25 points)

The course will be taught by an instructor(s) with at least 10 years of real-world engineering experience in designing and implementing telco wireless technologies. The instructor(s) must be knowledgeable and current in the area of telco wireless networking and usage in communications and demonstrate the ability to adapt course materials to knowledge, interest, and skill level of the students. It is envisioned that the course will be taught by a single instructor. However, this does not preclude the possibility of multiple, qualified individuals team-teaching the course.

The Vendor will provide the following with the bid:

- A resume and biography for the instructor(s) who will be teaching the course which clearly lists and describes his/her history of industry design, implementation and training experience in communications technology with an emphasis on telco wireless technologies.
- A list, description, and methodology of courses taught by the instructor(s) in the previous year. Include a description of the students taking these courses – typical education background, work experience and work responsibility.

3.4 Company Qualifications (25 points)

The Vendor must demonstrate a successful history of a minimum of five years conducting training in telco wireless technologies.

The Vendor will submit the following with the bid:

- A summary of company qualifications sufficient to demonstrate the company's capabilities, experience, staff, and instructors. Include the length of time in business offering communications training, making particular note of length of time in business facilitating telco wireless training.
- An explanation of how the contractor "trains the trainer" in preparation for conducting the contractor's courses.
- List of clients from the previous year, what courses were taught for those clients and type of customization if applicable, and the names of the instructors for those courses.

3.5 References (Pass/Fail)

A list of at least three (3) references specific to telco wireless fundamentals and usage training. References should include information that describes the type of services performed, type and level of customization if applicable, company name, location where

the services were provided, contact person(s), and contact person's current telephone number and email address.

3.6 Location and Date

Contractor must be available to provide the course March 2-6, 2015, or March 9-13, 2015, at the California Department of Transportation's Sacramento Regional Transportation Management Center in Rancho Cordova, California, or Caltrans' Ron LeCroix Training Center in Woodland, California. An alternate site in the Sacramento, California, area may be considered. The specific date and location will be agreed to with MSU and the Contractor.

DELIVERABLES, DUE DATES, AND PAYMENT

Contractor will invoice for full contracted amount upon completion of the final deliverable (overall course evaluation).

Deliverable	Due Date	Acceptance Process
1. Course outline • Input from the PTAP will be incorporated. • Will include description, learning objectives, method of instruction, course length, and lab activities.	**December 19th, 2014**	Course outline will be approved by the PTAP.
2. Course materials drafts (Telco Wireless) • Draft student materials - Student materials will be the primary instructional materials for the course. These materials will be prepared for students in the form of a workbook, and will consist of primary course content and supplementary content materials. Student materials will be suitable for binding as well as electronic presentation. Topics shall include those listed as learning objectives in the Course Scope. • Draft instructor guide - An instructor guide will be prepared to guide the instructor in presentation of the course based on the content of the student materials. In addition to student materials, notes, discussion points, and instructional methodology guides will be prepared for course instructors. • Draft assessment tools - Formal and informal assessment tools will be prepared in conjunction with the student materials and instructor guides. Quizzes, tests, and open-ended problem solving activities will be considered as primary assessment tools. Answers may be provided for objective questions and sample responses and rubrics will be included to assist in assessing open-ended problem solving	**January 7th, 2015**	Draft versions of course materials will be reviewed and approved by the PTAP.

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activities. General course evaluation instruments will be included. • Draft hands-on activities/lab manual - Hands-on activities will be developed to supplement course content where appropriate and as described in the learning objectives section of the Course Scope. These activities will be compiled into a lab manual for optional use with the course. To promote flexibility in presentation and duration of the course, the materials will be presented as optional or supplementary. In addition to hands-on, in-class activities, other activities will be considered for inclusion such as field trips to deployments or product research activities.		
3. Final course materials	**January 26th, 2015**	Final course content and materials will be approved by the PTAP.
4. Equipment list - A list of equipment to be used in the course including the designated party responsible for supplying each piece	**February 2nd, 2015**	Equipment list will be confirmed and finalized by the contractor, the instructor if different, and the PTAP.
5. Course logistics – location, facilities, start and end times, student enrollment, instructor contact information, printed materials	**February 2nd, 2015**	Course logistics will be confirmed and finalized with the contractor, the instructor if different, and the PTAP.
6. One hour dry run training session – the course instructor will present over the telephone a one hour preview session of the course to the PTAP and a potential student. • Session will include description or demonstration of at least one hands-on activity.	**February 9th, 2015**	PTAP will approve the pedagogy and the amount and level of hands-on/laboratory activities intended for the course delivery.
7. Course delivery	**March 2nd-6th, 2015 OR**	Contractor shall deliver five days of training as developed.

	March 9th-13th, 2015	The training shall be at the Caltrans Sacramento Regional Transportation Management Center or Caltrans' Ron LeCroix Training Center (or alternate location) for up to 12 students.
8. Student assessment	During and at the conclusion of course delivery	Students will be evaluated to measure the effectiveness of the training in meeting the established learning objectives.
9. Course and instructor evaluation by students	Immediately upon completion of course	Contractor, with input from the PTAP, will develop and administer a course and instructor evaluation to the students.
10. Overall course evaluation	1 week after course completion	Together, the contractor, instructor if different, and the PTAP will discuss and appraise the overall course, instructor, and student learning.

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EXHIBIT B
Contracted Services Agreement
Between
Montana State University
And

_____

A. PARTIES

THIS CONTRACT is entered into between Montana State University-Bozeman, _____, herein referred to as "MSU" and the "University", and _____, hereinafter referred to as the "Contractor".

Contractor Information:
Name:
Address:

Phone #: Fax #:
Point of Contact:

Note: Contractor's SSN/FTI number must be provided before payment will be processed. If Contractor is a Non-Resident Alien, payment is subject to withholding in accordance with IRS 1042 reporting requirements and Contractor shall request instructions for Non-Resident Alien tax withholding. Non-Resident Alien: YES ☐ or No ☐

MSU at Bozeman Information:
Name:
Address:

Phone #: Fax #
Point of Contact:
Index Number:

1. Purpose:.

2. Effective Date and Duration: This Contract shall take effect on **(insert date)**, 20(__), **(or upon contract execution)** and terminate on **(insert date)**, 20(__), unless terminated earlier in accordance with the terms of this Contract. (Section 18-4-313, MCA)

3. Services: The Contractor agrees to perform the following services: See Deliverables from RFB #414030-1401.

4. Consideration: MSU agrees to pay Contractor the sum of $_____ for satisfactory completion and acceptance of the contracted service. All payment terms will be computed from the date of delivery of supplies or services OR receipt of a properly executed invoice, whichever is later. Unless otherwise noted, the University is allowed 30 days to pay such invoices. All Contractors may be required to provide banking information at the time of Contract execution in order to facilitate University electronic funds transfer payments. If travel expenses are agreed to be paid by MSU, they will be at the MSU rate and pursuant to the MSU travel policy. MSU agrees to pay this amount as follows:

5. Relationship of the Parties: It is mutually agreed that Contractor is an independent contractor and not an employee of MSU for purposes of this Contract. It is understood that the Contractor is not subject to the supervision and control of MSU; nor is the Contractor carrying out the regular business of MSU. Each of the parties will be solely and entirely responsible for its own acts and/or the acts of its employees or agents. No benefits provided by MSU to its employees, including unemployment and workers' compensation insurance, will be provided to the Contractor or his/her/its employees.

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6. Ownership and Publication of Materials: All customization of Contractors' material and other information generated under this contract shall be the sole property of MSU. Contractor shall own all of its original course materials.

7. Access to Records: The Contractor shall adequately account for and maintain reasonable records for his/her/its performance and allow access to these records by MSU, the Legislative Auditor and/or the Legislative Fiscal Analyst as may be necessary for audit purposes and in determining compliance with the terms of this Contract.

The Contractor shall submit a record of expenditures incurred for the performance and completion of this Contract. MSU may verify all expenditure receipts and disburse funds in an amount equal to the approved expenditures.

All records pertaining to this contract must be retained by the Contractor for a period of five years from the completion date of this Contract. If any litigation, claim or audit is started before the expiration of the five-year period, the records must be retained until the litigation, claim or audit findings have been resolved.

8. Required Insurance:

8.1 General Requirements. The Contractor shall maintain for the duration of this Contract, at its cost and expense, insurance against claims for injuries to persons or damages to property, including contractual liability, which may arise from or in connection with the performance of the work by the Contractor, agents, employees, representatives, assigns, or subcontractors. This insurance shall cover such claims as may be caused by any negligent act or omission.

8.2 Primary Insurance. The Contractor's insurance coverage shall be primary insurance as respect to the University, its officers, officials, employees, and volunteers and shall apply separately to each project or location. Any insurance or self-insurance maintained by the University, its officers, officials, employees or volunteers shall be excess of the Contractor's insurance and shall not contribute with it.

8.3 Specific Requirements for Commercial General Liability. The Contractor shall purchase and maintain occurrence coverage with combined single limits for bodily injury, personal injury, and property damage of $500,000 per occurrence and $1,000,000 aggregate per year to cover such claims as may be caused by any act, omission, or negligence of the Contractor or its officers, agents, representatives, assigns or subcontractors.

8.4 Additional Insured Status. The University, its officers, officials, employees, and volunteers are to be covered and listed as additional insureds; for liability arising out of activities performed by or on behalf of the Contractor, including the insured's general supervision of the Contractor; products and completed operations; premises owned, leased, occupied, or used.

8.5 Specific Requirements for Automobile Liability. The Contractor shall purchase and maintain coverage with split limits of $500,000 per person (personal injury), $1,000,000 per accident occurrence (personal injury), and $100,000 per accident occurrence (property damage), OR combined single limits of $1,000,000 per occurrence to cover such claims as may be caused by any act, omission, or negligence of the Contractor or its officers, agents, representatives, assigns or subcontractors.

8.6 Additional Insured Status. The University, its officers, officials, employees, and volunteers are to be covered and listed as additional insureds for automobiles leased, hired, or borrowed by the Contractor.

8.7 Deductibles and Self-Insured Retentions. Any deductible or self-insured retention must be declared to and approved by the University. At the request of the agency either: (1) the insurer shall reduce or eliminate such deductibles or self-insured retentions as respects the University, its officers, officials, employees, or volunteers; or (2) at the expense of the Contractor, the Contractor shall procure a bond guaranteeing payment of losses and related investigations, claims administration, and defense expenses.

8.8 Certificate of Insurance/Endorsements: A certificate of insurance from an insurer with a Best's rating of no less than A- indicating compliance with the required coverages, has been received by the Purchasing

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Department, MSU, 104 Montana Hall, PO Box 172600, Bozeman, MT 59717-2600. The Contractor must notify the University immediately, of any material change in insurance coverage, such as changes in limits, coverages, change in status of policy, etc. The University reserves the right to require complete copies of insurance policies at all times.

9. Compliance With The Workers' Compensation Act: Contractors are required to comply with the provisions of the Montana Workers' Compensation Act while performing work for the State of Montana in accordance with sections 39-71-120, 39-71-401, and 39-71-405, MCA. Proof of compliance must be in the form of workers' compensation insurance, an independent Contractor's exemption, or documentation of corporate officer status. Neither the Contractor nor its employees are employees of the University. This insurance/exemption must be valid for the entire term of this Contract. A renewal document must be sent to the Purchasing Department, MSU, 104 Montana Hall, PO Box 172600, Bozeman, MT 59717-2600, upon expiration.

10. Indemnification: The Contractor agrees to defend, indemnify and hold MSU harmless from any and all losses and claims that may result to MSU because of the activity of the Contractor, his/her/its agents and/or employees.

11. Non-discrimination: The Contractor agrees that under Section 49-3-207, Montana Code Annotated, and the federal civil rights acts, no part of this Contract shall be performed in a manner which illegally discriminates against any person on the basis of race, color, religion, creed, political ideas, sex, age, marital status, physical or mental handicap, or national origin.

