Professional Capacity Building for Communications

Phase 5

Needs Assessment and Gap Analysis

by

Leann A.F. Koon
Research Associate

Western Transportation Institute
College of Engineering
Montana State University

A report prepared for the

California Department of Transportation
Division of Research, Innovation, and System Information
Sacramento, California

July 30, 2021

DISCLAIMER

The contents of this report reflect the view of the author, who is responsible for the facts and the accuracy of the data herein. The contents do not necessarily reflect the official views or policies of the State of California, the California Department of Transportation, or Montana State University. This report does not constitute a standard, specification, or regulation.

Alternative accessible formats of this document will be provided upon request. Persons with disabilities who need an alternative accessible format of this information, or who require some other reasonable accommodation to participate, should contact Neil Hetherington, Visual Communications Manager, Western Transportation Institute, Montana State University, PO Box 174250, Bozeman, MT 59717-4250, telephone number 406-994-3566, e-mail: hetherington@montana.edu.

ACKNOWLEDGEMENTS

Thank you to the Caltrans senior functional managers from around the state who described and prioritized their district's or office's need for training relative to ITS data communications. The author also recognizes and thanks the members of the Project Technical Advisory Panel (PTAP) for their work developing, planning, and facilitating the needs assessment working meeting: Sean Campbell, Project Manager, Chief, ITS Special Projects Branch, California Department of Transportation, Division of Research, Innovation, and System Information; Jeremiah Pearce, Chief, Office of ITS Engineering and Support, Caltrans District 2; Steve Hancock, Caltrans Office of Systems Development, CAV Implementation; and Jose Perez, (retired) Project Manager, Caltrans Division of Research, Innovation, and System Information.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Caltrans	California Department of Transportation
CCTV	Closed Circuit Television
CDMA	Code Division Multiple Access
CMS	Changeable Message Sign
DHCP	Dynamic Host Configuration Protocol
DS1	Digital Signal at Level 1 (1.544 Mb/s)
DSL	Digital Subscriber Line
EMS	Extinguishable Message Signs
FCC	Federal Communications Commission
FHWA	Federal Highway Administration
G	Generation (e.g., 3G is 3rd Generation)
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
HAR	Highway Advisory Radio
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ITS	Intelligent Transportation Systems
LAN	Local Area Network
LTE	Long Term Evolution
MPLS	Multiprotocol Label Switching
MSU	Montana State University
PCB	Professional Capacity Building
PCS	Personal Communications System
POTS	Plain Old Telephone Service (wireline telco services)
PTAP	Project Technical Advisory Panel
RF	Radio Frequency
RFB	Request for Bids
RWIS	Road Weather Information Systems
SME	Subject Matter Expert
TCP	Transmission Control Protocol
TMC	Transportation Management Center
TMS	Traffic Management System
VDSL	Very high bit rate Digital Subscriber Line
VPN	Virtual Private Network
WAN	Wide Area Network
WCET	Wireless Communication Engineering Technologies
WTI	Western Transportation Institute
xDSL	Digital Subscriber Line (of any type such as ADSL, HDSL, or VDSL)

1. INTRODUCTION

Rural Intelligent Transportation Systems (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. 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), 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. 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. 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.

The Professional Capacity Building for ITS Communications project is currently in its fifth phase. Needs assessments and gap analyses were conducted in Phase 1 (2009) and Phase 3 (2015) of the project. Because five years have passed since the last needs assessment, the PTAP and the research team agreed that another needs assessment was warranted and important for directing this phase and future phases of the project.

This report describes the design and results of the needs assessment working meeting held with Caltrans senior functional managers. Next steps are suggested as well.

Note: the research team and the PTAP worked together closely to conduct this needs assessment meeting. The group is subsequently referred to as the project team.

2. NEEDS ASSESSMENT

2.1. Assessment Design

The project team reviewed past needs assessments conducted for this project and it was agreed that a different approach/survey would be more appropriate for this project phase. (Note: the other needs assessments have been comprehensive online surveys.) The primary objective for this assessment is to identify and describe training that is most applicable to the ITS engineers and technicians in the field and directly working with ITS technologies. To accomplish this objective, the group opted for a two-stage assessment – stage one would involve District supervisors and TMS functional managers from all the Caltrans districts as well as several offices at Caltrans Headquarters. Depending on the results of the first assessment, ITS engineers and technicians within the districts would potentially be surveyed with more specific questions.

This assessment also differed from past assessments in that it included all Caltrans Districts and relevant Offices versus focusing on primarily rural Districts where this project is based. The training courses developed through this project include content applicable to both rural and urban ITS applications and have since been procured and delivered around the state. Professional capacity building for ITS data communications is a relevant concern across the board.

To maximize data collection while being as efficient as possible, the stage one needs assessment was an interactive working meeting facilitated live by the project team via WebEx. The goal of the meeting was to collect data to help the project team make an academic decision as to what training best fits the PCB program based on current and future needs. The meeting was also designed to help review and enhance the comprehensive training curriculum for transportation communication systems that has been developed through this project.

The team iteratively developed an outline for the meeting, needs assessment questions, background information, a meeting preparation survey, and supporting documentation (e.g., meeting agenda, script). The target audience was identified by the project team and the project manager facilitated meeting invitations and related correspondence.

Because familiarity with the project varied for the intended audience, several pieces of background information were shared with the invitees prior to the working meeting:

- PCB for Communications Curriculum Scope and Sequence
- Project Background and Summary Fact Sheet
- Compendium of syllabi for training courses offered through the PCB project
- Traffic Operations Strategic Plan Highlights (November 2017)
- ITS Maintenance & Support Improvement Project Highlights (October 2017)

Participants were asked to prepare in advance by reading through these documents and becoming familiar with their content. They were referenced throughout the meeting.

To get the conversation started and help facilitate an efficient discussion, meeting participants were given the primary questions to be discussed and asked to answer the questions in a brief survey in advance of the meeting. This pre-meeting survey was an online survey designed and facilitated using SurveyMonkey. This survey was also an opportunity for those unable to attend the meeting to provide some valuable input to the assessment. Participants were asked to list and describe what

training (relative to ITS data communications and related technologies) they felt their staff needed for their District to realize the full benefits of ITS technologies. They were then asked what specific skills or skill sets that training should focus on. The last question asked for the top three priorities for training out of the topics/skills listed in questions one and two.

The project team used several tools to facilitate and collect information during the working meeting. The meeting itself was conducted via WebEx, voice only. The project team used a PowerPoint presentation to introduce the meeting, review the meeting objective and agenda, discuss the project need, and introduce the PCB for Communications curriculum. It was also used to conclude the meeting with Next Steps, link to a Top 10 survey, thank you and project contacts.

For most of the meeting, the project team used Mentimeter (www.mentimeter.com) to engage the group, collect needs assessment data, and display results in real-time. Mentimeter is interactive presentation software – participants can answer questions using a device with a web browser. Results are displayed in real-time which encourages participation and discussion. Participants were first asked to "introduce" themselves by entering their name and Caltrans affiliation. This allowed the project team to acknowledge everyone, welcome and thank them for joining.

After introductions and a review of the meeting agenda and logistics, the project team discussed the PCB for Communications project and the main subjects and topics in the Curriculum. Participants were given a few minutes to read the Curriculum Overview section of the document. The project team moved the discussion to Mentimeter and asked participants to rank one (highest priority) to six (lowest priority) the need for training in each of the subject areas, first based on current project load and then based on future project load. Results were noted verbally by the project team and accompanied by any questions or discussion from the group.

Next, the meeting delved down into more detail taking a closer look at the individual topics and learning objectives in each of the subject areas. Participants first had a few minutes to read the topic section in the Curriculum. They were then asked to rate the importance of training for each topic; participants could rate training as very important, important, or not important on a 5-point scale. They could also indicate a 0 if they were unfamiliar with a topic. Participants ranked the topics within each subject according to their District, Office, or Division's training priorities. The moment to read and the two questions were repeated for each of the six subject areas in the Curriculum. Finally, participants were then asked what they thought of the current Curriculum, first indicating anything that could be removed and then anything that could be added. Comments were encouraged and responses were acknowledged and discussed as they showed up on Mentimeter.

To bring it full circle with no boundaries (i.e., the established Curriculum), participants produced a word cloud with their three most important training needs relative to ITS data communications.

The meeting then shifted to the coursework that has already been delivered through the PCB for Communications project. The group was asked to rate their perception of the usefulness of each of the delivered courses. On a 5-point scale, response options were very useful, somewhat useful, and not at all useful. Participants then rated the importance of the courses based on both their current and anticipated project workload. Choices were on the same 5-point scale with 5 indicating very important, 3 as important, and a 1 designating a course as not important. A 0 indicated the respondent was not familiar with the course. The project team then asked for feedback and discussion on the training courses and participants included their comments in Mentimeter.

To keep the meeting moving smoothly, results were briefly acknowledged after each question and discussion reserved for designated times during the meeting.

Finally, to close the meeting and the needs assessment, the group was asked to rank their top 10 highest priorities for training out of the 30 topics in the Curriculum. This ranking was collected online using SurveyMonkey. To allow participants time to respond, this last survey was left open for a few days after the working meeting.

2.2. Data Collection and Analysis

Data were collected through the pre-meeting survey, the working meeting and Mentimeter presentation, and the Top 10 survey. Five individuals started the pre-meeting survey by entering contact information and four answered the survey questions. Nineteen Caltrans district and Headquarters personnel participated in the working meeting. They represented Caltrans Districts 1, 2, 4, 6, 7, 8, 10, 11, 12; Headquarters Maintenance; Maintenance TMS Asset Management; and DRISI. No response has been received from Districts 3, 5, or 9.

Data were collected and analyzed by Mentimeter, SurveyMonkey, and Microsoft Excel. Since this needs assessment was conducted live and respondents didn't have the opportunity to go back to fill in or change answers, the number of respondents on each question is just listed as a total versus a percentage of meeting participants.

The needs assessment data is organized according to the questions which are categorized by subjects, topics, PCB for Communications training, and general training priorities/needs. Ranking questions are presented with the total number of respondents, the number of respondents ranking each item by priority, and the overall ranking in simple tables. The data is also shown on a simple column (bar) chart.

This needs assessment was designed to identify the training priorities for ITS data communications based on current and future project work being conducted. The goal was also to collect feedback on the training already delivered to help inform decisions about future training to develop and deliver. The results help quantify training needs and priorities; topics that are higher priorities for training were identified based on the rankings and the representative charts.

2.3. Participants

The first stage of the needs assessment was directed at senior functional managers in each Caltrans district and some of the relevant offices at Caltrans Headquarters. Thirty-two (32) individuals from Caltrans Districts 1 through 12 (TMS Field, TMS Central, Maintenance), Headquarters Operations, and Headquarters Maintenance were invited to the working meeting. Participants (19) represented Caltrans Districts 1, 2, 4, 6, 7, 8, 10, 11, and 12; Headquarters Maintenance; Maintenance TMS Asset Management; and DRISI.

2.4. Major Subject Areas

The PCB for Communications Curriculum Scope and Sequence is divided into six major subject areas which are further divided into a variety of more specific topics. Each of those topics has several associated learning objectives. The subject areas are: Plant Wireless, Telco Wireless, Plant Wired, Telco Wired, IP Fundamentals, and Small Data Center Design for Transportation Management Centers (TMCs). The group was asked to rank their need for training in the subject areas first based on current project load and then based on future project work.

IP Fundamentals ranked first in need for training based on current and future project load. Plant Wired, Plant Wireless, and Telco Wireless were ranked close together in 2nd, 3rd, or 4th place for current and future project work training needs. Small Data Center Design was ranked 5th in need for training currently and in the future. Telco Wired ranked last for both current and future training needs. For future project work, all subjects except Telco Wired had at least one first place ranking for training need and the final ranking was relatively close together.

This group indicated a strong need for IP Fundamentals training. Training in this subject is of top priority based on current project work and anticipated future ITS projects in the various Districts and within Caltrans Headquarters. Training in Plant Wireless, Plant Wired, and Telco Wireless technologies are also important but of somewhat lower priority. According to this group, the need for training in Telco Wired technologies is currently less important than for the other subjects. This group also indicated that there will be a lesser need for Telco Wired training in the future as well.

The following tables (Table 1, Table 2, Table 3, Table 4) and charts (Figure 1, Figure 2) show the detailed results collected through Mentimeter.

Table 1: The need for training in each subject ranked based on current project work.