12. Modification: This contract contains the entire agreement between the parties, and no statements, promises or inducements made by either party, or agents or either party, that are not contained in this Contract are valid or binding. This Contract may not be enlarged, modified, or altered except by written amendment by the parties.

13. Termination:

13.1 This Contract may be terminated at any time upon the written mutual consent of the parties.

13.2 MSU may terminate this Contract for failure of the Contractor to perform any of the services, duties or conditions contained in this Contract after providing the Contractor written notice of the stated failure. The written notice must demand performance of the stated failure within a specified period of time of not less than 5 business days. If the demanded performance is not completed within the specified period, the termination is effective at the end of the specified period.

13.3 The above remedies are in addition to any other remedies provided by law or the terms of this Contract.

13.4 The University must terminate this Contract if funds are not appropriated or otherwise made available to support the University's continuation of performance of this Contract in a subsequent fiscal period. (See section 18-4-313(4), MCA.)

14. Severability: If one part of this Contract is held to be illegal, void or in conflict with any Montana law, the validity of the remainder of this Contract remains operative and binding.

15. Assignment, Transfer and Subcontracting: There will be no assignment or transfer of this Contract, or of any interest in this Contract, unless both parties agree in writing. No services required under this Contract, may be performed under subcontract unless both parties agree in writing.

16. Notice: All notices relating to this Contract will be in writing and given to the contact person at the address provided for in this Contract.

17. Venue: This Contract will be interpreted according to the laws of the State of Montana. The parties agree that, in the event of litigation concerning this Contract, venue shall be in the Eighteenth Judicial District of the State of Montana, in and for the County of Gallatin.

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18. General: This Contract consists of **(insert number)** numbered pages, and any Attachments as required. In the case of dispute or ambiguity about the minimum levels of performance by the Contractor the order of precedence of document interpretation is in the same order. The original will be retained by MSU. A copy of the original shall have the same force and effect as the original for all purposes. To express the parties' intent to be bound by the terms of this Contract, they have executed this document on the dates set forth below.

Montana State University

Principal Investigator *(if required)*	Date	Contractor Name/Title	Date
Department Head *(if required)*	Date	MSU Legal Counsel Approved for Legal Format ***(required for contracts exceeding $25,000)***	Date
Dean *(if required)*	Date		
Director of Purchasing Approved for Form ***(required for contracts exceeding $25,000)***	Date	OSP Administrator/Vice President (***OSP signature required for contracts exceeding $5,000)***	Date

Contract invalid unless signed by all required parties

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APPENDIX C: TELCO WIRELESS COURSE EVALUATION FORM

Course and Instructor Evaluation

Course: *Telco Wireless Fundamentals and Usage* *Telecom Wireless Fundamentals* Professional Capacity Building for Communications	**Instructor:** Scott Baxter TONEX
Training Location: Ron Le Croix Training Center, Woodland, CA	**Date:** March 9-13, 2015
Student Name (*optional*):	**Caltrans District (*optional*):**

Thank you for participating in the *Telco Wireless Fundamentals and Usage* course presented by TONEX, the California Department of Transportation, and the Western Transportation Institute. We are planning to offer another communications training course in the future and need your feedback to make it as relevant and practical as possible. Please take a few moments to complete this evaluation of the *Telco Wireless Fundamentals and Usage* course.

1. **Please evaluate the instructor and circle one rating for each question below.**

Instructor	Excellent	Very Good	Good	Fair	Poor
Knowledge of subject matter	5	4	3	2	1
Presentation skills and delivery	5	4	3	2	1
Ability to answer questions	5	4	3	2	1
How well prepared was the instructor?	5	4	3	2	1
How well did the instructor encourage questions and facilitate discussion?	5	4	3	2	1
How well did the instructor organize and manage the course to stay on task?	5	4	3	2	1
Overall rating of instructor	5	4	3	2	1

Please provide any comments: _____

_____

_____

_____

1

2. How likely would you be to attend another course taught by this instructor? Circle one rating.

Very Likely		Neutral		Not At All Likely
5	4	3	2	1

3. Please evaluate the *Telco Wireless Fundamentals and Usage* course and circle one rating for each characteristic.

Course	Excellent	Very Good	Good	Fair	Poor
Content overall	5	4	3	2	1
Subject matter	5	4	3	2	1
Level of detail	5	4	3	2	1
Instructional methodology	5	4	3	2	1
How easy was the course to understand?	5	4	3	2	1
How relevant was the course to your job?	5	4	3	2	1
Hands-on activities	5	4	3	2	1
Application to real situations	5	4	3	2	1
Presentation structure and organization	5	4	3	2	1
How well were course objectives achieved?	5	4	3	2	1
How well did the course meet your expectations?	5	4	3	2	1
How well did the course meet your needs?	5	4	3	2	1
Overall quality of course	5	4	3	2	1

Please provide any comments: _____

_____

_____

_____

4. Do you agree that the correct objectives were targeted? Circle one level of agreement.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
5	4	3	2	1

Please explain: _____

_____

_____

_____

2

5. How satisfied were you with the following aspects of the *Telco Wireless Fundamentals and Usage* course? Please circle one level of satisfaction for each category.

Aspect	Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
Location	5	4	3	2	1
Facility/Classroom	5	4	3	2	1
Course length	5	4	3	2	1
Pace of course	5	4	3	2	1
Time of year course was offered	5	4	3	2	1

Please provide any comments: _____

6. Would you recommend this course to others?

Definitely	Likely	Neutral	Maybe	No
5	4	3	2	1

Why or why not? _____

7. Please evaluate the course materials and circle one rating for each question below.

Materials	Excellent	Very Good	Good	Fair	Poor
Overall quality	5	4	3	2	1
Organization, flow and structure of information	5	4	3	2	1
How well did the course materials follow the course presentation?	5	4	3	2	1
Usefulness, practicality of course materials	5	4	3	2	1
How easy were the materials to understand?	5	4	3	2	1
Potential value as future reference material	5	4	3	2	1

Please provide any comments: _____

3

8. **I will apply the following in my job:** _____

9. **I will have difficulty applying the following to my job:** _____

10. ***This course was offered as part of Phase 3 of the Professional Capacity Building for Communications project. The project team is investigating and developing a comprehensive training curriculum for communications as applied to Intelligent Transportation Systems (ITS). As part of Phase 1 of the project, the research team conducted a Needs Assessment to evaluate the training needs and interests of Caltrans personnel as related to ITS communications.***

    Were you able to participate in the Needs Assessment survey? (Circle one.) YES NO NOT SURE

    Based on the results of the Needs Assessment, this course was chosen as part of the solution for building professional capacity in ITS communications. Did this course meet your needs and expectations for communications training in Telco Wireless? Please explain.
    _____

11. **How likely would you be to participate in another training course as part of the Professional Capacity Building for Communications project?**

Very Likely		Neutral		Not At All Likely
5	4	3	2	1

12. **In what other subject areas related to ITS communications would you be interested in receiving training?** _____

Please provide any comments that will help improve future Professional Capacity Building for Communications training courses. _____

4

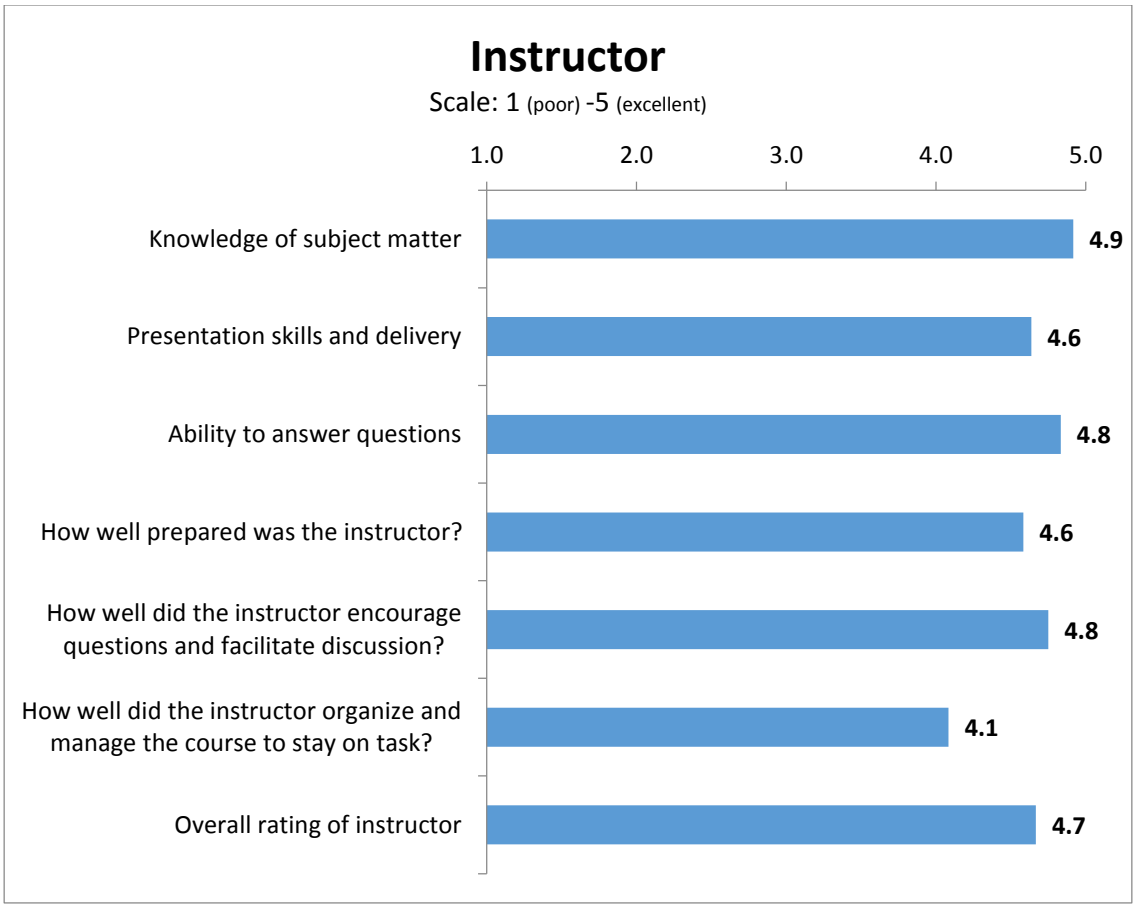
Thank you for your feedback and comments!

APPENDIX D: PARTICIPANT EVALUATIONS (WTI) – TELCO WIRELESS COURSE

The overall evaluation was developed by WTI and administered to the students at the conclusion of the Telco Wireless course. The results are below.

1. Please evaluate the instructor and circle one rating for each question below.

Instructor	*Number of students who rated the item at each level*					
	5	4	3	2	1	
	Excellent	Very Good	Good	Fair	Poor	Average Rating
Knowledge of subject matter	11	1	0	0	0	4.9
Presentation skills and delivery	7	4	0	0	0	4.6
Ability to answer questions	10	2	0	0	0	4.8
How well prepared was the instructor?	8	3	1	0	0	4.6
How well did the instructor encourage questions and facilitate discussion?	9	3	0	0	0	4.8
How well did the instructor organize and manage the course to stay on task?	5	4	2	1	0	4.1
Overall rating of instructor	8	2	0	0	0	4.7

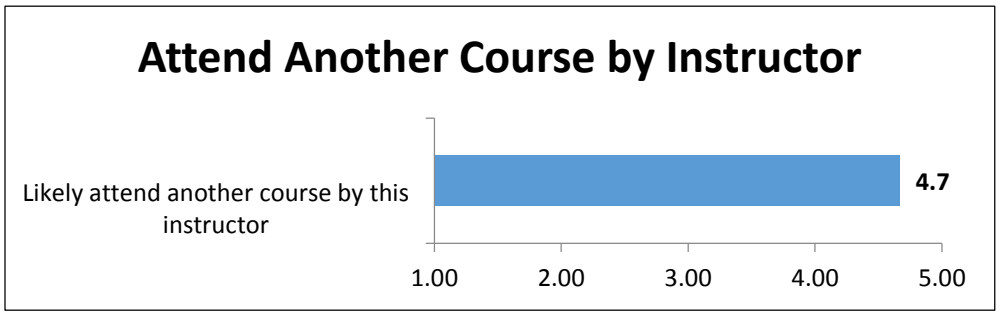


Comments:

- "He was a little tough to follow where instructor was when he skipped ahead in the booklet or went to the other additional document. It was good that he put it in website and thumb drive, tho."
- "Very thorough and easy to understand. Would take another course again."
- "More hand on and exercise, config."
- "Instructor spent more time in the introduction than expected. The order of the lab/examples were confusing with the jumping around."
- "Instructor was very knowledgeable!"
- "Great instructor. Noticed description from the syllabus."
- "Class was well organized. However, the instructor did jump around a fair amount."