Question: Rank the need for training in the following subjects based on your CURRENT project load.						
Total Respondents	16					
	Number of Respondents					
Subjects	**1st place**	**2nd place**	**3rd place**	**4th place**	**5th place**	**6th place**
Plant Wireless	2	4	3	3	1	1
Telco Wireless	2	1	6	4	1	0
Plant Wired	3	4	3	1	1	3
Telco Wired	0	1	1	2	5	5
IP Fundamentals	9	4	1	1	1	0
Small Data Center Design for TMCs	0	2	1	2	4	4

Table 2: Subjects ranked by training need based on current project work.

Subjects	**Ranking**
IP Fundamentals	1
Plant Wired	2
Plant Wireless	3
Telco Wireless	4
Small Data Center Design for TMCs	5
Telco Wired	6

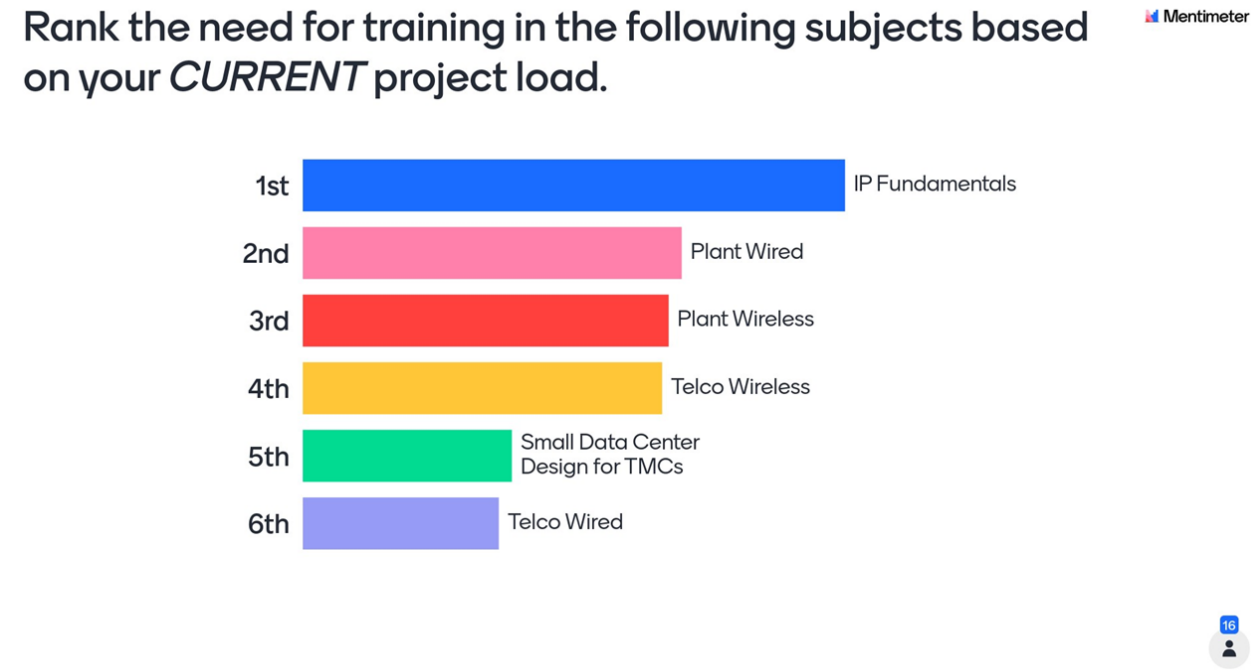

Figure 1: The need for training in the subjects ranked based on current project work.

Table 3: The need for training in each subject ranked based on anticipated future project work.

Question: Rank the need for training in the following subjects based on your anticipated FUTURE project load.						
Total Respondents	16					
	Number of Respondents					
Subjects	**1st place**	**2nd place**	**3rd place**	**4th place**	**5th place**	**6th place**
Plant Wireless	1	4	7	3	0	1
Telco Wireless	3	5	2	1	3	1
Plant Wired	3	2	4	4	1	2
Telco Wired	0	1	0	2	7	5
IP Fundamentals	7	1	2	1	4	1
Small Data Center Design for TMCs	2	3	1	5	0	5

Table 4: Subjects ranked by training need based on future project work.

Subjects	Ranking
IP Fundamentals	1
Plant Wireless	2
Telco Wireless	3
Plant Wired	4
Small Data Center Design for TMCs	5
Telco Wired	6

Figure 2: The need for training in the subjects ranked based on anticipated future project work.

2.5. Curriculum Topics

Each major subject area is broken down into specific topics and learning objectives. The group was asked two questions about the topics in each subject area. The first question asked participants to rate the *importance* of training in each topic. The choices were on a five-point scale with a 5 designating 'very important' and a 1 indicating 'not important'. A 0 indicated the respondent was

unfamiliar with the particular topic. The second question asked the group to rank the training *priority* for the topics in each subject – highest priority down to lowest priority.

To remove the bounds of the subject groupings, participants were asked to rank their top 10 training priorities out of the 30 topics in the Curriculum.

For reference, the following list includes the major subject areas and their associated topics.

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, GPRS, 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)

F. Small Data Center Design for Transportation Management Centers
   a. TMC Overview
   b. Data Center Design Short Course for TMC Managers
   c. Data Center Design for TMC / ITS Engineers
   d. Site and Facility Tours

2.5.1. Plant Wireless

The Plant Wireless subject area includes the following topics:

- Plant Wireless Core and RF Systems Design
- 802.11 (WiFi) and Related
- Microwave
- Short Haul Radio

Plant Wireless Core / RF System Design and 802.11 (WiFi) and Related were both rated just over 4 on a five-point scale (4.3 and 4.1 respectively) for importance of training. Microwave and Short Haul Radio were rated just under 3 (important) (2.9 and 2.7 respectively) for importance of training in those topics. However, 1 of the 15 respondents was unfamiliar with the Microwave topic and three indicated they were unfamiliar with Short Haul Radio. Out of 16 respondents, 13 ranked Plant Wireless Core / RF System Design as the highest priority for training. 802.11 (WiFi) and Related was ranked solidly in second place. Short Haul Radio and Microwave were ranked closely in 3rd and 4th place, respectively.

Training in Plant Wireless core technologies, particularly RF system design, is quite important to this group. Training for 802.11 (WiFi) and related technologies is also quite important. While still somewhat important, training in Microwave and Short Haul Radio technology was rated lower.

The following tables and charts show the training importance rating and relative priority for training among the Plant Wireless technologies as collected in Mentimeter. See Table 5, Table 6, Table 7, Figure 3, Table 8, Table 9, and Figure 4.

Table 5: Importance of training in each Plant Wireless topic.

Question: Plant Wireless - how IMPORTANT is training in the following topics?							
Total Respondents	15						
		Number of Respondents					
Topics	**Weighted average**	**0** Not Familiar with Topic	**1** Not Important	**2**	**3** Important	**4**	**5** Very Important
Plant Wireless Core and RF System Design	4.3	0	1	0	2	2	10
802.11 (WiFi) and Related	4.1	0	0	2	1	6	6
Microwave	2.9	1	2	3	3	3	3
Short Haul Radio	2.7	3	2	2	2	1	5

Table 6: Importance of training for Plant Wireless topics from more important to less important.

Topics	**More Important to Less Important**
Plant Wireless Core and RF System Design	4.3
802.11 (WiFi) and Related	4.1
Microwave	2.9
Short Haul Radio	2.7

Table 7: Number of respondents not familiar with Plant Wireless topics.

Topics	Number of Respondents Not Familiar with Topic
Plant Wireless Core and RF System Design	0
802.11 (WiFi) and Related	0
Microwave	1
Short Haul Radio	3

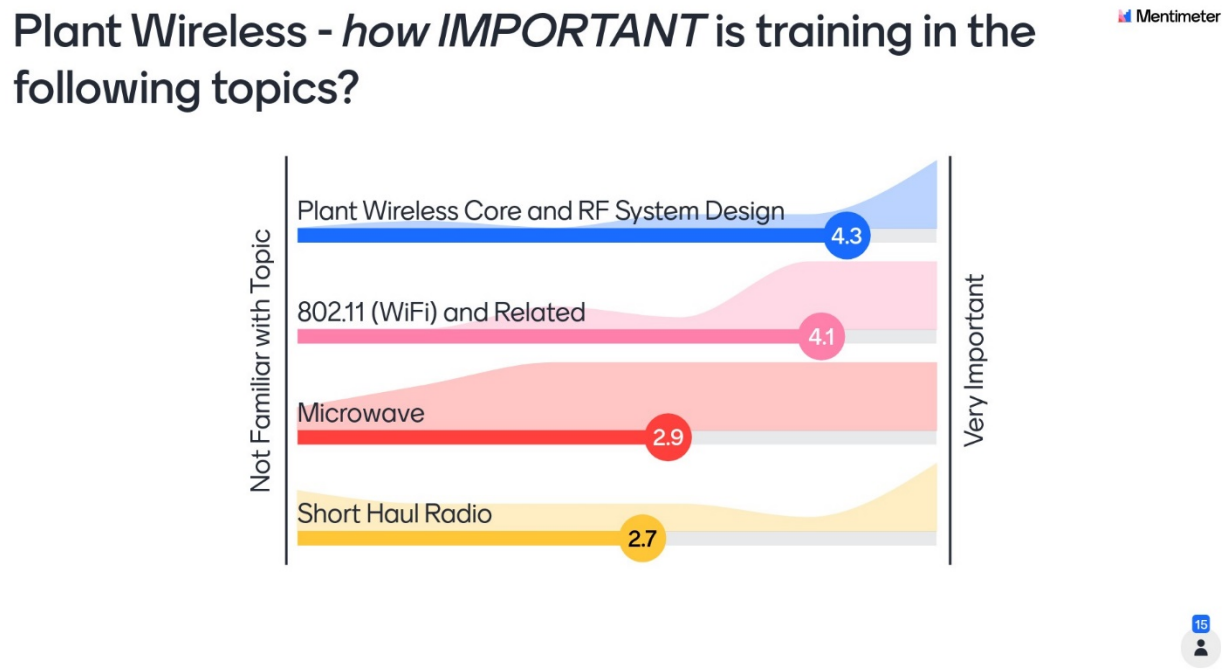

Figure 3: Importance of training in each Plant Wireless topic.

Table 8: Training priority for Plant Wireless topics.

Question: Plant Wireless - which topic is your highest PRIORITY for training?				
Total Respondents	16			
	Number of Respondents			
Topics	**1st place**	**2nd place**	**3rd place**	**4th place**
Plant Wireless Core and RF System Design	13	2	1	0
802.11 (WiFi) and Related	2	7	4	2
Microwave	0	4	3	6
Short Haul Radio	1	2	5	5

Table 9: Plant Wireless topics ranked by training priority.

Topics	**Ranking**
Plant Wireless Core and RF System Design	1
802.11 (WiFi) and Related	2
Short Haul Radio	3
Microwave	4

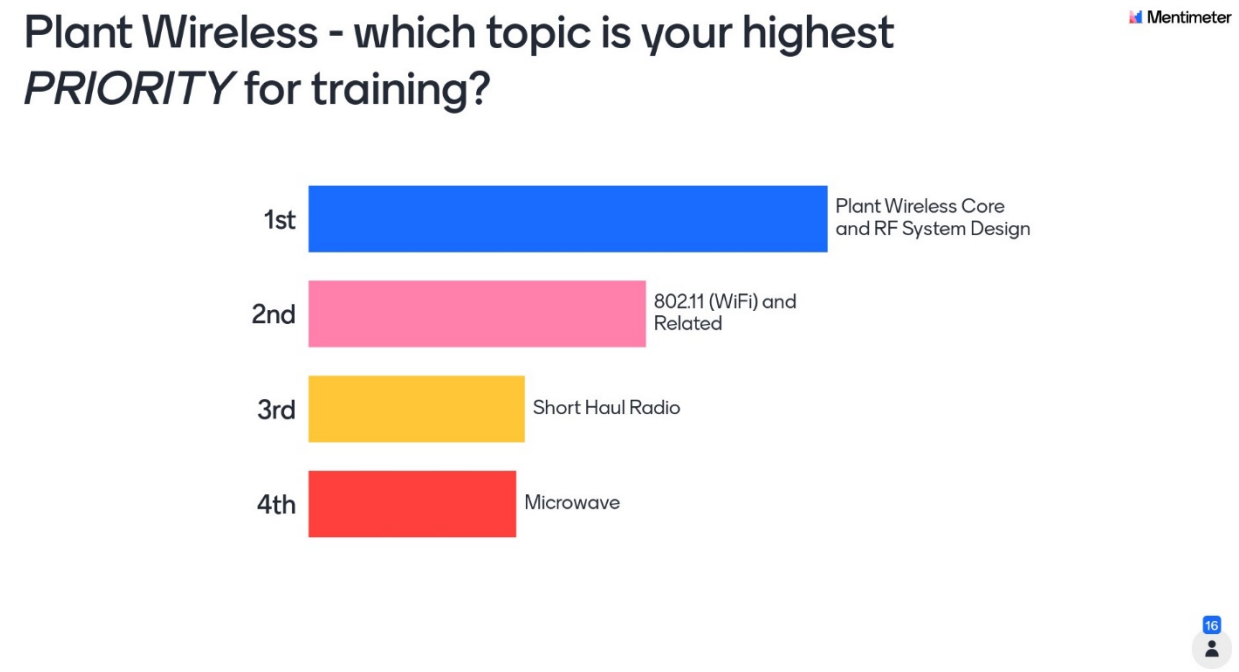

Figure 4: Priority ranking of topics for Plant Wireless training.

2.5.2. Telco Wireless

The Telco Wireless subject area includes the following topics:

- Telco Wireless Core and Cellular/PCS Basics
- GSM Data, GPRS, 3G and Next Generations
- CDMA Data, 3G and Next Generations
- LTE (Long Term Evolution), 4G and Next Generations

Training in the topic of LTE, 4G and Next Generation technologies was rated quite important with 11 out of 16 respondents rating it "very important" (average 4.6). Training in Telco Wireless Core and Cellular / PCS Basics was also rated as being important with a 4.3 average rating. Conversely, respondents indicated that training in GSM Data, GPRS, 3G and Next Generations and CDMA Data, 3G and Next Generations technologies was only somewhat important with average ratings of 2.6 and 2.1 respectively. A couple individuals indicated they were unfamiliar with the CDMA Data, 3G and Next Generations topic. Respondents ranked training in core Telco Wireless technologies and basic cellular/PCS technology as highest priority among Telco Wireless topics in the curriculum. LTE, 4G and Next Generations technology training was closely ranked in second place. Training in GSM Data, GPRS, 3G and Next Generations was solidly ranked in third place followed by training for CDMA Data, 3G and Next Generations in fourth place.

Training is needed for later generation Telco Wireless technologies such as LTE, as well as for the basics as indicated by this group. There is lesser need and interest in training for older Telco Wireless technologies.

The detailed results are presented in the following tables and charts. See Table 10, Table 11, Table 12, Figure 5, Table 13, Table 14, and Figure 6.

Table 10: Importance of training in each Telco Wireless topic.

Question: Telco Wireless - how IMPORTANT is training in the following topics?							
Total Respondents	16						
		Number of Respondents					
Topics	**Weighted average**	**0** Not Familiar with Topic	**1** Not Important	**2**	**3** Important	**4**	**5** Very Important
Telco Wireless Core and Cellular/PCS Basics	4.3	0	2	0	0	4	10
GSM Data, GPRS, 3G and Next Generations	2.6	0	5	4	2	3	2
CDMA Data, 3G and Next Generations	2.1	2	3	6	2	2	1
LTE (Long Term Evolution), 4G and Next Generations	4.6	0	0	1	0	4	11

Table 11: Importance of training for Telco Wireless topics from more important to less important.

Topics	**More Important to Less Important**
LTE (Long Term Evolution), 4G and Next Generations	4.6
Telco Wireless Core and Cellular/PCS Basics	4.3
GSM Data, GPRS, 3G and Next Generations	2.6
CDMA Data, 3G and Next Generations	2.1

Table 12: Number of respondents not familiar with Telco Wireless topics.

Topics	Number of Respondents Not Familiar with Topic
Telco Wireless Core and Cellular/PCS Basics	0
GSM Data, GPRS, 3G and Next Generations	0
CDMA Data, 3G and Next Generations	2
LTE (Long Term Evolution), 4G and Next Generations	0

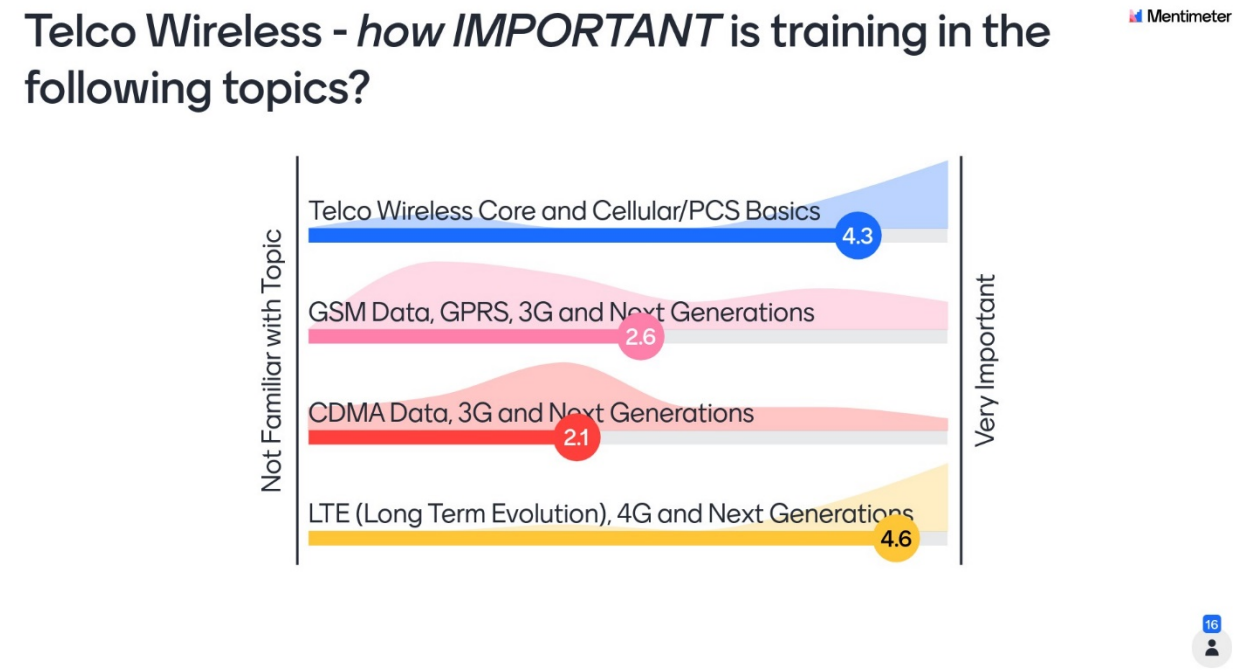

Figure 5: Importance of training in each Telco Wireless topic.

Table 13: Training priority for Telco Wireless topics.

Question: Telco Wireless - which topic is your highest PRIORITY for training?				
Total Respondents	17			
	Number of Respondents			
Topics	**1st place**	**2nd place**	**3rd place**	**4th place**
Telco Wireless Core and Cellular/PCS Basics	10	7	0	0
GSM Data, GPRS, 3G and Next Generations	0	0	14	1
CDMA Data, 3G and Next Generations	0	0	2	13
LTE (Long Term Evolution), 4G and Next Generations	7	10	0	0

Table 14: Telco Wireless topics ranked by training priority.

Topics	**Ranking**
Telco Wireless Core and Cellular/PCS Basics	1
LTE (Long Term Evolution), 4G and Next Generations	2
GSM Data, GPRS, 3G and Next Generations	3
CDMA Data, 3G and Next Generations	4

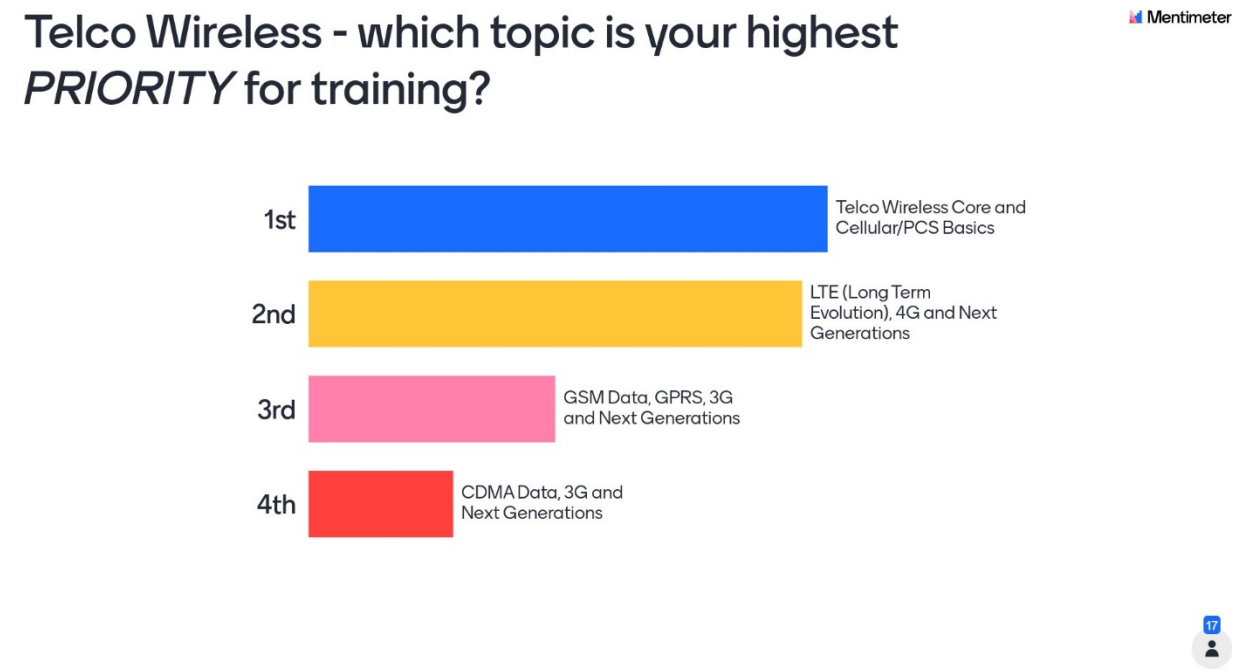

Figure 6: Priority ranking of topics for Telco Wireless training.

2.5.3. Plant Wired

The topics in the Plant Wired subject area include:

- Plant Wired Core and Plant Wiring Basics
- Serial Connectivity
- Plant xDSL
- Optical Fiber

Among the Plant Wired topics, training in Optical Fiber was rated "very important" by 15 of the 17 respondents. Training in Plant Wired Core / Plant Wiring Basics was also rated quite important with 11 of the 17 respondents (4.4 average) rating it a 5 or "very important." On the other hand, Serial Connectivity and xDSL training were rated far less important with average ratings of 2.6 and 1.9 respectively. One respondent indicated unfamiliarity with Serial Connectivity technology and two said they were unfamiliar with xDSL technologies. Plant Wired Core / Plant Wiring Basics and Optical Fiber were closely ranked first and second for training priority receiving the bulk of the first and second place votes. Serial Connectivity and xDSL trainings were ranked in third and fourth place, and between the two topics received all but one vote for either a third or fourth place ranking.

Optical Fiber training is a top priority for this group, not only among Plant Wired topics but also when compared to all the other topics in the Curriculum. Training in plant wired core technologies and wiring basics is also quite important. On the other hand, training in serial connectivity is only somewhat important, while xDSL training is relatively unimportant at this time.

See the following tables and charts for more details (Table 15, Table 16, Table 17, Figure 7, Table 18, Table 19, and Figure 8).

Table 15: Importance of training in each Plant Wired topic.

Question: Plant Wired - how IMPORTANT is training in the following topics?							
Total Respondents	17						
		Number of Respondents					
Topics	**Weighted average**	**0** Not Familiar with Topic	**1** Not Important	**2**	**3** Important	**4**	**5** Very Important
Plant Wired Core / Plant Wiring Basics	4.4	0	0	1	2	3	11
Serial Connectivity	2.6	1	3	4	4	3	2
xDSL	1.9	2	3	8	2	2	0
Optical Fiber	4.8	0	0	1	0	1	15

Table 16: Importance of training for Plant Wired topics from more important to less important.

Topics	**More Important to Less Important**
Optical Fiber	4.8
Plant Wired Core / Plant Wiring Basics	4.4
Serial Connectivity	2.6
xDSL	1.9

Table 17: Number of respondents not familiar with Plant Wired topics.