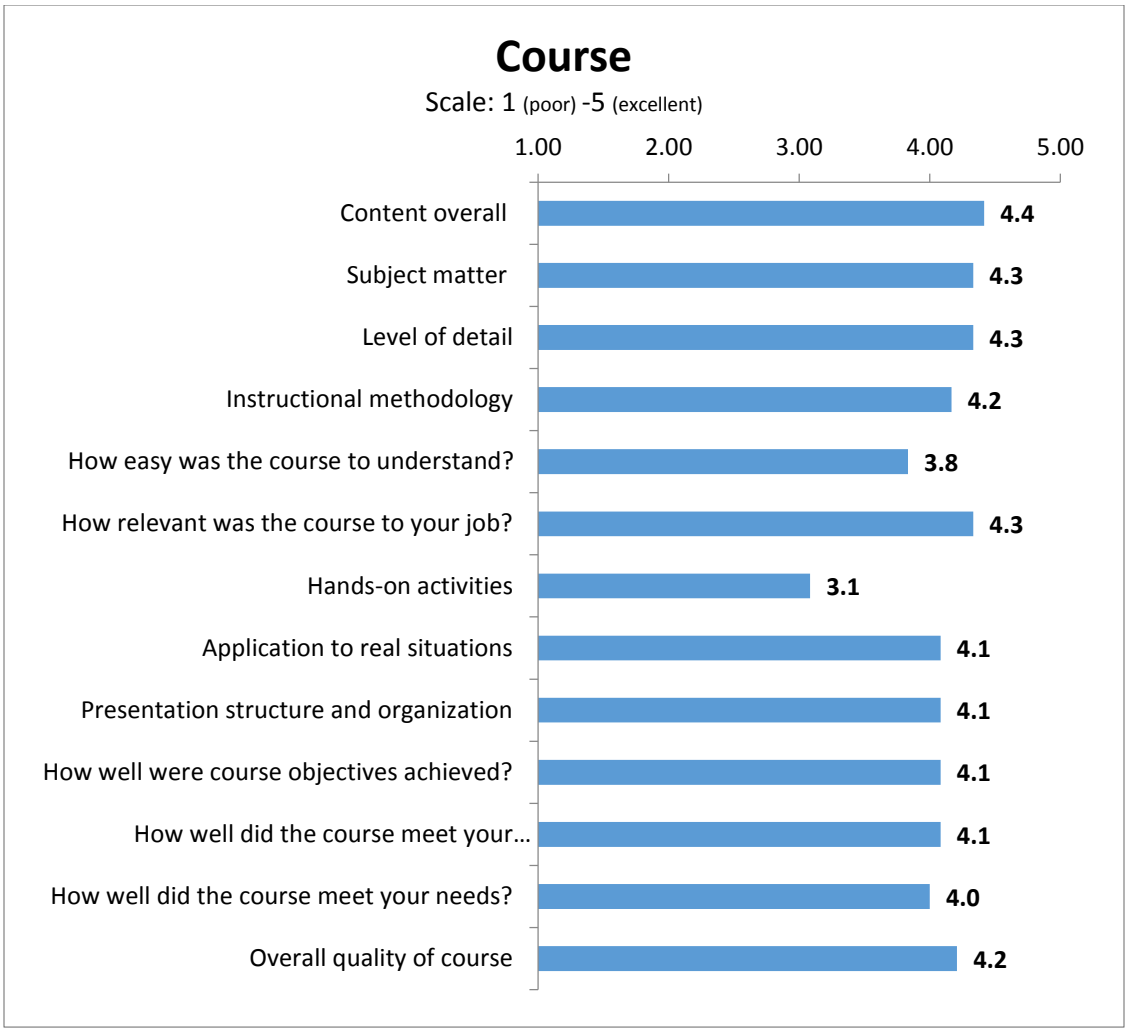
2. How likely would you be to attend another course taught by this instructor? Circle one rating.

Likely attend another course by this instructor	*Number of students who rated the item at each level*					
	5	4	3	2	1	
	Very Likely		Neutral		Not At All Likely	Average Rating
Attend another course by instructor	9	2	1	0	0	4.67



3. Please evaluate the *Telco Wireless Fundamentals and Usage* course and circle one rating for each characteristic.

Course	*Number of students who rated the item at each level*					
	5	4	3	2	1	
	Excellent	Very Good	Good	Fair	Poor	Average Rating
Content overall	7	3	2	0	0	4.42
Subject matter	6	4	2	0	0	4.33
Level of detail	7	2	3	0	0	4.33
Instructional methodology	4	6	2	0	0	4.17
How easy was the course to understand?	2	7	2	1	0	3.83
How relevant was the course to your job?	5	6	1	0	0	4.33
Hands-on activities	2	2	4	3	1	3.08
Application to real situations	4	5	3	0	0	4.08
Presentation structure and organization	4	6	1	1	0	4.08
How well were course objectives achieved?	4	6	1	1	0	4.08
How well did the course meet your expectations?	5	5	1	0	1	4.08
How well did the course meet your needs?	4	5	2	1	0	4.00
Overall quality of course	5	5	1	0	0	4.21

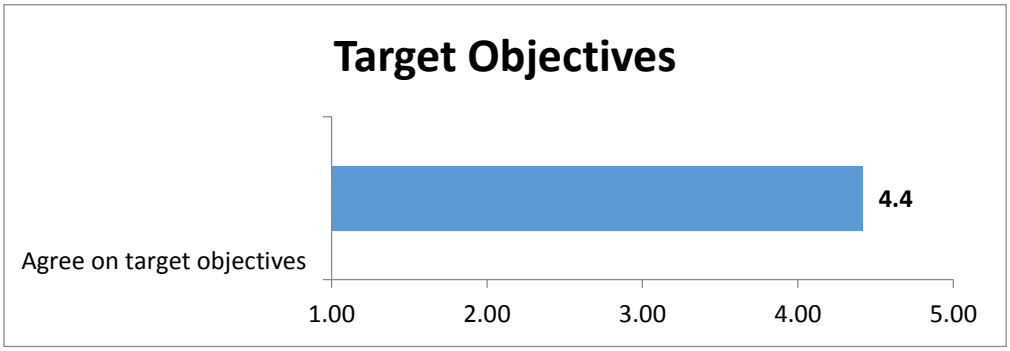


Comments:

- “"Hands on" activities were done by instructor. Would have been nice for students to have to do the labs. Perhaps material was too detailed on the provider side and not enough on CT specific applications. May be good idea to try to get specific questions from students prior to course and go into as much detail as possible.”
- “Would like to more configuring of modems.”
- “Excellent topic, very useful.”
- “Very good class, and for communication for ITS, not too much detail!”
- “More hands on training. Hands on labs and exercises were lacking. Even if there isn't great hands on material, set the students up with some real world scenarios and engage the class w/ problem solving.”
- “Did not have enough hands on. However, the subject didn't lend to much hands on.”

4. Do you agree that the correct objectives were targeted? Circle one level of agreement.

Agreement on target objectives	*Number of students who rated the item at each level*					
	5	4	3	2	1	
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Average Rating
Agree on target objectives	6	5	1	0	0	4.42

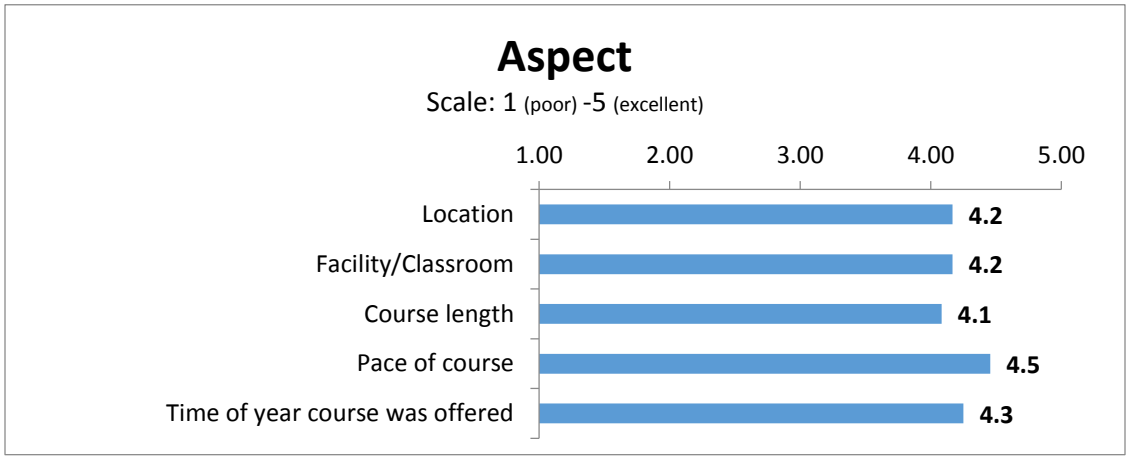


Comments:

- "Yes. Maybe in too much detail, though."
- "The instructor covered both the practical and theoretical aspects well."
- "3G, 4G, LTE will using at Caltrans for all ITS elements."
- "Some of them were, others weren't. (There were a lot of them.)"
- "Far more well prepared to deploy this technology in our district."
- "It seemed like some things were skipped."

5. How satisfied were you with the following aspects of the *Telco Wireless Fundamentals and Usage* course? Please circle one level of satisfaction for each category.

Aspects	*Number of students who rated the item at each level*					
	5	4	3	2	1	
	Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied	Average Rating
Location	6	3	2	1	0	4.17
Facility/Classroom	5	5	1	1	0	4.17
Course length	6	2	3	1	0	4.08
Pace of course	5	6	0	0	0	4.45
Time of year course was offered	6	3	3	0	0	4.25

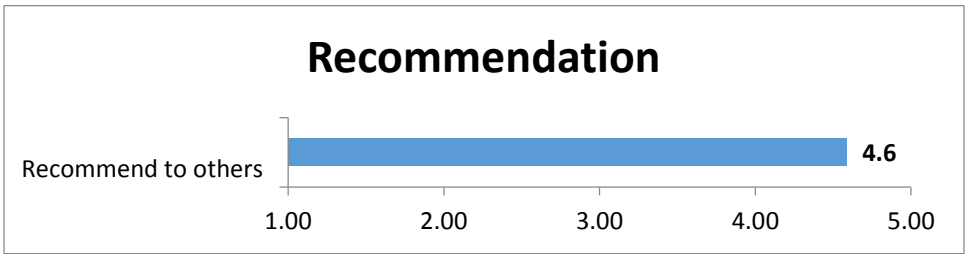


Comments:

- "Very satisfied w/ overall length, but I think it would have been good to spend more time on hands-on activities, and more tools for 2 students per group."
- "Needs to be about A 6-7 (8 hr.) day so about 48-56 hours rather than only 40. This will allow for more hands on labs."
- "The RTMC location was preferable."
- "I think the course materials for the applications used by CT could have been presented to us in two days without going in details of each technology. After all, districts are at the receiving end of technology, so system engineering is what gets designed and what desired by most districts."
- "Facility/classroom was marked "2" because each day I started to get a stiff neck with the table 90 [degrees] angled towards the screen/instructor. The lunch options were great!"