Topics	Number of Respondents Not Familiar with Topic
Plant Wired Core / Plant Wiring Basics	0
Serial Connectivity	1
xDSL	2
Optical Fiber	0

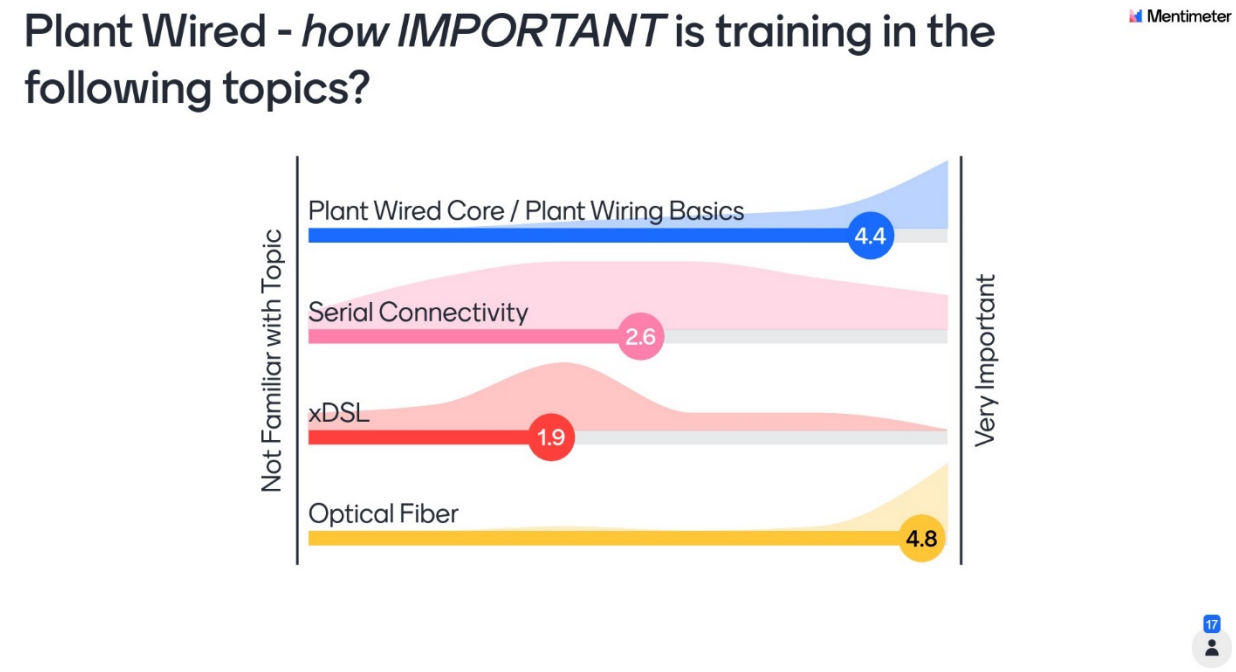

Figure 7: Importance of training in each Plant Wired topic.

Table 18: Training priority for Plant Wired topics.

Question: Plant Wired - which topic is your highest PRIORITY for training?				
Total Respondents	17			
	Number of Respondents			
Topics	**1st place**	**2nd place**	**3rd place**	**4th place**
Plant Wired Core / Plant Wiring Basics	8	9	0	0
Serial Connectivity	1	0	9	7
xDSL	0	0	7	10
Optical Fiber	8	8	1	0

Table 19: Plant Wired topics ranked by training priority.

Topics	**Ranking**
Plant Wired Core / Plant Wiring Basics	1
Optical Fiber	2
Serial Connectivity	3
xDSL	4

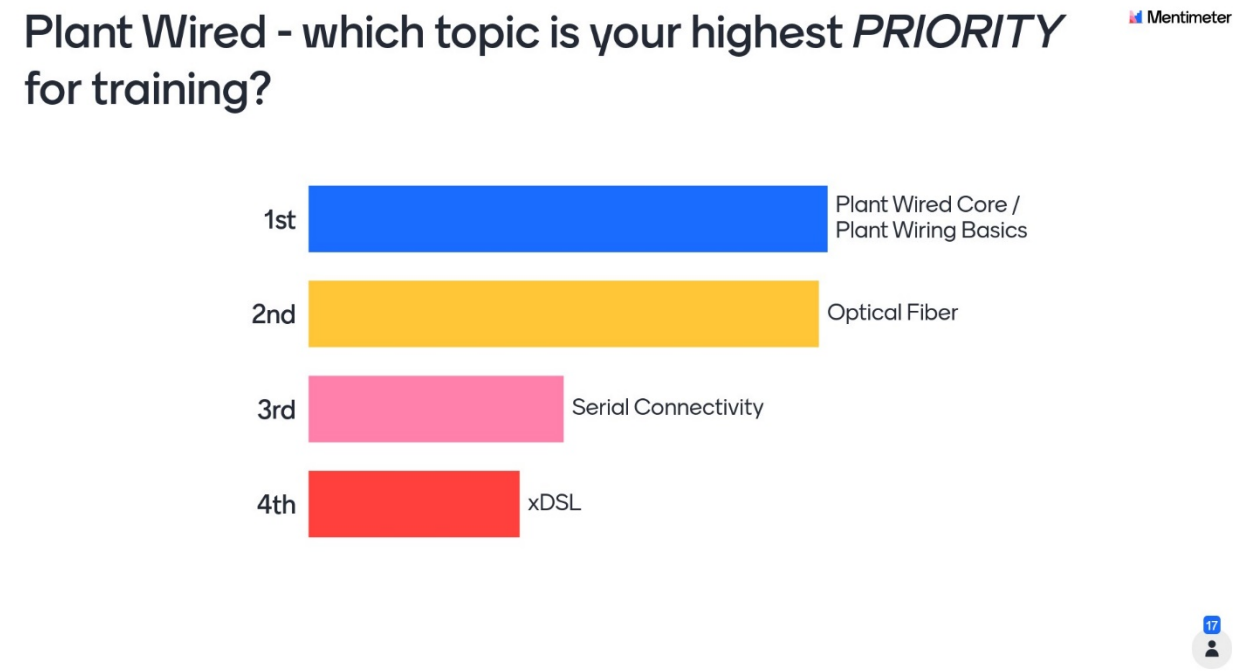

Figure 8: Priority ranking of topics for Plant Wired training.

2.5.4. Telco Wired

The following topics are included in the Telco Wired subject area:

- Telco Wired Core
- POTS
- Analog Data Circuits
- ISDN
- Telco xDSL
- DS1 / T1
- Fractional DS1 / T1
- Frame Relay
- MPLS

Training in any of the nine topics in the Telco Wired subject area was generally rated of lower importance overall compared to topics in the other subject areas. Telco Wired Core received the highest rating for training importance with a 3.6 average for the 15 respondents. DS1/T1 training was rated somewhat important averaging a 2.1 rating, followed by POTS and xDSL at an even 2.0. With that said, more respondents indicated they were unfamiliar with the Telco Wired topics compared to the topics in the other subject areas. At least one person was unfamiliar with each of the Telco Wired topics. Four respondents indicated they were unfamiliar with Analog Data

Circuits, ISDN technologies, and Frame Relay. Telco Wired Core received the bulk of the first place votes for training priority (12 of 16). DS1/T1, POTS, xDSL, and MPLS were closely ranked in second, third, fourth, and fifth place respectively for training priority. ISDN and Frame Relay were ranked a close eighth and ninth respectively. With the exception of the core topic, priority for training was spread out among the other eight topics.

While the group indicated that training for core Telco Wired technologies is important, training for the rest of the Telco Wired technologies is only somewhat important at best. The number of individuals indicating they were unfamiliar with some of the Telco Wired topics could indicate a need for training. However, given the audience and results for the other subjects and topics, these results likely indicate that the Telco Wired technologies are used infrequently and not enough to warrant focused training.

The tables and charts that follow show the detailed results as collected through Mentimeter. See Table 20, Table 21, Table 22, Figure 9, Table 23, Table 24, and Figure 10.

Table 20: Importance of training in each Telco Wired topic.

Question: Telco Wired - how IMPORTANT is training in the following topics?							
Total Respondents	15						
		Number of Respondents					
Topics	**Weighted average**	**0** Not Familiar with Topic	**1** Not Important	**2**	**3** Important	**4**	**5** Very Important
Telco Wired Core	3.6	1	2	2	1	0	9
POTS	2.0	2	3	7	1	0	2
Analog Data Circuits	1.3	4	5	3	3	0	0
ISDN	1.0	4	8	2	1	0	0
xDSL	2.0	1	7	2	3	0	2
DS1/T1	2.1	1	3	6	4	1	0
Fractional DS1/T1	1.7	2	5	5	2	1	0
Frame Relay	1.2	4	6	4	0	1	0
MPLS	1.5	3	6	2	3	1	0

Table 21: Importance of training for Telco Wired topics from more important to less important.

Choices	More Important to Less Important
Telco Wired Core	3.6
DS1/T1	2.1
POTS	2.0
xDSL	2.0
Fractional DS1/T1	1.7
MPLS	1.5
Analog Data Circuits	1.3
Frame Relay	1.2
ISDN	1.0

Table 22: Number of respondents not familiar with Telco Wired topics.

Topics	Number of Respondents Not Familiar with Topic
Telco Wired Core	1
POTS	2
Analog Data Circuits	4
ISDN	4
xDSL	1
DS1/T1	1
Fractional DS1/T1	2
Frame Relay	4
MPLS	3

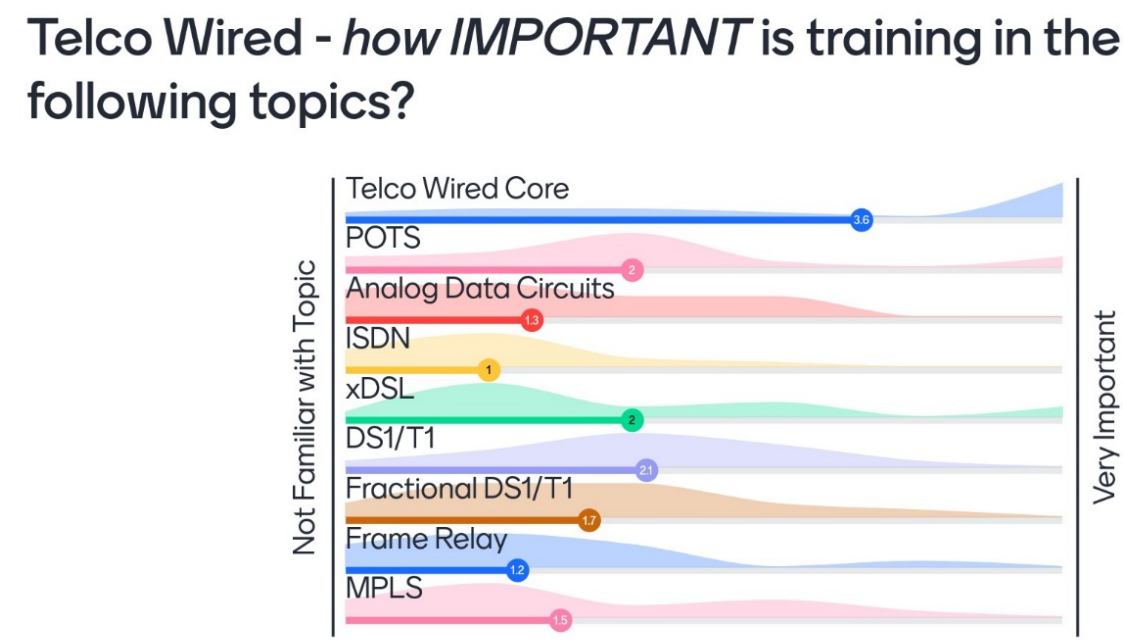

Figure 9: Importance of training in each Telco Wired topic.

Table 23: Training priority for Telco Wired topics.

Question: Telco Wired - which topic is your highest PRIORITY for training?									
Total Respondents	16								
	Number of Respondents								
Topics	**1st place**	**2nd place**	**3rd place**	**4th place**	**5th place**	**6th place**	**7th place**	**8th place**	**9th place**
Telco Wired Core	12	1	0	1	0	0	0	1	0
POTS	0	3	1	4	5	0	1	0	1
Analog Data Circuits	1	1	1	1	1	3	3	2	2
ISDN	0	1	0	0	1	6	2	3	2
xDSL	1	3	4	1	0	2	1	2	2
DS1/T1	0	3	4	3	1	1	2	0	1
Fractional DS1/T1	0	1	2	3	3	2	1	3	0
Frame Relay	0	2	1	0	0	1	4	2	5
MPLS	2	1	2	2	4	0	1	2	2

Table 24: Telco Wired topics ranked by training priority.

Topics	Ranking
Telco Wired Core	1
DS1/T1	2
POTS	3
xDSL	4
MPLS	5
Fractional DS1/T1	6
Analog Data Circuits	7
ISDN	8
Frame Relay	9

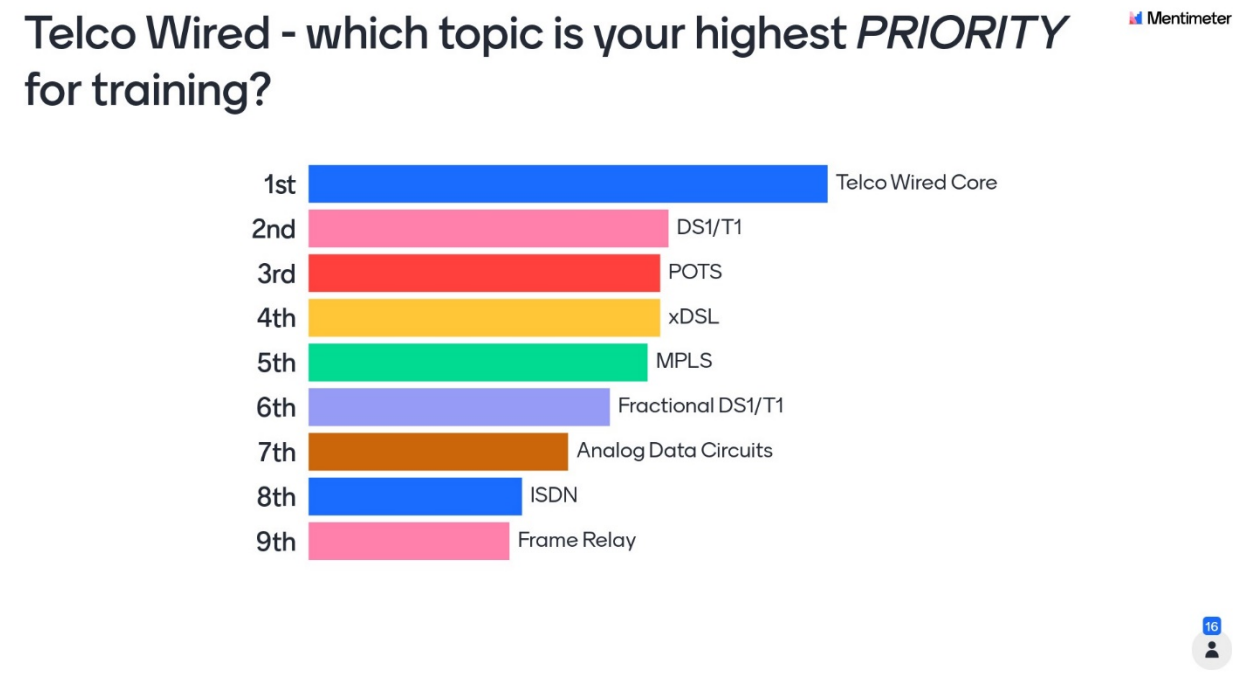

Figure 10: Priority ranking of topics for Telco Wired training.

2.5.5. IP Fundamentals

The IP Fundamentals subject area includes the following five topics:

- IP Networking Core
- Local Area Networks - LANs
- Wide Area Networks - WANs
- Network Security
- Vendor Specific Equipment Training (e.g., Cisco, Juniper, other)

The group made clear that IP Fundamentals training is a top priority for training in their districts and offices. Respondents generally rated IP Fundamentals training of higher importance compared to topics in the other subject areas. All 17 respondents rated training in Understanding IP Networks / IP Networking Core "very important." The importance of Local Area Networks (LANs) and Network Security training averaged a 4.6 out of 5; Wide Area Networks (WANs) and Vendor Specific Equipment Training received an average importance rating of 4.5. Everyone was familiar with the IP Fundamentals topics. The IP Networking Core topic was rated highest priority by all but two of the respondents. LANs, Network Security, Vendor Specific Equipment Training, and WANs followed one right after the other in second through fifth places.

The following tables and charts show more detailed results. (Table 25, Table 26, Table 27, Figure 11, Table 28, Table 29, and Figure 12)

Table 25: Importance of training in each IP Fundamentals topic.

Question: IP Fundamentals - how IMPORTANT is training in the following topics?							
Total Respondents	17						
		Number of Respondents					
Topics	**Weighted average**	**0** Not Familiar with Topic	**1** Not Important	**2**	**3** Important	**4**	**5** Very Important
Understanding IP Networks / IP Networking Core	5.0	0	0	0	0	0	17
Local Area Networks (LANs)	4.6	0	0	0	1	4	12
Wide Area Networks (WANs)	4.5	0	0	1	1	3	12
Network Security	4.6	0	0	0	1	4	12
Vendor Specific Equipment Training (e.g., Cisco, Juniper, other)	4.5	0	0	0	3	2	12

Table 26: Importance of training for IP Fundamentals topics from more important to less important.

Topics	**More Important to Less Important**
Understanding IP Networks/IP Networking Core	5.0
Local Area Networks (LANs)	4.6
Network Security	4.6
Wide Area Networks (WANs)	4.5
Vendor Specific Equipment Training (e.g., Cisco, Juniper, other)	4.5

Table 27: Number of respondents not familiar with IP Fundamentals topics.

Topics	Number of Respondents Not Familiar with Topic
Understanding IP Networks/IP Networking Core	0
Local Area Networks (LANs)	0
Wide Area Networks (WANs)	0
Network Security	0
Vendor Specific Equipment Training (e.g., Cisco, Juniper, other)	0

Figure 11: Importance of training in each IP Fundamentals topic.

Table 28: Training priority for IP Fundamentals topics.

Question: IP Fundamentals - which topic is your highest PRIORITY for training?					
Total Respondents	17				
	Number of Respondents				
Topics	**1st place**	**2nd place**	**3rd place**	**4th place**	**5th place**
Understanding IP Networks / IP Networking Core	15	1	0	0	1
Local Area Networks (LANs)	0	6	7	4	0
Wide Area Networks (WANs)	0	0	5	7	5
Network Security	1	5	3	5	3
Vendor Specific Equipment Training (e.g., Cisco, Juniper, other)	1	5	2	1	8

Table 29: IP Fundamentals topics ranked by training priority.

Topics	**Ranking**
Understanding IP Networks/IP Networking Core	1
Local Area Networks (LANs)	2
Network Security	3
Vendor Specific Equipment Training (e.g., Cisco, Juniper, other)	4
Wide Area Networks (WANs)	5

Figure 12: Priority ranking of topics for IP Fundamentals training.

2.5.6. Small Data Center Design for TMCs

The Small Data Center Design for Transportation Management Centers (TMCs) subject is very complex and includes aspects of the other five subjects. It has been organized into four focus areas:

- TMC Overview
- TMC Manager Short Course
- TMC / ITS Engineer Course
- Site and Facility Tours

The majority of the 18 respondents rated training in Data Center Design for TMC /ITS Engineers and the TMC Overview as "very important." The short course for TMC Managers was rated "Important" to quite important with a 3.7 average rating. Site and Facility Tours were rated similarly at 3.6. No one indicated they were unfamiliar with the topics in this subject area. TMC Overview training was ranked highest priority followed by the design course for TMC / ITS Engineers. The design short course for TMC Managers was ranked a solid third and the Site and Facility Tours ranked fourth by the majority of the 18 respondents.

The group indicated the need for training relative to data center design and TMCs is fairly important. Given the complexity of this subject area, it is likely that some objectives are of higher priority for training than others depending on a District's TMC status. Some of this may be reflected in the needs and priorities identified within the other subject areas. There is a stronger

need for data center design training for TMC / ITS engineers versus TMC managers. Site and facility tours would be important to this group as well.

See the following tables and charts for more detailed information as collected through Mentimeter. (Table 30, Table 31, Table 32, Figure 13, Table 33, Table 34, and Figure 14)

Table 30: Importance of training in each Small Data Center Design for TMCs topic.

Question: Small Data Center Design for TMCs - how IMPORTANT is training in the following topics?							
Total Respondents	18						
		Number of Respondents					
Topics	**Weighted average**	**0** Not Familiar with Topic	**1** Not Important	**2**	**3** Important	**4**	**5** Very Important
TMC Overview	4.1	0	2	0	2	4	10
Data Center Design Short Course for TMC Managers	3.7	0	3	1	2	5	7
Data Center Design for TMC / ITS Engineers	4.3	0	1	2	1	1	13
Site and Facility Tours	3.6	0	2	1	6	3	6

Table 31: Importance of training for Small Data Center Design for TMCs topics from more important to less important.

Topics	**More Important to Less Important**
Data Center Design for TMC / ITS Engineers	4.3
TMC Overview	4.1
Data Center Design Short Course for TMC Managers	3.7
Site and Facility Tours	3.6

Table 32: Number of respondents not familiar with Small Data Center Design for TMCs topics.

Topics	Number of Respondents Not Familiar with Topic
TMC Overview	0
Data Center Design Short Course for TMC Managers	0
Data Center Design for TMC / ITS Engineers	0
Site and Facility Tours	0

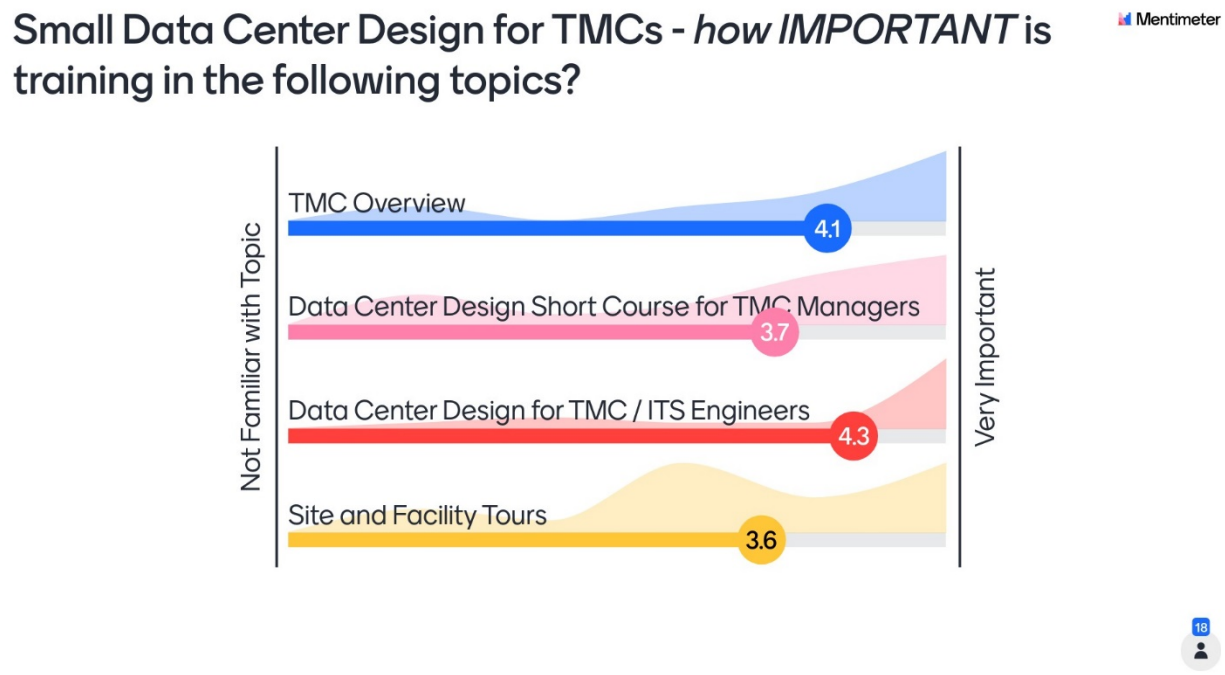

Figure 13: Importance of training in each Small Data Center Design for TMCs topic.

Table 33: Training priority for Small Data Center Design for TMCs topics.

Question: Small Data Center Design for TMCs - which topic is your highest PRIORITY for training?				
Total Respondents	18			
	Number of Respondents			
Topics	**1st place**	**2nd place**	**3rd place**	**4th place**
TMC Overview	10	4	3	1
Data Center Design Short Course for TMC Managers	1	3	10	3
Data Center Design for TMC / ITS Engineers	7	8	1	1
Site and Facility Tours	0	2	3	12

Table 34: Small Data Center Design for TMCs topics ranked by training priority.