6. Would you recommend this course to others?

Recommend to others	*Number of students who rated the item at each level*					
	5	4	3	2	1	
	Definitely	Likely	Neutral	Maybe	No	Average Rating
Recommend to others	8	3	1	0	0	4.58

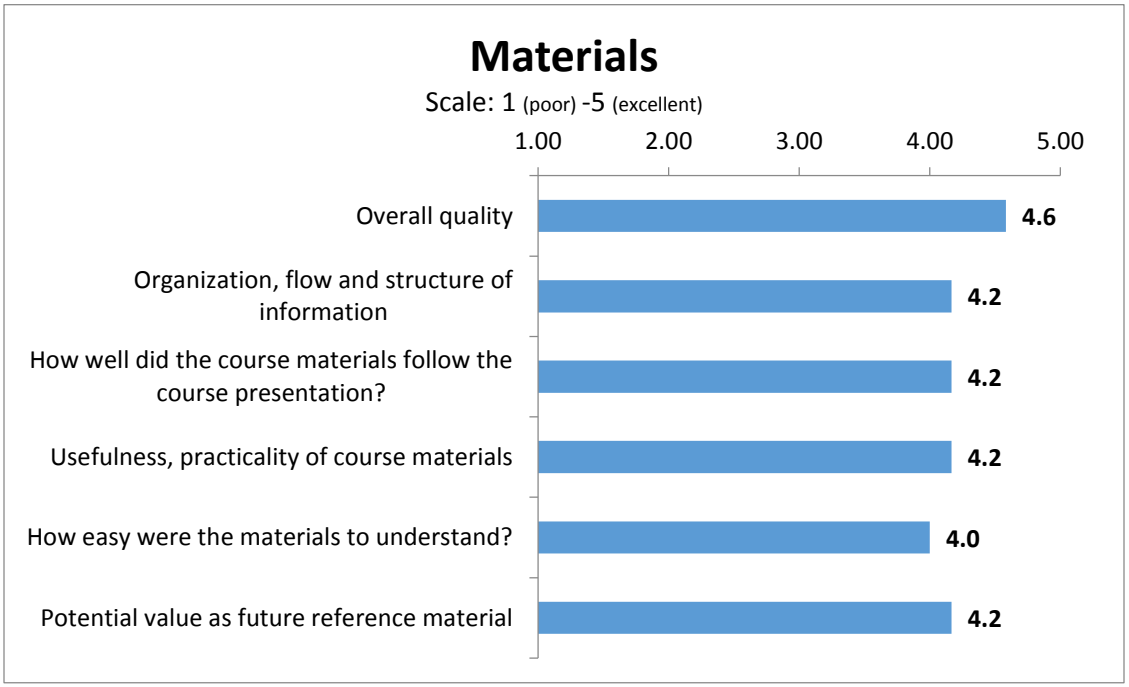


Comments:

- "I would recommend it, if modified a little."
- "The level of detail presented was excellent as was the subject matter."
- "Good for who do the communication. Ex: TMC"
- "Some parts are relevant to our job, but others weren't."
- "Free education. It help to bridge the knowledge across the board."
- "Very applicable to understanding basic pit falls and "behind the curtains of the technologies off wireless."

7. Please evaluate the course materials and circle one rating for each question below.

Materials	*Number of students who rated the item at each level*					
	5	4	3	2	1	
	Excellent	Very Good	Good	Fair	Poor	Average Rating
Overall quality	8	3	1	0	0	4.58
Organization, flow and structure of information	5	5	1	1	0	4.17
How well did the course materials follow the course presentation?	5	5	1	1	0	4.17
Usefulness, practicality of course materials	5	5	1	1	0	4.17
How easy were the materials to understand?	2	8	2	0	0	4.00
Potential value as future reference material	5	5	1	1	0	4.17



Comments:

- "Updated course materials was great."
- "The materials didn't seem that sequential."
- "The instructor did provide much valuable post class resources."

8. I will apply the following in my job:

- "The understanding of antenna placement and diversity. General LTE/"4G" understanding of wireless encoding/frequency methods."
- "Application of wireless technology and the tools, process of determining what is best for the application."
- "D-3 - we are in the process of changing all of our cellular modems. We are going towards LTE technology. This course gave me some pointer[s]--for design, implementation."
- "Cell service survey tools."
- "The use of www.sensorly.com in site surveys."
- "Evaluation of LTE sites, deployment of LTE modems. Tools presented in this training will help me in deployment of these modems and make an informed decision on type of antenna needed to boost poor signal locations."
- "Find the location ITS with 4G/LTE signal or using 3G."
- "Location of antennas and types. Analysis of RF technology for cellular applications as it relates to different carriers."
- "Wireless comm.: data throughput, access, availability. G-net app was a great hands on tool."
- "Use signal strength and quality tools when implementing wireless in field locations."

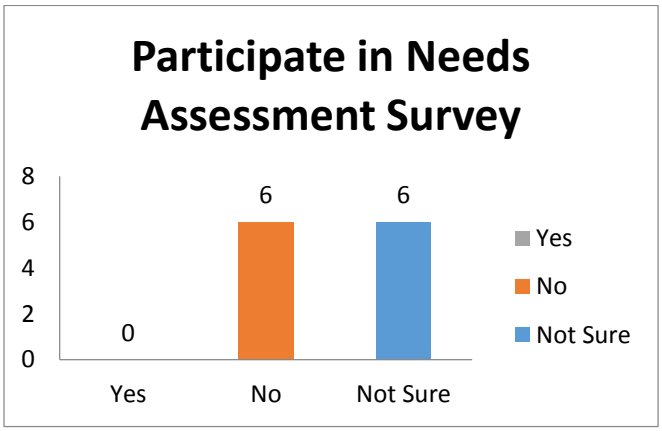
9. I will have difficulty applying the following to my job:

- "N/A"
- "Information presented in this training (RF) will help me to evaluate a site once a challenging site surface."
- "Spectrum analyzer to analyze field experiences. Reading material in a spiral-bound "book" (binders I find easier)"

10. ***This course was offered as part of Phase 3 of the Professional Capacity Building for Communications project. The project team is investigating and developing a comprehensive training curriculum for communications as applied to Intelligent Transportation Systems (ITS). As part of Phase 1 of the project, the research team conducted a Needs Assessment to evaluate the training needs and interests of Caltrans personnel as related to ITS communications.***

Were you able to participate in the Needs Assessment Survey? (Circle one.) YES NO NOT SURE

Were you able to participate in the Needs Assessment survey?	Number
Yes	0
No	6
Not Sure	6

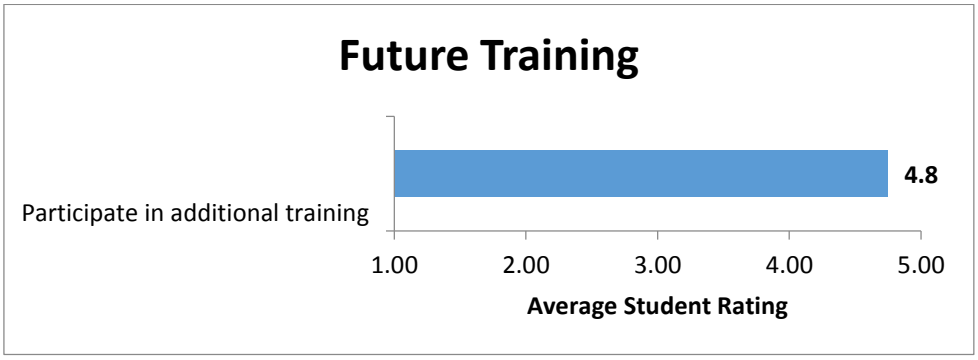


Based on the results of the Needs Assessment, this course was chosen as part of the solution for building professional capacity in ITS communications. Did this course meet your needs and expectations for communications training in Telco Wireless? Please explain.

- "Yes. Very useful info about all wireless technologies."
- "N/A"
- "Yes. The course explained the advantages and disadvantages of different cell technologies."
- "This course will apply to me. I do the communication that [*connects*] to ITS at my work."
- "The course met my needs for the type of applications used in my district and exceeded in other areas of coverage."
- "Not really, some of it did, but not 5 days' worth. Also see other comments."
- "Yes we do need this information to expand our system, provide alternate communications paths and provide services we currently cannot."
- "Yes, instructor was very experienced in the industry and answered a lot of questions we had."

11. How likely would you be to participate in another training course as part of the Professional Capacity Building for Communications project?

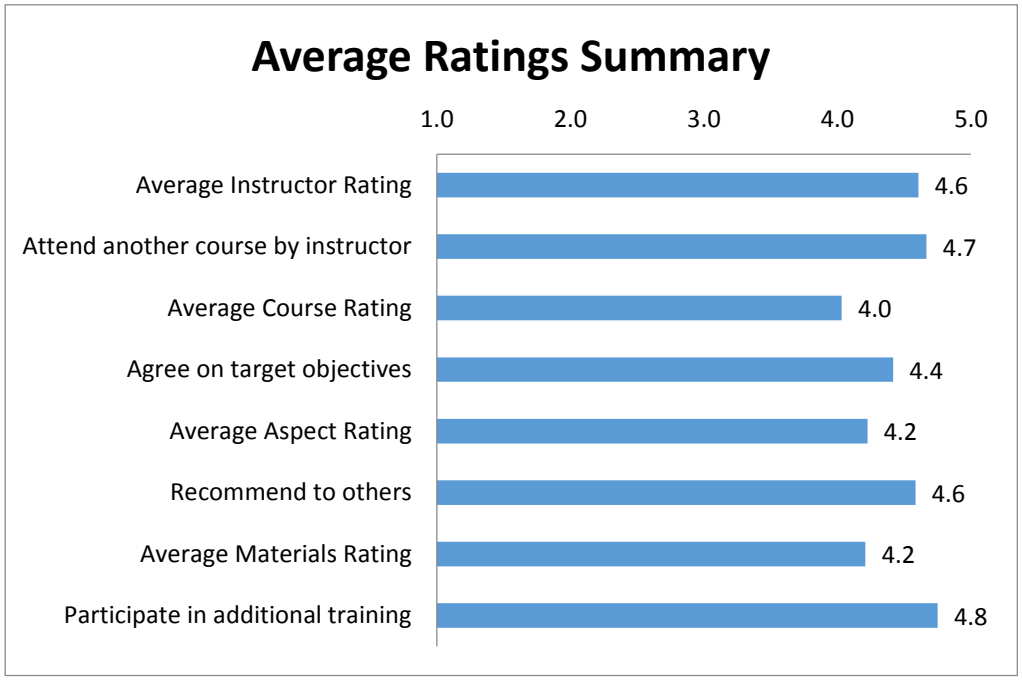
Participate in another training for PCB	*Number of students who rated the item at each level*					
	5	4	3	2	1	
	Very Likely		Neutral		Not At All Likely	Average Rating
Participate in additional training	9	3	0	0	0	4.75



12. In what other subject areas related to ITS communications would you be interested in receiving training?

- Modem configurations
- IP networking
- Non-wireless communications
- Security
- Short range communications
- RFID and Bluetooth between vehicles and at base station
- IPV6
- Video compression/encoding schemes
- RF and security
- Telco provided network extensions
- Fiber communication
- TCP/IP Networking
- Telco specific technologies. Such as DSL, MPLS, metro Ethernet, private radio.

The following chart is a summary of the average ratings for each evaluation question.



Please provide any comments that will help improve future Professional Capacity Building for Communications training courses.

- "Perhaps some courses specifically related to specific ITS systems, covering from field to central office."
- "Configuring modems used by the state for example Digi or Sierra wireless modems."
- "Needs more examples using a hands on tool. More lab time."
- "More hands on."
- "The structure of the course may have been done slightly different due to the diverse audience. 1. Wireless technology and its practical application and implementation 2. Building blocks of these technologies without the technical depth presented since the clients (districts) are at the receiving end of these technologies (users) 3. I think the course could be presented over 3 days if the above items were taken into consideration."
- "Compare order of slides to syllabus. The HVAC system kept the room too cold."

APPENDIX E: PARTICIPANT EVALUATIONS (TONEX) – TELCO WIRELESS COURSE

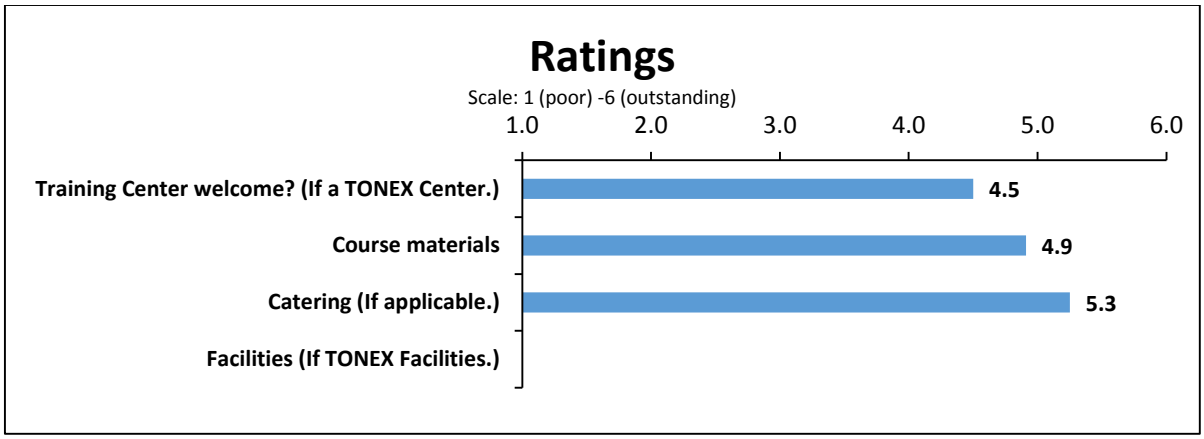
TONEX also distributed an evaluation form for the overall course. The results are presented below.

Our Administration

Administration	*Number of students who rated the item at each level*		
	Yes	No	N/A
Received confirmation email?	10	0	1
Received directions?	10	0	1
Received syllabus?	11	0	0

How do you rate:

How do you rate:	*Number of students who rated the item at each level*						
	6	5	4	3	2	1	
	Outstanding	Excellent	Very Good	Good	Average	Poor	Average Rating
Training Center welcome? (If a TONEX Center.)	1	0	0	1	0	0	4.5
Course materials	3	5	2	1	0	0	4.9
Catering (If applicable.)	2	1	1	0	0	0	5.3
Facilities (If TONEX Facilities)	0	0	0	0	0	0	N/A

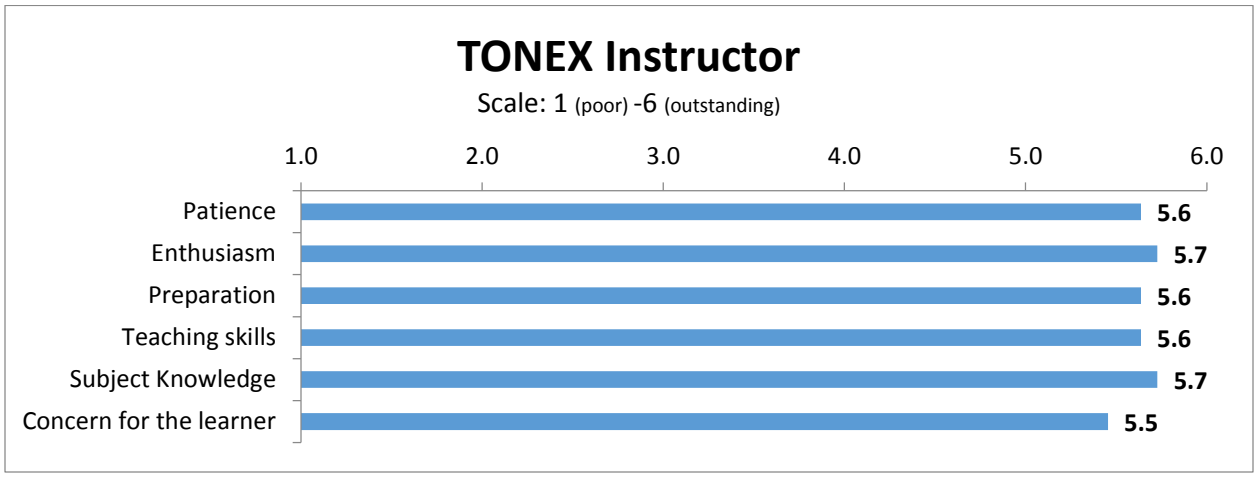


In the Training Room:

In the Training Room	*Number of students*		
	Yes	No	N/A
Classroom clean and orderly	11	0	0
Classroom comfortable	10	1	0
Informed of safety procedures	9	2	0
Instructor learned name	10	1	0
Contents met personal objectives	11	0	0
Contents met stated course objectives	10	0	0
Learned and benefited from course	11	0	0
Proctor provided instructions	9	0	2
Storage provided for "not permitted" items	5	0	6
Proctor assisted with sign-in (exam)	2	0	9
Would recommend to colleague	11	0	0
Relevant to work	11	0	0

How do you rate your Trainer:

Instructor	*Number of students who rated the item at each level*						
	6	5	4	3	2	1	
	Outstanding	Excellent	Very Good	Good	Average	Poor	Average Rating
Patience	7	4	0	0	0	0	5.6
Enthusiasm	9	1	1	0	0	0	5.7
Preparation	7	4	0	0	0	0	5.6
Teaching skills	7	4	0	0	0	0	5.6
Subject Knowledge	8	3	0	0	0	0	5.7
Concern for the learner	7	2	2	0	0	0	5.5



Future Courses

Are you interested in any other courses? If so, please use the space below to inform us of your requirements.

- "Microwave wireless system design/implementation."

Finally

To continue to provide a second-to-none service we welcome any constructive comments. Please use the space below.

- "Class was very rich in content. From my perspective, maybe a little too much detail on the provider side. I was expecting a little more concentration on user/application side. Overall good class. Great enthusiasm from instructor."
- "More hands on lab needs to be included in this course."
- "It would be nice if the examples/labs were ran in sequence, more examples of spectrum analyzer would be beneficial."
- "Very useful information, instructor was very knowledgeable."
- "You mixed jokes with useful info. Excellent! It made it fun!"
- "More training in configuring modems."

APPENDIX F: NEEDS ASSESSMENT SURVEY

Caltrans

Professional Capacity Building for Communications (2015)

1. Introduction

Thank you for taking the time to complete this survey. The Western Transportation Institute (WTI) and Caltrans Division of Research, Innovation, and System Information are investigating communications training for Caltrans personnel as applied to Intelligent Transportation Systems (ITS). The feedback you give in this survey is important to help define training topics and depth of training.

This survey should take approximately 30 minutes of your time. Participation is voluntary. By taking the survey, you consent to the use of your responses for the objective stated above.

Your contact information will only be used by the researchers for the purposes of this study and for course development and delivery. The researchers will not contact you for any other reason and your contact information will not be released or shared for any other reason. If you have any questions concerning your rights as a human subject and/or the use of your contact information, please contact:

Institutional Review Board
Montana State University
960 Technology Blvd, Room 127
P.O. Box 173610
Bozeman, MT 59717
Phone: (406) 994-6783
Fax: (406) 994-4303

If you have any questions about the survey, please contact WTI at leann.koon@coe.montana.edu or call 406-994-7643.

Survey Directions
In order to progress through this survey, please use the navigation links presented on the survey pages:

- **Use the Next button to continue to the next page.**
- **Use the Previous button to return to the previous page.**
- **Use the Exit this Survey link to exit the survey.**
- **Use the Submit button on the last page to submit your survey responses.**

NOTE: Clicking the Back button in your browser before a page is completed will clear all data entered on the current page. Your responses will be saved as you progress through the survey and you can start up again where you left off by re-opening the survey using the provided link.

1

However, we recommend that you complete the survey in one session. Please click the Next button to proceed to the survey:

2

Professional Capacity Building for Communications (2015)

2. Agency

Please answer the following question before beginning the survey.

2.1. Do you work for Caltrans or are you taking this survey based on an email request from a Caltrans employee?

- ◯ Yes
- ◯ No

3

Caltrans

Professional Capacity Building for Communications (2015)

3. Contact Information and Background

3.1. Please enter the following information.
Note: If you are not a Caltrans employee, skip Caltrans District/Dept.

First Name:	
Last Name:	
Email Address:	
Caltrans District/Dept:	
Location:	
Job Title:	
Years in Position:	

3.2 Please list technical training that you have received related to your career or job. (E.g., degrees, certifications, professional training classes, etc.)

Throughout the rest of the survey, we will ask you about your experience with specific communication technologies relative to ITS.

4

Caltrans

Professional Capacity Building for Communications (2015)

4. Plant Wireless Communications

The Plant Wireless subject area includes topics related to user owned and installed wireless communications. It provides knowledge and skills necessary to design, implement and maintain wireless communication links.

Such topics include:

- **Plant Wireless Core and RF Systems Design: Fundamentals of radio frequency communications**
- **802.11 (WiFi) and Related: Unlicensed high bandwidth 2.4 or 5.8 GHz communication**
- **Microwave: Point to Point high bandwidth radio communication**
- **Short Haul Radio: Short distance microwave communication (e.g., 18 and 23 GHz systems)**
- **Privately Owned WiMAX: WiMAX data networks**

4.1. Please indicate your level of experience for these technologies, as applied to ITS Communications:

	Substantial Experience	Some Experience	No Experience	Not Familiar with Topic
Plant Wireless Core and RF Systems Design	○	○	○	○
802.11 (WiFi) and related	○	○	○	○
Microwave	○	○	○	○
Short haul radio	○	○	○	○
Privately owned WiMAX	○	○	○	○

Please list additional topics in Plant Wireless Communications which you feel are important to experience and training as applied to ITS Communications.

5

4.2. How important is training in the following technologies, as applied to ITS Communications?

	Very Important	Important	Not Important	Not Familiar with Topic
Plant Wireless Core and RF Systems Design	○	○	○	○
802.11 (WiFi) and related	○	○	○	○
Microwave	○	○	○	○
Short haul radio	○	○	○	○
Privately owned WiMAX	○	○	○	○

4.3. Would you like training in the following technologies, as applied to ITS Communications?

	Yes	No
Plant Wireless Core and RF Systems Design	○	○
802.11 (WiFi) and related	○	○
Microwave	○	○
Short haul radio	○	○
Privately owned WiMAX	○	○

4.4. How often do you work with the following technologies, as applied to ITS Communications?

	Daily	Weekly	Monthly	Yearly	Sometime in the future	Sometime in the past	Do not use this technology
Plant Wireless Core and RF Systems Design	○	○	○	○	○	○	○
802.11 (WiFi) and related	○	○	○	○	○	○	○
Microwave	○	○	○	○	○	○	○
Short haul radio	○	○	○	○	○	○	○
Privately owned WiMAX	○	○	○	○	○	○	○

6

Caltrans

Professional Capacity Building for Communications (2015)

5. Sample Topics for Classes in Plant Wireless Communciations

5.1. Please rate the level of detail in the following example training objectives for a class in Plant Wireless Core and RF Systems Design.