Topics	**Ranking**
TMC Overview	1
Data Center Design for TMC / ITS Engineers	2
Data Center Design Short Course for TMC Managers	3
Site and Facility Tours	4

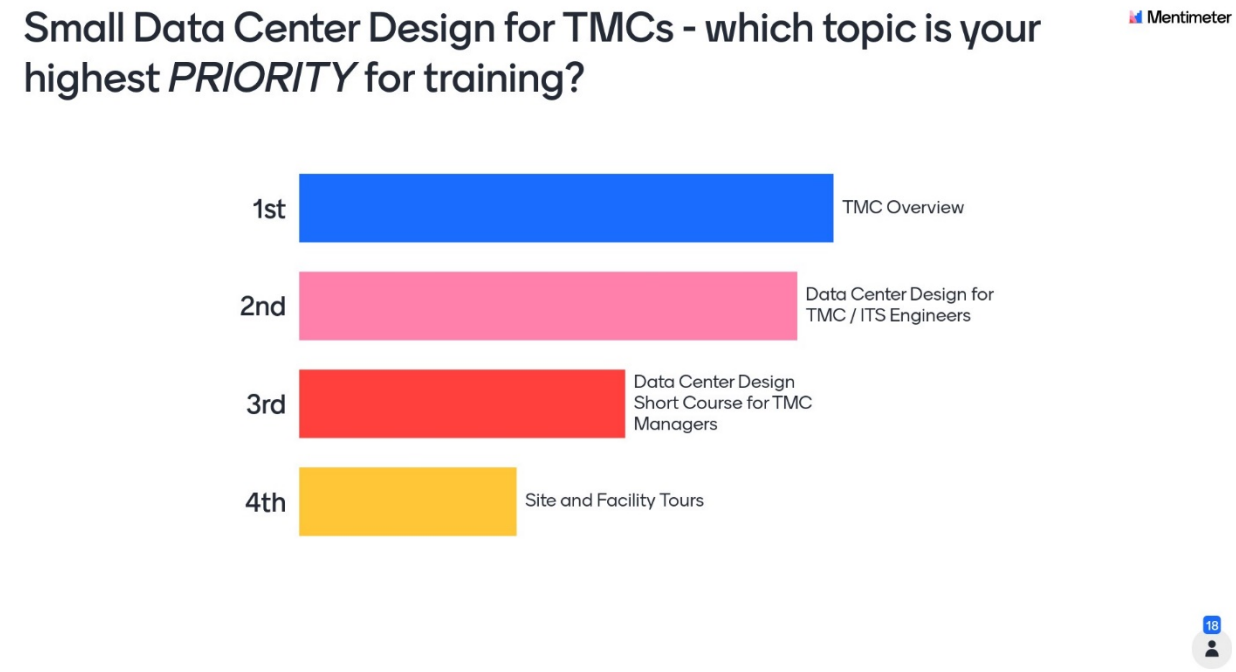

Figure 14: Priority ranking of topics for Small Data Center Design for TMCs training.

2.5.7. Top 10 Curriculum Topics

Recognizing that individual topics within subject areas are likely more or less important than particular topics in other subject areas, participants were asked to rank their top 10 training priorities out of the 30 topics in the Curriculum. This removed the bounds of the subject areas to help identify topics that are generally more important and also topics that are less important in the overall Curriculum. With eight responses, a solid ranking is difficult to discern. However, some general observations can be made.

Of the 30 topics, 20 received at least one vote for a spot in the top 10 training priorities, leaving 10 topics that received no votes. Of those receiving votes, both Telco Wireless Core / Cellular/PCS Basics and IP Networking Core received votes from all 8 respondents, with IP Networking Core receiving 4 number 1 rankings. Optical Fiber and Network Security received votes from 7 of the 8 respondents, followed by LTE, 4G and Next Generations, LANs, and WANs with six votes each. Plant Wired Core and Plant Wiring Basics, Plant Wireless Core and RF System Design, TMC/ITS Engineer Course, and Wide Area Networks (WANs) each received one first place vote. Optical Fiber was ranked second by two respondents while Telco Wireless Core and Cellular/PCS Basics, TMC/ITS Engineer Course, WANs, Telco Wired Core, Microwave, and Network Security also received one second place vote each.

The following chart (Figure 15) shows the curriculum topics that received at least one vote according to the total number of votes received. The individual votes are shown in Table 35.

Figure 15: Top 10 training priorities (curriculum topics) by total votes received.

Table 35: Curriculum topics receiving at least one priority vote for training.

Topic	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	Total Votes
IP Networking Core	4	0	1	0	2	0	1	0	0	0	8
Telco Wireless Core and Cellular / PCS Basics	0	1	0	2	0	1	1	1	1	1	8
Optical Fiber	0	2	3	0	1	0	0	0	1	0	7
Network Security	0	1	0	0	3	2	0	0	1	0	7
Wide Area Networks - WANs	1	1	0	2	1	0	0	0	0	1	6
Local Area Networks - LANs	0	0	3	2	0	0	1	0	0	0	6
LTE, 4G and Next Generations	0	0	1	0	1	2	0	2	0	0	6
Plant Wireless Core and RF System Design	1	0	0	0	0	3	1	0	0	0	5
TMC / ITS Engineer Course	1	1	0	0	0	0	0	1	0	1	4
Plant Wired Core and Plant Wiring Basics	1	0	0	1	0	0	1	1	0	0	4
Microwave	0	1	0	0	0	0	1	0	1	1	4
Vendor Specific Equipment Training (e.g., Cisco, Juniper, other)	0	0	0	0	0	0	1	1	2	0	4
TMC Overview	0	0	0	0	0	0	0	1	1	1	3
Telco Wired Core	0	1	0	0	0	0	0	0	1	0	2
POTS	0	0	0	1	0	0	0	0	0	0	1
MPLS	0	0	0	0	0	0	1	0	0	0	1
802.11 (WiFi) and related	0	0	0	0	0	0	0	1	0	0	1
Short haul radio	0	0	0	0	0	0	0	0	0	1	1
Serial Connectivity	0	0	0	0	0	0	0	0	0	1	1
TMC Manager Short Course	0	0	0	0	0	0	0	0	0	1	1

The following topics received no votes for training priority:

- Analog Data Circuits
- CDMA Data, 3G, Next Generations
- DS1 / T1
- Fractional DS1 / T1
- Frame Relay
- GSM Data, GPRS, 3G, Next Generations
- ISDN
- Plant xDSL
- Site and Facility Tours
- Telco xDSL

These results are generally similar to what was seen during the working meeting. IP Networking Fundamentals are a priority for training at this time. Newer wireless technologies, basic core topics, and optical fiber are also of higher priority for training. Conversely, Telco Wired technologies, with the exception of the basics, and older Telco Wireless technologies are relatively less important at this time.

2.5.8. Curriculum Review

After discussing the Curriculum at the subject and topic level, the group was asked to suggest any topics for addition or removal from the Curriculum. In general, responses followed a similar pattern as the other groups of questions with the group suggesting the focus for training should be on newer technologies and less on topics that are being phased out. One respondent summarized, "We should focus on future technologies, and stop learning how to use technologies that are sun-setting." For example, the group suggested that less time could be devoted to topics such as frame relay, ISDN, or GPRS, or that they could be removed from the Curriculum at this time. On the other hand, the group suggested adding topics such as 5G wireless and Linux, and spending more time addressing topics like network management, troubleshooting, and security.

The group had the following responses for topics that could / should be *removed* from the Curriculum.

*Note: Given the dynamic nature of the working meeting and the other responses in this section of the meeting, several comments/responses appeared to be suggestions for additions (vs. removals) to the Curriculum. Those that were included in the first question about removal from the Curriculum but seemed to be addition suggestions are marked with an * and listed with the other comments on addition to the Curriculum.*

Question: "What do you think about the current Curriculum? Is there anything that could / should be REMOVED? Comments?"

- *ISDN*
- *2G, GPRS, CDMA. T-1*

- *Are T1 and frame relay services readily available anymore?*
- *Frame Relay*
- *We should focus on future technologies and stop learning how to use technologies that are sun-setting.*
- *Serial Communications*
- *I would like to see more wireless or fiber technologies and less wired.*
- *GSM, GPRS, 3G, CDMA*
- *Frame Relay, ISDN, Analog Data Circuits*
- *Remove 3G.*
- *We are moving forward to IP conversion and fiber optic. So we should focus on networking, wireless. Less on analog topics.*
- *ISDN technology is phasing out and the need for training in this area of technology can be eliminated.*
- *Analog Data Circuits, ISDN, DS1, Frame Relay*

The group had the following responses about topics that could / should be included in the Curriculum. As noted above, the responses marked with an * were entered in response to removal from the Curriculum but given the context, appear to be suggestions for additions.

Question: "What do you think about the current Curriculum? Is there anything that could / should be ADDED? Comments?"

- *Python or other scripting languages*
- *Network troubleshooting*
- *Fiber optics management*
- *5G and beyond*
- *IP v6*
- *5G wireless*
- *Fiber optic testing and documentation*
- *Linux*
- *Virtual Machine environments*
- *rhel os / linux*
- *Linux*
- *Network documentation*
- *High availability for Linux?*
- *Network Management*

- *Test equipment*
- *Performance testing*
- *Linux*
- *APN's*
- *FirstNet*
- *IP Fundamentals*
- *Fiber optic management*
- *Wireless Fundamentals*
- *5 G technology*
- *I would like to see more wireless or fiber technologies and less wired.*
- *Add Intro to 5G. More emphasis on Network Security. Add Network Monitoring Tools. Add network troubleshooting course.*
- *What about adding 5G?*
- *We are moving forward to IP conversion and fiber optic. So we should focus on networking, wireless.*
- *More on IP networking and network security.*
- *Half of our CCTVs (200) are wireless in desert area. D8 needs training and troubleshooting skills for that. Antennas and brands that work well needed.*
- *Add 5G.*
- *Add Network Troubleshooting.*
- **IP V6*
- **5G and beyond*
- **5G*
- **5G, FirstNet*
- **Network Management*
- **RHEL OS / Linux*
- **Radio system design. Antenna selection. (For CCTV, CMS, so reliability is critical.) Solar power system sizing/specification for these elements too.*
- **VMWare and Servers*
- **Ethernet Troubleshooting, Various Test Equipment Usage and applications, benchmark testing of networking equipment, performance testing of communication systems*
- **APN's*

- **1. How to troubleshoot fiber optic communications for breaks or downed equipment. Using the test equipment. 2. Troubleshooting CCTVs and detection. 3. IP/Networking network management skills to help with troubleshooting comm failures.*

2.6. Top Training Needs

To move the conversation beyond the bounds of the established Curriculum and document any training needs that may not already be included, the group was asked to list their three most important training needs relative to ITS data communications. These could be topics in the Curriculum or any that could be added. The group produced a word cloud representing their answers (see Figure 16 below). Larger words/phrases were mentioned more often.

Figure 16: Word cloud developed for 3 most important ITS data communications training needs.

As shown, security and network management rise to the top as high priority training topics. A closer look at the individual answers indicates that troubleshooting, testing, design, and fundamental skills, are important general concepts, in addition to security and management. IP related technology was mentioned multiple times while fiber optics and RF were also listed more than once. Keeping pace with new technologies and learning about technology that is on the horizon are also important.

For reference and more detail, these are the actual responses:

- Testing
- Network Troubleshooting
- TCP-IP Fundamentals

- Network IP Troubleshooting
- ITS Network Design
- Network Fundamentals
- Keeping up with new tech
- IP Fundamentals
- Security
- IP Networks
- High Frequency RF
- TCP-IP Network Design
- Fiber Optics Management
- Point-to-Point Radio Test
- Security
- RF Fundamentals
- Network Management
- Security
- IP
- Network Security
- Cellular Troubleshooting
- Network Management
- Fiber Optics
- Future Wireless Technology
- Network Management
- Network Management
- VMware Virtual Environment

2.7. PCB for Communications Courses

This research project is currently in its fifth phase and multiple courses have been delivered since its inception. In addition to developing and providing new training, courses have also been updated and repeated by the same instructors based on the original offering. To assess which courses to consider delivering again in the short and longer term, the group was asked to rate their perception of the usefulness of each of the delivered courses. The courses were then further rated for importance based on current and future project work.