- Define and explain terminology and general concepts for plant wireless communication systems.
- Compare equipment specifications for RF systems.
- Select appropriate equipment for the site and system requirements (e.g., filters, power dividers, combiners, directional couplers).
- Evaluate tower and antenna site requirements, including availability of existing towers, tower structure (e.g., self supporting or guyed), and potential antenna sharing.
- Calculate a link budget allowing for RF power, bandwidth, bit error rate, and channel noise among other variables.
- Calculate system losses due to path, system, and obstructions (i.e., transmission line loss, connector losses, path loss, and/or combiner loss).
- Evaluate the effects of fading using statistical fading models and distance-power (path loss) relationships in different propagation environments.
- Calculate path-related impairment such as the effects of outdoor terrain and structures on signal propagation.
- Analyze antenna polarization mismatch and apply the Power Loss Factor.
- Determine and apply antenna parameters such as antenna type and size, antenna patterns and polarization, gain, gain pattern, Effective (or Equivalent) Radiated Power (ERP), receive and transmit diversity, and proper installation to provide adequate coverage, mitigate interference, and reuse frequency.
- Optimize coverage of a radio system using propagation analysis tools such as ComStudy, and appropriate coverage calculation and verification techniques.
- Determine appropriate antenna spacing using adaptive antenna methods and techniques.
- Develop a block diagram of a radio system showing the location of all RF units in the system.
- Perform and interpret RF system measurements using test equipment such as network analyzers, spectrum analyzers, and time domain reflectometers (TDR). Example tests and evaluations include but are not limited to the following:
    - ERP
    - Received Signal Strength Indication (RSSI)
    - Noise Figure/Factor (NF)
    - Noise temperature
    - Receiver sensitivity
    - Sources and impact of external noise
    - Signal-to-noise ratio (S/N)

7

- Co-channel and adjacent channel interference analysis
- Intermodulation interference

- Use computer tools to evaluate radio links and perform propagation studies.
- Maintain and repair equipment according to system manufacturer, FCC and/or Caltrans guidelines.
- Evaluate the pros and cons of common alternatives.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to plant wireless fundamentals and ITS that you feel should be addressed.

5.2. Please rate the level of detail in the following example training objectives for a class in 802.11 and related technologies.

- Understand the fundamentals of 802.11 and 802.16 alternatives, and unlicensed high bandwidth 2.4 or 5.8 GHz communications.
- Determine when and where 802.11 can be used effectively.
- Correctly install appropriate equipment.
- Correctly configure equipment using proper antenna alignment and accurate field strength measurements.
- Carefully follow user instructions for proper equipment installation and use.
- Select and operate appropriate test equipment for troubleshooting to successfully address problems.
- Maintain and repair equipment according to system manufacturer, FCC and/or Caltrans guidelines.
- Evaluate the pros and cons of common alternatives.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to 802.11 and ITS that you feel should be addressed.

8

5.3. Please rate the level of detail in the following example training objectives for a class in Microwave Communications.

- Determine when and where microwave communication technology can be used effectively.
- Perform microwave path analysis and determine proper Fresnel zone clearance.
- Apply the fundamentals of microwave path configuration to correctly install microwave communications equipment.
- Correctly configure equipment considering such factors as tower type (stand alone or guyed), tower height, antenna type, antenna gain, antenna orientation, antenna polarization, and frequency (licensed or unlicensed).
- Carefully follow user instructions for proper equipment installation and use.
- Select and operate appropriate test equipment for troubleshooting to successfully address problems.
- Maintain and repair equipment according to system manufacturer, FCC and/or Caltrans guidelines.
- Evaluate the pros and cons of common alternatives.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to microwave technologies and ITS that you feel should be addressed.

5.4. Please rate the level of detail in the following example training objectives for a class in Short Haul Radio.

- Determine when and where short haul radio communication technology can be used effectively.
- Perform a microwave path analysis and determine level of Fresnel clearance.
- Effectively install appropriate equipment with an understanding of transmit ERP requirements and limitations, siting limitations, and interference potentials.
- Correctly configure equipment, taking into consideration antenna type, gain, and siting, in addition to receiver sensitivity requirements.
- Carefully follow user instructions for proper equipment installation and use.
- Select and operate appropriate test equipment for troubleshooting to successfully address problems.
- Maintain and repair equipment according to system manufacturer, FCC and/or Caltrans guidelines.
- Evaluate the pros and cons of common alternatives.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to short haul radio and ITS that you feel should be addressed.

9

5.5. Please rate the level of detail in the following example training objectives for a class in privately owned WiMAX.

- Determine when and where WiMAX communication technology can be used effectively.
- Choose an appropriate frequency band for the application (2300 or 3800 MHz bands, possibly 700 MHz band in the future).
- Successfully install equipment with an understanding of the basics of WiMAX, transmit ERP requirements and limitations, and interference potentials.
- Correctly configure equipment, taking into consideration antenna type, gain, and siting, in addition to receiver sensitivity requirements.
- Carefully follow user instructions for proper equipment installation and use.
- Select and operate appropriate test equipment for troubleshooting to successfully address problems.
- Maintain and repair equipment according to system manufacturer, FCC and/or Caltrans guidelines.
- Evaluate the pros and cons of common alternatives.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to privately owned WiMAX and ITS that you feel should be addressed.

10

Caltrans

Professional Capacity Building for Communications (2015)

6. Telco Wireless Communications

The Telco Wireless subject area includes topics related to leased wireless communications. It provides knowledge and skills necessary to design, implement and maintain systems that interface to Telco provided wireless communications.

Such topics include:

- **Telco Wireless Core and Cellular/PCS Basics: Basic knowledge of cellular & PCS communication**
- **GSM data, 3G and Next Generations: Global System for Mobile communications**
- **CDMA Data, 3G and Next Generations: Code Division Multiple Access communications**
- **LTE (Long Term Evolution), 4G and Next Generations**
- **Telco owned WiMAX (broadband): WiMAX data services**

6.1. Please indicate your level of experience for these technologies, as applied to ITS Communications:

	Substantial Experience	Some Experience	No Experience	Not Familiar with Topic
Telco Wireless Core and Cellular/ PCS Basics	○	○	○	○
GSM data, 3G and Next Generations	○	○	○	○
CDMA data, 3G and Next Generations	○	○	○	○
LTE, 4G and Next Generations	○	○	○	○
Telco owned WiMax	○	○	○	○

Please list additional topics in Telco Wireless Communications which you feel are important to experience and training as applied to ITS Communications.

11

6.2. How important is training in the following technologies, as applied to ITS Communications?

	Very Important	Important	Not Important	Not Familiar with Topic
Telco Wireless Core and Cellular/ PCS Basics	○	○	○	○
GSM data, 3G and Next Generations	○	○	○	○
CDMA data, 3G and Next Generations	○	○	○	○
LTE, 4G and Next Generations	○	○	○	○
Telco owned WiMax	○	○	○	○

6.3. Would you like training in the following technologies, as applied to ITS Communications?

	Yes	No
Telco Wireless Core and Cellular/ PCS Basics	○	○
GSM data, 3G and Next Generations	○	○
CDMA data, 3G and Next Generations	○	○
LTE, 4G and Next Generations	○	○
Telco owned WiMax	○	○

6.4. How often do you work with the following technologies, as applied to ITS Communications?

	Daily	Weekly	Monthly	Yearly	Sometime in the future	Sometime in the past	Do not use this technology
Telco Wireless Core and Cellular/ PCS Basics	○	○	○	○	○	○	○
GSM data, 3G and Next Generations	○	○	○	○	○	○	○
CDMA data, 3G and Next Generations	○	○	○	○	○	○	○
LTE, 4G and Next Generations	○	○	○	○	○	○	○
Telco owned WiMax	○	○	○	○	○	○	○

12

Caltrans

Professional Capacity Building for Communications (2015)

7. Sample Topics for Classes in Telco Wireless Communciations

7.1. Please rate the level of detail in the following example training objectives for a class in Telco Wireless Core and Cellular/ PCS Basics.

- Define and explain terminology and general concepts for telco wireless communication systems.
- Discuss the concepts of wireless propagation and related theory.
- Review the history of available services and spectrum (E.g., 1X, 2G, 2.5G, 3G, 4G, etc.).
- Examine and discuss carrier supporting network infrastructure and how it operates, including capabilities, potential bottlenecks, etc.
- Determine the coverage area and signal strength at a specific location by conducting necessary field strength measurements.
- Locate and classify cellular sites using the Federal Communications Commission (FCC) data base.
- Select and effectively utilize cellular/PCS data services.
- Ascertain tower and antenna requirements for the particular application (e.g., cellular modem at a fixed site for a CCTV).
- Compare, contrast and evaluate available modems and hardware and select the best alternative for specific applications.
- Successfully install and configure equipment considering such factors as modem type and data rate, and antenna requirements, gain and gain orientation for a fixed site.
- Properly implement cellular/PCS equipment, taking into account the potential for system overload and the type of site receiver (dialup or fixed).
- Conduct thorough bandwidth and throughput testing and apply the results.
- Maintain and repair the system and equipment according to system provider, accepted standards, and/or Caltrans guidelines.
- Assess and compare the pros and cons of common alternatives.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to Telco wireless fundamentals and ITS that you feel should be addressed.

13

7.2. Please rate the level of detail in the following example training objectives for a class in GSM data, 3G and Next Generations.

- Discuss the technical characteristics and basic operation of GSM communication systems.
- Determine when and where GSM communications technology can be used effectively.
- Deduce the required and optimal data rate with a working understanding of the data rate provided by various options such as General Packet Radio Service (GPRS), Enhanced Data rates for GSM or Global Evolution (EDGE), etc.
- Select appropriate equipment necessary for specific applications.
- Successfully install and configure equipment considering such factors as modem type and data rate, and antenna requirements, gain and gain orientation for a fixed site.
- Properly implement GSM equipment accounting for the potential for system overload and the type of site receiver (dialup or fixed).
- Conduct thorough bandwidth and throughput testing and apply the results.
- Maintain and repair the system and equipment according to system provider/equipment vendor and/or Caltrans guidelines.
- Assess and compare the pros and cons of common alternatives.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to GSM, 3G and next generation technologies and ITS that you feel should be addressed.

14

7.3. Please rate the level of detail in the following example training objectives for a class in CDMA data, 3G and Next Generations.

- Discuss the technical characteristics and basic operation of CDMA communication systems.
- Determine when and where CDMA communications technology can be used effectively.
- Deduce the required and optimal data rate with a working understanding of the data rate provided by various options such as 1xRTT, EV-DO, etc.
- Select appropriate equipment necessary for specific applications.
- Successfully install and configure equipment considering such factors as modem type and data rate, and antenna requirements, gain and gain orientation for a fixed site.
- Properly implement CDMA equipment accounting for the potential for system overload and the type of site receiver (dialup or fixed).
- Conduct thorough bandwidth and throughput testing and apply the results.
- Maintain and repair the system and equipment according to system provider/equipment vendor and/or Caltrans guidelines.
- Assess and compare the pros and cons of common alternatives.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to CDMA, 3G and next generation technologies and ITS that you feel should be addressed.

15

7.4. Please rate the level of detail in the following example training objectives for a class in LTE (Long Term Evolution), 4G and Next Generations.

- Discuss the technical characteristics and basic operation of LTE communication systems.
- Determine when and where LTE communications technology can be used effectively.
- Deduce the required and optimal data rate with a working understanding of the data rate provided by various LTE options.
- Select appropriate equipment necessary for specific applications.
- Successfully install and configure equipment considering such factors as modem type and data rate, and antenna requirements, gain and gain orientation for a fixed site.
- Properly implement LTE equipment accounting for the potential for system overload and the type of site receiver (dialup or fixed).
- Conduct thorough bandwidth and throughput testing and apply the results.
- Maintain and repair the system and equipment according to system provider/equipment vendor and/or Caltrans guidelines.
- Assess and compare the pros and cons of common alternatives.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to LTE, 4G and next generation technologies and ITS that you feel should be addressed.

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7.5. Please rate the level of detail in the following example training objectives for a class in Telco owned WiMax.

- Discuss the technical characteristics and basic operation of WiMAX communication systems.
- Determine when and where WiMAX communications technology can be used effectively.
- Determine the required data rate considering such factors as broadband data rates, IEEE 802.16e, IEEE 801.16m, and service providers.
- Select appropriate equipment necessary for specific applications.
- Successfully install and configure equipment considering such factors as modem type and data rate, and antenna requirements, gain and gain orientation for a fixed site.
- Properly use equipment, taking into account the range limitations of 2.5 GHz frequency and whether the system is dialup or continuous use.
- Conduct thorough bandwidth and throughput testing and apply the results.
- Maintain and repair the system and equipment according to system provider/equipment vendor and/or Caltrans guidelines.
- Assess and compare the pros and cons of common alternatives.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to Telco owned WiMAX and ITS that you feel should be addressed.