Not surprisingly given responses to the other questions, the advanced IP networks/protocols course and the Ethernet and TCP/IP Fundamentals course were perceived to be highly useful, averaging

a 4.8 out of 5 score. About three quarters of the 13 respondents indicated they thought the two courses were very useful. *Mastering Fiber Optic Network Design and Installation* and *Telecom Wireless Fundamentals* were also perceived as fairly useful, averaging 4.5 and 4.4 respectively.

While *Small Data Center Design, Structured Cabling, and Grounding* and *RF System Design* were perceived less useful compared to the other courses, they were still rated as somewhat useful. The RF course was the first one delivered through the PCB for communications project and it fell short of the PTAP's and project's expectations for content and delivery. It has been noted that it will be redesigned if offered again. Since that course was delivered in 2010, the process for procuring new coursework was made more rigorous which will also address some of the noted deficiencies. In regard to the complex small data center design for TMCs course, structured cabling was advertised to be a key topic. However, while the overall course was well-received, structured cabling was not addressed to the extent expected. This may have contributed to the somewhat lower perception of usefulness. Usefulness of this course could also be quite variable depending on the differing status of TMCs around the state.

The following tables and charts show the question results in more detail. See Table 35, Table 36, and Figure 17.

Table 36: Perception of usefulness of courses delivered through the PCB for ITS Data Communications project.

Question: What is your perception of the usefulness of the courses already delivered through the PCB for ITS Data Communications project?						
Total Respondents	13					
		Number of Respondents				
Courses	**Weighted average**	**1** Not at all useful	**2**	**3** Somewhat useful	**4**	**5** Very useful
Radio Frequency (RF) System Design, October 2010	3.0	0	4	4	0	2
Mastering Fiber Optic Network Design and Installation, September 2012	4.5	0	0	1	4	6
Hands-On Ethernet and TCP/IP Fundamentals, September 2013, 2017-2019	4.8	0	0	0	3	9
Telecom Wireless Fundamentals, March 2015, 2018-2019	4.4	0	0	1	5	6
Small Data Center Design, Structured Cabling, and Grounding, October 2018	3.4	0	2	4	4	1
Hands-On Advanced IP Networks/Protocols, March 2019	4.8	0	0	0	2	10

Table 37: PCB courses perceived more useful to less useful.

Courses	Perceived More Useful to Less Useful
Hands-On Advanced IP Networks/Protocols, March 2019	4.8
Hands-On Ethernet and TCP/IP Fundamentals, September 2013, 2017-2019	4.8
Mastering Fiber Optic Network Design and Installation, September 2012	4.5
Telecom Wireless Fundamentals, March 2015, 2018-2019	4.4
Small Data Center Design, Structured Cabling, and Grounding, October 2018	3.4
Radio Frequency (RF) System Design, October 2010	3.0

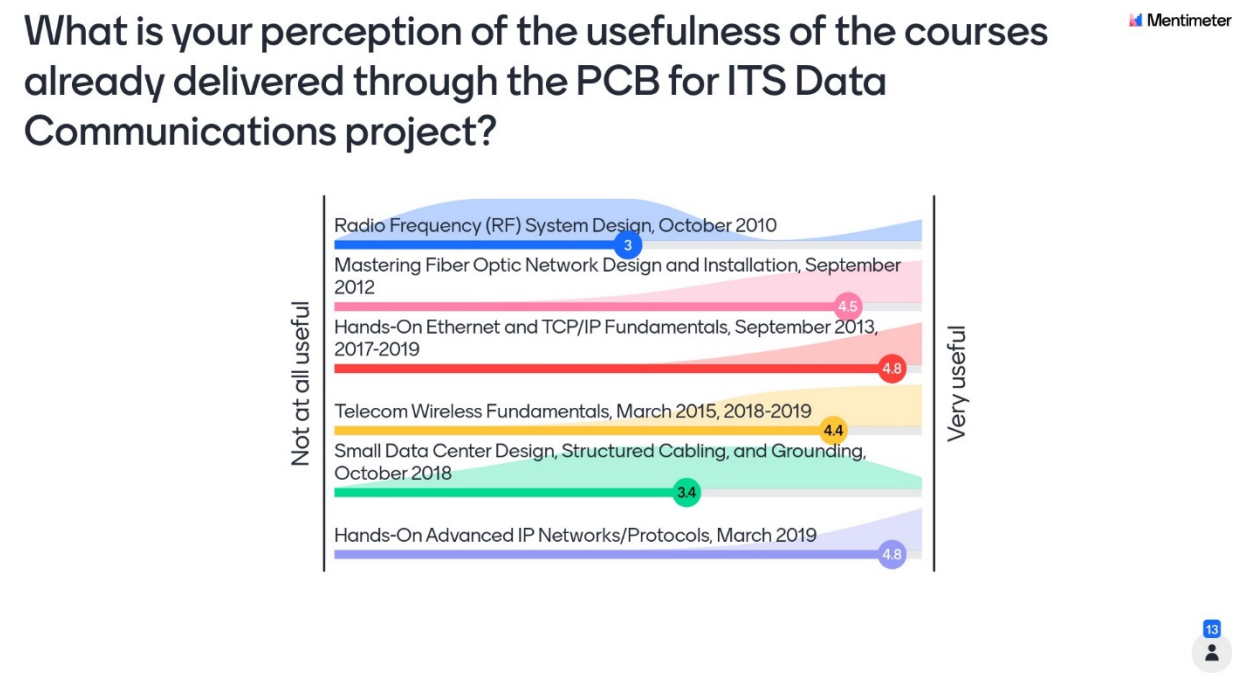

Figure 17: Perception of usefulness of courses delivered through the PCB for ITS Data Communications project.

One of the primary goals of this working meeting was to gather information to help the PTAP choose what new content to develop and which courses to procure again. Based on current projects underway, *Hands-On Ethernet and TCP/IP Fundamentals, Hands-On Advanced IP Networks/Protocols,* and *Telecom Wireless Fundamentals* are all quite important averaging 4.6, 4.3, and 4.3 respectively. Of the 14 total respondents, 11 rated the IP Fundamentals course a 5 for very important; 8 of the 14 respondents rated the other two courses very important. The fiber optics course was rated 3.6 / important. At this time, based on current project load, the group indicated that the *RF System Design* course and the *Small Data Center Design, Structured Cabling, and Grounding* course are relatively less important. As noted above, the *RF System Design* course as delivered fell short of expectations which may have contributed to its lower priority rating.

The level of importance for the training courses based on anticipated future project work was very similar to that of what is important currently, with individuals adjusting their ratings up or down somewhat. Two respondents indicated they were unfamiliar with the RF course, while one each said they were unfamiliar with the fiber optic course and the data center design for TMCs course. The following charts and tables show the detailed results. (Table 37, Table 38, Figure 18 Table 39, Table 40, Figure 19, and Table 41)

Table 38: Importance of PCB courses based on current project work.

Question: Based on your CURRENT project load, how important are the following courses?							
Total Respondents	14						
		Number of Respondents					
Courses	**Weighted avg.**	**0** Not familiar with course	**1** Not Important	**2**	**3** Important	**4**	**5** Very Important
Radio Frequency (RF) System Design	2.5	2	1	6	1	1	3
Mastering Fiber Optic Network Design and Installation	3.6	1	2	1	0	3	7
Hands-On Ethernet and TCP/IP Fundamentals	4.6	0	0	1	1	1	11
Hands-On Advanced IP Networks/Protocols	4.3	0	0	1	2	3	8
Telecom Wireless Fundamentals	4.3	0	0	1	2	3	8
Small Data Center Design, Structured Cabling, and Grounding	2.4	1	2	5	4	1	1

Table 39: PCB courses more important to less important based on current project work.

Courses	More Important to Less Important
Hands-On Ethernet and TCP/IP Fundamentals	4.6
Hands-On Advanced IP Networks/Protocols	4.3
Telecom Wireless Fundamentals	4.3
Mastering Fiber Optic Network Design and Installation	3.6
Radio Frequency (RF) System Design	2.5
Small Data Center Design, Structured Cabling, and Grounding	2.4

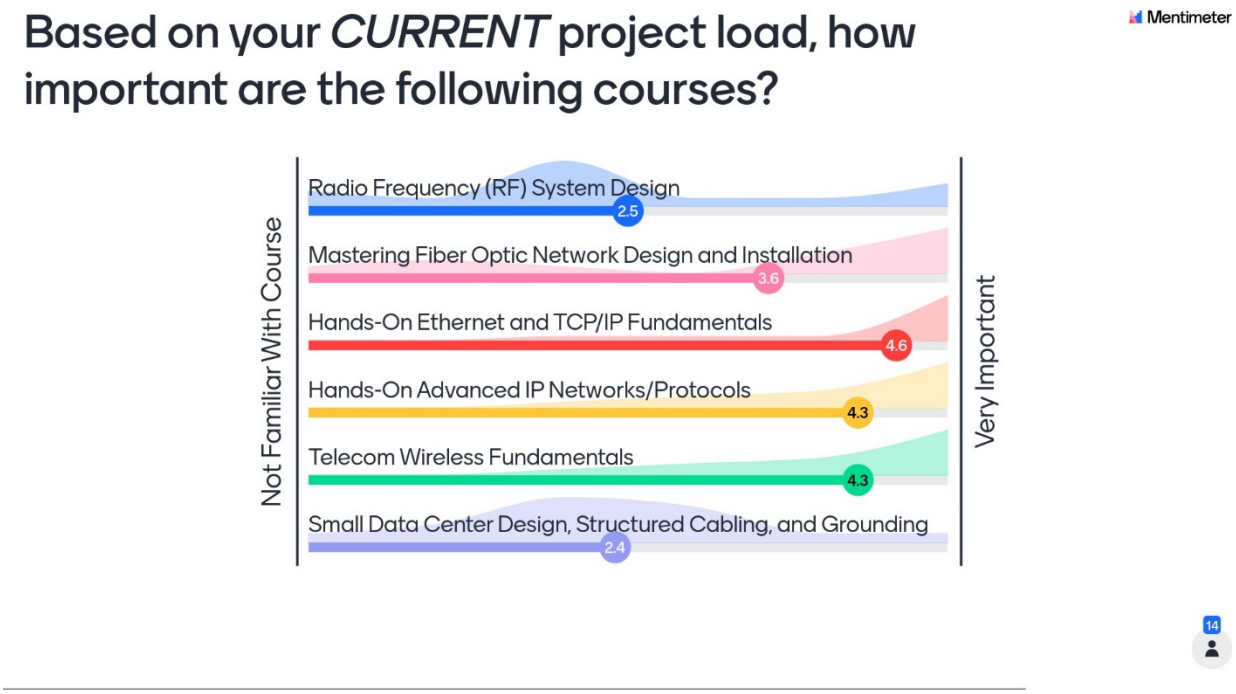

Figure 18: Importance of courses based on current project work.

Table 40: Importance of PCB courses based on anticipated future project work.

Question: Based on your anticipated FUTURE project load, how important are the following courses?							
Total Respondents	14						
		Number of Respondents					
Courses	**Weighted avg.**	**0** Not familiar with course	**1** Not Important	**2**	**3** Important	**4**	**5** Very Important
Radio Frequency (RF) System Design	2.6	0	4	4	1	3	2
Mastering Fiber Optic Network Design and Installation	3.6	0	3	0	2	4	5
Hands-On Ethernet and TCP/IP Fundamentals	4.5	0	0	0	1	5	8
Hands-On Advanced IP Networks/Protocols	4.4	0	1	0	1	2	10
Telecom Wireless Fundamentals	4.4	0	0	1	1	4	8
Small Data Center Design, Structured Cabling, and Grounding	2.6	1	3	1	6	1	2

Table 41: PCB courses more important to less important based on future project work.