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Professional Capacity Building for Communications (2015)

8. Plant Wired Communications

The Plant Wired subject area includes topics related to user owned and installed wired communications. It provides knowledge and skills necessary to design, implement and maintain wired communications links.

Such technologies include:

- **Plant Wired Core / Plant Wiring Basics: Basic knowledge of wired communication**
- **Serial Connectivity: EIA/RS-232, EIA/RS-422, EIA/RS-485**
- **xDSL: Various types of Digital Subscriber Line**
- **Optical Fiber: High speed communication using glass fiber and light**

8.1. Please indicate your level of experience for these technologies, as applied to ITS Communications:

	Substantial Experience	Some Experience	No Experience	Not Familiar with Topic
Plant Wired Core / Plant Wiring Basics	○	○	○	○
Serial Connectivity	○	○	○	○
xDSL	○	○	○	○
Optical Fiber	○	○	○	○

Please list additional topics in Plant Wired Communications which you feel are important to experience and training as applied to ITS Communications.

8.2. How important is training in the following technologies, as applied to ITS Communications?

	Very Important	Important	Not Important	Not Familiar with Topic
Plant Wired Core / Plant Wiring Basics	○	○	○	○
Serial Connectivity	○	○	○	○
xDSL	○	○	○	○
Optical Fiber	○	○	○	○

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8.3. Would you like training in the following technologies, as applied to ITS Communications?

	Yes	No
Plant Wired Core / Plant Wiring Basics	○	○
Serial Connectivity	○	○
xDSL	○	○
Optical Fiber	○	○

8.4. How often do you work with the following technologies, as applied to ITS Communications?

	Daily	Weekly	Monthly	Yearly	Sometime in the future	Sometime in the past	Do not use this technology
Plant Wired Core / Plant Wiring Basics	○	○	○	○	○	○	○
Serial Connectivity	○	○	○	○	○	○	○
xDSL	○	○	○	○	○	○	○
Optical Fiber	○	○	○	○	○	○	○

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Professional Capacity Building for Communications (2015)

9. Sample Topics for Classes in Plant Wired Communciations

9.1. Please rate the level of detail in the following example training objectives for a class in Plant Wired Core / Plant Wiring Basics.

- Define and explain terminology and general concepts for plant wired communication systems.
- Explain the differences, advantages, disadvantages, and appropriate applications for a variety of wire and cable types, for example, twisted pair (standard telephone), CAT-5, and CAT-6.
- Read and interpret equipment specifications.
- Explain and apply a variety of wire and cable topologies.
- Correctly install various wire and cable types considering connectors, terminations, and shielded versus unshielded, among other factors. Wiring related issues are standards based to insure equivalence/compatibility with telco wiring. Cable and other wiring transmission issues (e.g., transmission distance related impairments, cable and wiring types, etc.) will be carefully addressed.
- Understand, design, and install with proper workmanship structured cabling including component parts, backbone wiring structures, horizontal wiring structures, and cross-connected wiring structures.
- Successfully test, troubleshoot, and certify wiring structures.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to plant wired fundamentals and ITS that you feel should be addressed.

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9.2. Please rate the level of detail in the following example training objectives for a class in Serial Connectivity.

- Technically explain the operating fundamentals for serial connections.
- Determine when and where serial connections can be used effectively.
- Establish equipment requirements for proper installation.
- Successfully install/employ serial connections considering data rate and protection requirements, and recommended standards (e.g., EIA/RS-232, EIA/RS-422, EIA/RS-485).
- Compare and contrast DTE and DCE devices and how both are utilized.
- Describe and apply proper methodology for interfacing with wireless modems.
- Select and correctly configure necessary equipment. Examples may include but are not limited to suitable modems, Ethernet to serial converters, and terminal equipment.
- Carefully follow user instructions for proper equipment installation and use.
- Select and operate appropriate test equipment for troubleshooting to successfully address problems.
- Maintain and repair equipment according to system provider, accepted standards, and/or Caltrans guidelines.
- Evaluate the pros and cons of common alternatives.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to serial connectivity and ITS that you feel should be addressed.

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9.3. Please rate the level of detail in the following example training objectives for a class in xDSL.

- Technically explain the features and operation of xDSL communication including, but not limited to, bandwidth, modulation, bi-directional data rates, interference potentials, and point-to-point distance limits.
- Determine when and where xDSL can be used and the appropriate type of xDSL for the application (e.g., DSL, ADSL, HDSL, VDSL).
- Establish equipment requirements for proper installation of xDSL communication systems.
- Successfully install and configure necessary equipment, taking into consideration twisted pair wiring needs, shielding or burying to reduce interference, and distance limitations.
- Determine effective data rates.
- Productively utilize xDSL equipment with a working understanding of asymmetric limitations, potential interference and transmission impairment sources (e.g., AM radio, amateur radio transmissions, unterminated stubs, crosstalk, noise sources (e.g., lightning)).
- Select and operate appropriate test equipment for troubleshooting to successfully address problems.
- Maintain and repair equipment according to system provider, accepted standards, and/or Caltrans guidelines.
- Evaluate the pros and cons of common alternatives.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives relative to xDSL technologies and ITS that you feel should be addressed.

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9.4. Please rate the level of detail in the following example training objectives for a class in Optical Fiber.

- Technically explain the fundamental principles and operation of optical fiber, including, but not limited to, fiber types, data rates and optical carrier requirements, and connectivity options.
- Ascertain when and where optical fiber technology can be used effectively.
- Define the most efficient and effective fiber path, taking into consideration such variables as the number of access points and whether the system is buried (preferred) or a pole system.
- Calculate a link budget.
- Describe and design different fiber topology options.
- Establish equipment requirements for proper installation and effective operation of optical fiber communication systems.
- Select the appropriate fiber type for the application (i.e., single versus multimode, number of strands).
- Successfully install and configure necessary equipment, for example, Ethernet fiber media converters that convert a digital signal to/from an optical signal.
- Explain and demonstrate the issues, challenges, and appropriate methods for fusion fiber splicing.
- Functionally describe the various methods of connectorization, identify appropriate connector types for specific applications, and explain the advantages and disadvantages for each.
- Discuss and demonstrate splice case methods and issues associated with underground and aerial applications (e.g., use of mechanical splices and connectors as a temporary "make-good").
- Productively utilize optical fiber equipment (e.g., identify and specify receiving media converter).
- Select and operate appropriate test equipment for troubleshooting, for example, determining the location of fiber cuts using an Optical Time Domain Reflectometer (OTDR).
- Maintain and repair the system and equipment according to accepted standards, system provider, and/or Caltrans guidelines. Develop and demonstrate a working knowledge and skill set for tasks such as fiber splicing.
- Assess and compare the pros and cons of common alternatives.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to optical fiber technology and ITS that you feel should be addressed.

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Professional Capacity Building for Communications (2015)

10. Telco Wired Communications

The Telco Wired subject area includes topics related to leased wired communications. It provides knowledge and skills necessary to design, implement and maintain wired communications systems that interface to Telco provided wired communications.

Such technologies are usually operated by telephone companies and include:

- **POTS: Plain Old Telephone Service**
- **ISDN: Integrated Services Digital Network**
- **MPLS: Multiprotocol Label Switching**
- **xDSL: Digital Subscriber Line**
- **DS1/T1: Digital channel at 1.544 Mb/s / A framed (into 24 64 kb/s digital voice channels) Digital Signal at level 1**
- **Fractional DS1/T1: Less than 24 64 kb/s digital voice channels**
- **Frame Relay: A high speed packet switched service that utilizes a fixed frame structure with transmission rates typically between 56 kb/s and 1.544Mb/s.**
- **Analog Data Circuits: Using analog Voice Frequency (VF) local access, this service supports the transmission of data via an analog modem within the frequency range of 300 - 3000 Hz.**

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10.1. Please indicate your level of experience for these technologies, as applied to ITS Communications:

	Substantial Experience	Some Experience	No Experience	Not Familiar with Topic
POTS	○	○	○	○
ISDN	○	○	○	○
MPLS	○	○	○	○
xDSL	○	○	○	○
DS1/T1	○	○	○	○
Fractional DS1/T1	○	○	○	○
Frame Relay	○	○	○	○
Analog Data Circuits	○	○	○	○

Please list additional topics in Telco Wired Communications which you feel are important to experience and training as applied to ITS Communications.

10.2. How important is training in the following technologies, as applied to ITS Communications?

	Very Important	Important	Not Important	Not Familiar with Topic
POTS	○	○	○	○
ISDN	○	○	○	○
MPLS	○	○	○	○
xDSL	○	○	○	○
DS1/T1	○	○	○	○
Fractional DS1/T1	○	○	○	○
Frame Relay	○	○	○	○
Analog Data Circuits	○	○	○	○

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10.3. Would you like training in the following technologies, as applied to ITS Communications?

	Yes	No
POTS	○	○
ISDN	○	○
MPLS	○	○
xDSL	○	○
DS1/T1	○	○
Fractional DS1/T1	○	○
Frame Relay	○	○
Analog Data Circuits	○	○

10.4. How often do you work with the following technologies, as applied to ITS Communications?

	Daily	Weekly	Monthly	Yearly	Sometime in the future	Sometime in the past	Do not use this technology
POTS	○	○	○	○	○	○	○
ISDN	○	○	○	○	○	○	○
MPLS	○	○	○	○	○	○	○
xDSL	○	○	○	○	○	○	○
DS1/T1	○	○	○	○	○	○	○
Fractional DS1/T1	○	○	○	○	○	○	○
Frame Relay	○	○	○	○	○	○	○
Analog Data Circuits	○	○	○	○	○	○	○

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Professional Capacity Building for Communications (2015)

11. Sample Topics for Classes in Telco Wired Communciations

11.1. Please rate the level of detail in the following example training objectives for a class in POTS.

- Define and discuss the terminology, technical characteristics and basic operation of POTS communication systems.
- Determine when and where POTS communications technology can be used effectively.
- Assess performance challenges such as analog transmission impairments, line length or interference potentials from multiple users on telco cable, etc.
- Establish requirements and select equipment appropriate for specific applications, including ITS equipment, modem, and line interface, etc.
- Define modem requirements, for instance, data rates and environmental conditions, to establish modulation schemes, site equipment data rate requirements, etc.
- Carefully follow user instructions for proper equipment installation and use.
- Successfully install and configure equipment, taking into account how the system will be used (e.g., point-to-point, point-to-multipoint, etc.).
- Select and operate appropriate test equipment for troubleshooting to successfully address problems.
- Maintain and repair the system and equipment according to system provider/equipment vendor and/or Caltrans guidelines.
- Assess and compare the pros and cons of common alternatives.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to POTS technology and ITS that you feel should be addressed.

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11.2. Please rate the level of detail in the following example training objectives for a class in ISDN.

- Define and discuss the terminology, technical characteristics and basic operation of ISDN communication systems.
- Determine when and where ISDN communications technology can be used effectively, paying close attention to local availability.
- Define and select ISDN system options, for example Basic Rate Interface (BRI), Primary Rate Interface (PRI), or other options.
- Fully understand the communications protocol between the end device and the central office switch.
- Establish equipment requirements for specific applications (e.g., user terminal does not require modem).
- Correctly implement and utilize equipment including that which is telco provided.
- Carefully follow user instructions for proper system installation, configuration, and use.
- Select and operate appropriate test equipment for troubleshooting to successfully address problems.
- Maintain and repair the system and equipment according to system provider/equipment vendor and/or Caltrans guidelines (i.e., ISDN equipment, telco provided service).
- Assess and compare the pros and cons of common alternatives.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to ISDN technology and ITS that you feel should be addressed.

11.3. Please rate the level of detail in the following example training objectives for a class in MPLS.

- Define and discuss the terminology, technical characteristics and basic operation of MPLS communication systems.
- Determine when and where MPLS communications technology can be used effectively.
- Define data rate requirements.
- Establish equipment requirements.
- Correctly implement and utilize equipment, including that which is telco provided.
- Carefully follow user instructions for proper system installation, configuration, and use.
- Effectively operate equipment.
- Select and operate appropriate test equipment for troubleshooting to successfully address problems.
- Maintain and repair the system and equipment according to Telco service provider, equipment vendor and/or Caltrans guidelines.
- Evaluate the pros and cons of common alternatives.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to MPLS technology and ITS that you feel should be addressed.

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11.4. Please rate the level of detail in the following example training objectives for a class in xDSL.

- Define and discuss the terminology, technical characteristics and basic operation of xDSL communication systems.
- Determine when and where xDSL communications technology can be used effectively, taking into account distance (i.e., 18,000 ft or less to central office (CO) or optical fiber fed neighborhood cross-connect for DSL and ADSL, 12,000 ft for HDSL and 3,000 ft up to 26 Mb/s or 1,200 ft up to 51 Mb/s for VDSL), and required data rate.
- Evaluate potential interference sources and transmission impairment sources (e.g., AM radio, amateur radio transmissions, unterminated stubs, crosstalk, noise sources (e.g., lightning, distance, other digital channels).
- Define effective data rates by measuring transmission times, among other activities.
- Define acceptable upload and download speeds for specific applications and compare pricing options for different speed levels.
- Compare and discuss static versus dynamic addressing as used in ITS communications.
- Establish equipment requirements considering factors such as location and weather restrictions, modem options, and the need for wireless connections.
- Select appropriate equipment for specific applications. For instance, choose the best modem for the job based on modem documentation and current deployments.
- Correctly implement and utilize equipment, paying close attention to procedures for connecting to the standard POTS line.
- Carefully follow user instructions for proper system installation, configuration, and use.
- Select and operate appropriate test equipment for troubleshooting to successfully address problems.
- Maintain and repair the system and equipment according to system provider/equipment vendor and/or Caltrans guidelines.
- Evaluate the pros and cons of common alternatives.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives relative to xDSL technologies and ITS that you feel should be addressed.

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11.5. Please rate the level of detail in the following example training objectives for a class in DS1/T1.

- Define and discuss the terminology, technical characteristics and basic operation of DS1/T1 communication systems.
- Determine when and where DS1/T1 communications technology can be used effectively.
- Define data rate requirements and evaluate the need for framing, considering the data capabilities of DS1/T1 lines and framing into voice channels.
- Ascertain the availability of DS1/T1 at a site utilizing telco site information.
- Establish equipment requirements (e.g., CSU/DSU, native channel termination or channel bank (T1)).
- Correctly implement and utilize equipment, including that which is telco provided.
- Carefully follow user instructions for proper system installation, configuration, and use.
- Effectively operate equipment to achieve high speed, continuously available, and highly reliable system communications.
- Select and operate appropriate test equipment for troubleshooting to successfully address problems.
- Maintain and repair the system and equipment according to Telco service provider, equipment vendor and/or Caltrans guidelines.
- Assess and compare the pros and cons of common alternatives.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to DS1/T1 technologies and ITS that you feel should be addressed.

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11.6. Please rate the level of detail in the following example training objectives for a class in Fractional DS1/T1.

- Define and discuss the terminology, technical characteristics and basic operation of Fractional T1 communication systems.
- Determine when and where Fractional DS1/T1 communications technology can be used effectively.
- Define data rate requirements and evaluate the need for framing, considering the data capabilities of DS1/T1 (Fractional DS1/T1) lines and framing into voice channels.
- Ascertain the availability of Fractional DS1/T1 at a site utilizing telco site information.
- Establish equipment requirements (e.g., CSU/DSU (128, 256 or 384 kb/s fractional DS1) or channel bank (T1)).
- Correctly implement and utilize equipment, including that which is telco provided.
- Carefully follow user instructions for proper system installation, configuration, and use.
- Effectively operate equipment to achieve high speed, continuously available, and highly reliable system communications.
- Select and operate appropriate test equipment for troubleshooting to successfully address problems.
- Maintain and repair the system and equipment according to Telco service provider, equipment vendor and/or Caltrans guidelines.
- Assess and compare the pros and cons of common alternatives.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to fractional DS1/T1 technologies and ITS that you feel should be addressed.

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11.7. Please rate the level of detail in the following example training objectives for a class in Frame Relay.

- Define and discuss the terminology, technical characteristics and basic operation of frame relay communication systems.
- Determine when and where frame relay communications technology can be used effectively.
- Define data rate requirements.
- Establish equipment requirements.
- Correctly implement and utilize equipment, including that which is telco provided.
- Carefully follow user instructions for proper system installation, configuration, and use.
- Effectively operate equipment.
- Select and operate appropriate test equipment for troubleshooting to successfully address problems.
- Maintain and repair the system and equipment according to Telco service provider, equipment vendor and/or Caltrans guidelines.
- Evaluate the pros and cons of common alternatives.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to frame relay technology and ITS that you feel should be addressed.

11.8. Please rate the level of detail in the following example training objectives for a class in Analog Data Circuits.

- Define and discuss the terminology, technical characteristics and basic operation of communication systems using analog data circuits.
- Determine when and where analog data circuit communications technology can be used effectively.
- Understand various voice band transmission impairments and their effect on data communications.
- Define data rate requirements.
- Establish equipment requirements.
- Correctly implement and utilize equipment, including that which is telco provided.
- Carefully follow user instructions for proper system installation, configuration, and use.
- Effectively operate equipment.
- Select and operate appropriate test equipment for troubleshooting to successfully address problems.
- Maintain and repair the system and equipment according to Telco service provider, equipment vendor and/or Caltrans guidelines.
- Evaluate the pros and cons of common alternatives.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to analog data circuits and ITS that you feel should be addressed.

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Professional Capacity Building for Communications (2015)

12. IP Fundamentals

The IP Fundamentals subject area includes topics that provide knowledge and skills concerning Internet Protocol (IP), IP networks and related technologies.

Such technologies include:

- **IP Networking Core: Basic knowledge of IP networking**
- **Local Area Networks (LAN): Local IP networks**
- **Wide Area Networks (WAN): Large scale IP networks**
- **Network Security: Principles of security for IP communication**
- **Vendor Specific Equipment Training: Topics specific to Cisco, Juniper, other equipment**

12.1. Please indicate your level of experience for these technologies, as applied to ITS Communications:

	Substantial Experience	Some Experience	No Experience	Not Familiar with Topic
IP Networking Core	○	○	○	○
Local Area Networks (LAN)	○	○	○	○
Wide Area Networks (WAN)	○	○	○	○
Network Security	○	○	○	○
Vendor Specific Equipment	○	○	○	○

Please list additional topics in IP networking fundamentals and usage which you feel are important to experience and training as applied to ITS Communications.

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12.2. How important is training in the following technologies, as applied to ITS Communications?

	Very Important	Important	Not Important	Not Familiar with Topic
Understanding IP Core	○	○	○	○
Local Area Networks (LAN)	○	○	○	○
Wide Area Networks (WAN)	○	○	○	○
Network Security	○	○	○	○
Vendor Specific Equipment	○	○	○	○

12.3. Would you like training in the following technologies, as applied to ITS Communications?

	Yes	No
Understanding IP Core	○	○
Local Area Networks (LAN)	○	○
Wide Area Networks (WAN)	○	○
Network Security	○	○
Vendor Specific Equipment	○	○

12.4. How often do you work with the following technologies, as applied to ITS Communications?

	Daily	Weekly	Monthly	Yearly	Sometime in the future	Sometime in the past	Do not use this technology
Understanding IP Core	○	○	○	○	○	○	○
Local Area Networks (LAN)	○	○	○	○	○	○	○
Wide Area Networks (WAN)	○	○	○	○	○	○	○
Network Security	○	○	○	○	○	○	○
Vendor Specific Equipment	○	○	○	○	○	○	○

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Professional Capacity Building for Communications (2015)

13. Sample Topics for Classes in IP Fundamentals and Use

13.1. Please rate the level of detail in the following example training objectives for a class in understanding IP networks/IP networking core.

- Discuss the technical characteristics and basic operation of communication systems using IP networking technologies.
- Explain the OSI Reference Model and its uses.
- Describe and differentiate simple networks and varying network topologies.
- Understand and apply the fundamentals of basic routing concepts, the TCP/IP Model, and the role of various devices in TCP/IP.
- Compare and contrast networking protocols (e.g., ARP, IP, ICMP, TCP, UDP).
- Correctly implement subnetting in a network. Topics to discuss include, but are not limited to, addressing and IPv4 versus IPv6.
- Discuss IP routing and protocols (e.g., RSTP, RIP, OSPF).
- Understand and explain applications for HTTP, HTTPS, FTP, SSH, and Telnet, etc.
- Properly implement DHCP and DNS.
- Explain the difference between sockets and ports and the function of each.
- Select and successfully employ appropriate tools to troubleshoot problems in a network.
- Discuss and apply basic security concepts.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to IP networking fundamentals and ITS that you feel should be addressed.

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13.2. Please rate the level of detail in the following example training objectives for a class in Local Area Networks (LAN).

- Articulate different applications for LANs in rural ITS communications.
- Understand and discuss the concepts of Ethernet and Power over Ethernet (PoE).
- Understand and discuss the concepts of a Virtual Local Area Network (VLAN).
- Discuss the functions and requirements of routers, switches, hubs, and bridges, as applied to LANs and ITS.
- Build a LAN for specific ITS applications.
- Effectively and efficiently utilize IP equipment for rural ITS applications.
- Investigate and employ available hardware and software tools to develop, analyze, and troubleshoot networks.
- Manage equipment with SNMP.
- Construct usable Ethernet cabling.
- Discuss and apply basic security concepts.
- Interpret network documentation.
- Prepare clear network documentation.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to LANs and ITS that you feel should be addressed.

13.3. Please rate the level of detail in the following example training objectives for a class in Wide Area Networks (WAN).

- Recognize and describe WAN applications for rural ITS communications.
- Research and select appropriate WAN hardware.
- Discuss common WAN services offered by telecommunication service providers.
- Compare and contrast WAN protocols such as SLIP, PPP, PPPoE, and Frame Relay.
- Explain the concept and application for Dial on Demand networking and Multiprotocol Label Switching (MPLS).
- Understand router functions.
- Correctly set up and configure routers for specific applications.
- Discuss and apply basic security concepts.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to WANs and ITS that you feel should be addressed.

13.4. Please rate the level of detail in the following example training objectives for a class in Network Security.

- Discuss and apply basic principles of encryption.
- Differentiate varying types of Virtual Private Networks (VPN).
- Explain and utilize Internet Protocol Security (IPSec) and Secure Sockets Layer (SSL).
- Comprehend, discuss, and use fundamentals of wireless security (e.g., WPA, WPA2, WEP, TKIP, MAC addresses, etc.).
- Understand and employ firewalls.
- Understand and utilize proxy servers.
- Discuss address translation, port forwarding, and active directories.
- Successfully set up a VPN.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to network security and ITS that you feel should be addressed.

13.5. Please rate the level of detail in the following example training objectives for a class in vendor specific equipment such as Cisco, Juniper, or other. Cisco is presented here as an example vendor.

- Understand and operate Cisco IOS for rural ITS applications.
- Comprehend Cisco switch and router security.
- Successfully perform Cisco switch startup and configuration.
- Satisfactorily manage Cisco switches.
- Successfully perform Cisco router startup and configuration.
- Satisfactorily manage Cisco routers.
- Set up the DHCP on a Cisco router.
- Establish a point-to-point WAN connection with the Point-to-Point Protocol (PPP) using Cisco equipment.
- Establish a point-to-point WAN connection with Frame Relay using Cisco equipment.

◯ **Not enough detail** ◯ **Just enough detail** ◯ **Too much detail** ◯ **Not familiar with this topic**

Please list any important additional training objectives related to vendor specific equipment and ITS that you feel should be addressed.

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Professional Capacity Building for Communications (2015)

14. Comments on this Survey

14.1. Please list any additional comments you have about this survey and its objectives.

Thank you for your time giving feedback on communications training for Caltrans personnel as applied to Intelligent Transportation Systems.

Please press the Submit button below to submit your responses.

We appreciate your input.

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