Courses	More Important to Less Important
Hands-On Ethernet and TCP/IP Fundamentals	4.5
Hands-On Advanced IP Networks/Protocols	4.4
Telecom Wireless Fundamentals	4.4
Mastering Fiber Optic Network Design and Installation	3.6
Radio Frequency (RF) System Design	2.6
Small Data Center Design, Structured Cabling, and Grounding	2.6

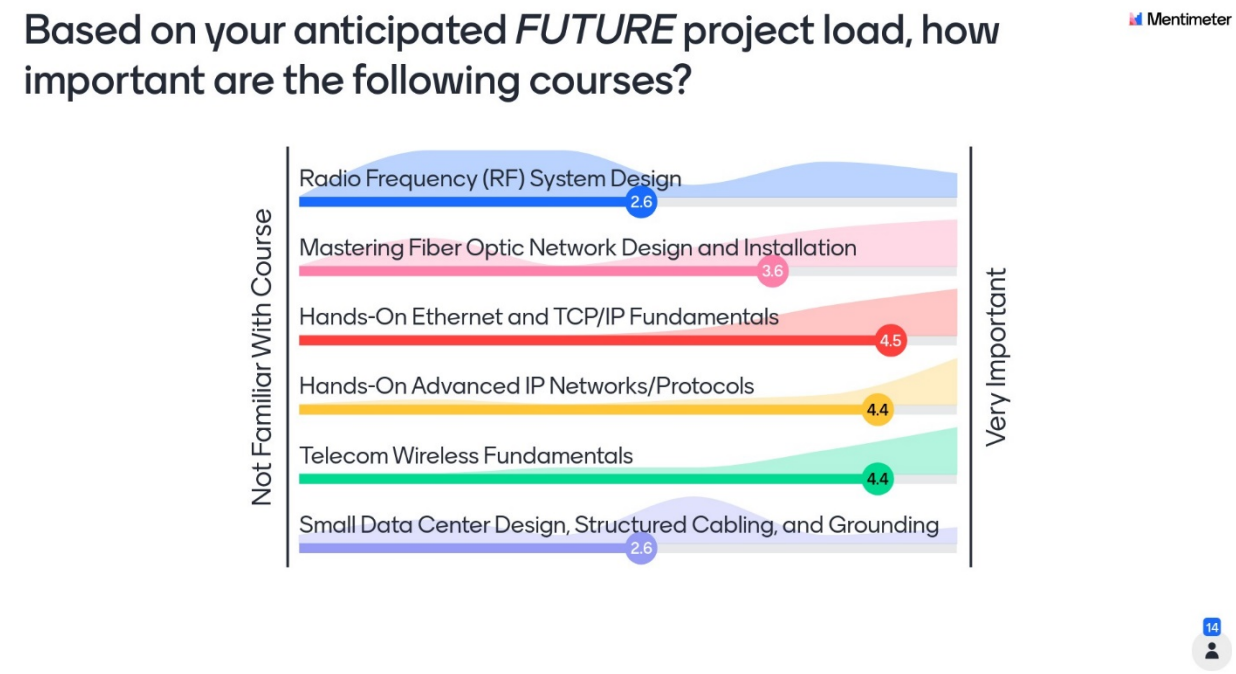

Figure 19: Importance of PCB courses based on future project work.

Table 42: Respondents not familiar with PCB courses.

Courses	Number of Respondents Not Familiar with Course
Radio Frequency (RF) System Design	2
Mastering Fiber Optic Network Design and Installation	1
Hands-On Ethernet and TCP/IP Fundamentals	0
Hands-On Advanced IP Networks/Protocols	0
Telecom Wireless Fundamentals	0
Small Data Center Design, Structured Cabling, and Grounding	1

Feedback and discussion were encouraged relative to the training courses. Several participants made comments indicating that training should be hands-on, realistic, and tailored to actual Caltrans applications. Some noted the value of in-person training, not only for the educational benefit but also for the opportunities to network between Caltrans Districts. Others asked about the coursework's target audience and suggested holding the trainings in various locations around the state.

Developing a network lab environment where equipment, networks, and applications can be designed and tested (e.g., "sandbox") was suggested by a couple individuals. During the live discussion, this idea was met with interest and enthusiasm. District 2, for example, has such a lab environment. Other offices/districts/shops do have different types of labs.

Another suggestion that the group expressed interest in was creating a list of ITS equipment being used by the various Districts. This list could include applications, advantages, disadvantages, and lessons learned. Such a list would be beneficial for targeting specific skills and skill sets for training, as well as for technology transfer statewide.

Specific comments collected during the working meeting are listed below:

- *"My staff has found them useful, in person for networking (social) between districts.*
- *Yes, the social networking is very valuable.*
- *Labs/hands-on training most beneficial.*
- *Must be hands on for Maintenance.*
- *Include actual case studies or situations.*
- *Some more Caltrans specific labs.*
- *Show a live network.*
- *Create a list of equipment being used by the various Districts.*

- *Add a network lab environment.*
- *Test jigs to test elements, networking equipment like Brian recommended. This is a must. To do a preinstallation test.*
- *Are these courses only for Engineers or can we include Field Maintenance?*
- *Make room for the electricians that do this type of support.*
- *Better advertisement of upcoming training.*
- *How can ITS staffs sign up for the training?*
- *Move the training seminars between districts.*
- *Historically, training always goes through Operations. Since some of the staff has moved to Maintenance, it must be forwarded to Traffic Systems Maintenance & HQ TSM to get training to TMEs. Construction only calls Ops for training."*

2.8. Summary

In general, Caltrans senior functional managers see a need for training related to ITS data communications, now and looking ahead to the future. Of the topics in the Curriculum, 13 were rated between 4 and 5 (quite important to very important) on a five-point scale for importance of training. Another 11 topics received somewhat important to important ratings for training importance. See Table 42.

Table 43: Summary - importance of training for each topic.

Subjects color code	**Plant Wireless (PWs)** **Telco Wireless (TWs)** **Plant Wired (PWd)** **Telco Wired (TWd)** **IP Fundamentals (IP)** **Small Data Center Design for TMCs (DC)**
Topic	**Importance of Training** **1 = Not Important** **2 = Somewhat Important** **3 = Important** **4 = Quite Important** **5 = Very Important**
Understanding IP Networks/IP Networking Core (IP)	5.0
Optical Fiber (PWd)	4.8
Local Area Networks (LANs) (IP)	4.6
Network Security (IP)	4.6
LTE (Long Term Evolution), 4G and Next Generations (TWs)	4.6
Vendor Specific Equipment Training (e.g., Cisco, Juniper) (IP)	4.5
Wide Area Networks (WANs) (IP)	4.5
Plant Wired Core / Plant Wiring Basics (PWd)	4.4
Plant Wireless Core and RF System Design (PWs)	4.3
Data Center Design for TMC / ITS Engineers (DC)	4.3
Telco Wireless Core and Cellular/PCS Basics (TWs)	4.3
TMC Overview (DC)	4.1
802.11 (WiFi) and Related (PWs)	4.1
Data Center Design Short Course for TMC Managers (DC)	3.7
Telco Wired Core (TWd)	3.6

Subjects color code	**Plant Wireless (PWs)** **Telco Wireless (TWs)** **Plant Wired (PWd)** **Telco Wired (TWd)** **IP Fundamentals (IP)** **Small Data Center Design for TMCs (DC)**
Topic	**Importance of Training** **1 = Not Important** **2 = Somewhat Important** **3 = Important** **4 = Quite Important** **5 = Very Important**
Site and Facility Tours (DC)	3.6
Microwave (PWs)	2.9
Short Haul Radio (PWs)	2.7
Serial Connectivity (PWd)	2.6
GSM Data, GPRS, 3G and Next Generations (TWs)	2.6
CDMA Data, 3G and Next Generations (TWs)	2.1
DS1/T1 (TWd)	2.1
POTS (TWd)	2.0
xDSL (TWd)	2.0
xDSL (PWd)	1.9
Fractional DS1/T1 (TWd)	1.7
MPLS (TWd)	1.5
Analog Data Circuits (TWd)	1.3
Frame Relay (TWd)	1.2
ISDN (TWd)	1.0

Now and in the future, training in the subject of IP Fundamentals is of overall priority, as a subject and for the individual topics within the subject area. Optical fiber training is also a high priority. Conversely, training in the Telco Wired subject area and its topics is relatively less important and of lower priority, with the exception of the core skills area.

Similarly, the basic and advanced IP networking courses, as well as the optical fiber course were perceived as highly useful. Based on current and anticipated future project work, the basic IP fundamentals course was again at the top of the list for importance. The advanced IP networking course and the Telecom wireless fundamentals course were tied for second and third for importance both now and in the future. The fiber optic network design and installation course was rated important as well, but behind these other courses for importance based on current and future project work.

It is interesting to observe that the topic of optical fiber was rated a top priority for importance of training, second only to core IP Fundamentals. The fiber optics course delivered in 2012 was perceived as very useful. However, the importance for training in optical fiber both now and in the future was rated comparatively lower than might have been expected given the other results. This may reflect the importance of updating courses and ensuring that content is current and relevant to District needs. The core topics and fundamental skills are important across the board. ITS engineers and technicians generally need the basics no matter the project load. More specific training needs would vary by District or Office, and by individual staff depending on position and particular project work.

In general, the group indicated that less time should be spent on technologies that are being phased out, and more time should be spent on the new and emerging technologies. The Curriculum could be enhanced with the addition of topics like Linux, virtual machine environments, and 5G wireless technologies, along with greater emphasis on network security and management.

This meeting was designed to effectively and efficiently identify overall training needs at the field level related to ITS data communications. The project team and the meeting participants indicated that this style of needs assessment worked well for the goals at hand. Some general meeting comments included, “Pretty interesting with the voting system.”, and “Thank you, great meeting…”

3. COMPARISION TO PREVIOUS PCB FOR COMMUNICATIONS NEEDS ASSESSMENTS

While this assessment differed in its approach compared to the previous two needs assessment surveys, the overall goal was still the same – to identify training that is most applicable to the ITS engineers and technicians in the field and directly working with ITS technologies. The need for professional capacity building in ITS data communications technologies is still evident for Caltrans ITS practitioners.

On the subject level, training related to IP Fundamentals continues to be of very high importance. Similarly, training for newer Telco Wireless topics again rose to the top as a significant need. Specifically, training in network security is a top priority for Caltrans as it was previously. Plant Wireless Core technologies and RF System Design training are also still quite important. Conversely, training needs for Telco Wired technologies have significantly decreased.

4. AVAILABLE TRAINING OPPORTUNITIES

Since the start of this project, many different organizations have been 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. These training providers are listed separately in the Identified Training Providers list (1). This is a dynamic document which will be updated over the course of this project phase (Phase 5).

Most of the topics in each of the six subject areas are addressed by a least one training provider at a level of detail ranging from moderate to significant. However, full training courses that focus on some of the wired communications technologies such as analog data circuits, POTS, serial connectivity, or DS1/T1, are limited to non-existent. In some cases, these topics are covered to varying degrees as parts of training in related topics and/or broader course offerings. There are also several reference resources available (e.g., tutorials, videos, books, fact sheets, etc.). Knowing these resources are available, coupled with relationships established through this project with various SMEs, it is likely that some training could be developed and/or customized that addresses topics without dedicated mainstream training opportunities.

Moreover, formal requests for bids (RFB) have been released for four training courses plus the training request for information for 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), Telecom Wireless Fundamentals, and Small Data Center Design for TMCs, Structured Cabling, and Grounding, have been delivered through this process. However, a course in Plant Wired Core / Plant Wiring Basics, serial connectivity, and xDSL was cancelled when it became clear the selected contractor would not be able to meet the objectives and expectations as set forth in the limited solicitation request for bids and the contracted services agreement. Also, the RF System Design course did not match the curriculum defined in the syllabus and was not recommended for continuity. The course will be revamped and put out for bid again if the project team chooses to pursue training in this topic.

Several courses have since been procured directly by Caltrans utilizing the same instructors / vendors that delivered the original training. *Hands-On Ethernet and TCP/IP Fundamentals* and *Telecom Wireless Fundamentals* have been updated and delivered multiple times around the state. *Hands-On Advanced IP Networks/Protocols* was procured in a similar manner from the same trainer that delivered the basics course. The basic and advanced IP Fundamentals courses will be delivered multiple times during this project phase. In addition, *Mastering Fiber Optic Network Design and Installation* is slated to be offered twice by the same instructor who delivered the original training in project phase 2.

The main objective of this project is to have subject matter experts provide onsite, practical, nuts and bolts training to ITS engineers and technicians. Qualifications set out in the RFBs include on-site delivery, ability to customize content, hands-on exercises, and as mentioned above, an established course that comes close to covering all 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 Wireless Communication Engineering Technologies (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, IP Fundamentals, and Small Data Center Design for TMCs 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.

5. GAPS

Gaps in ITS data communications training would be evident if no training opportunity appeared to be available that adequately addressed identified needs of Caltrans 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 this needs assessment meeting, training in IP Fundamentals topics is a clear priority. Two courses addressing the topics of Understanding IP Networks / IP Networking Core, LANs, WANs, and Network Security have been developed, procured, and delivered multiple times. *Hands-On Ethernet and TCP/IP Fundamentals* will be delivered twice more this year; *Hands-On Advanced IP Networks/Protocols* will be delivered three times. Both of these courses are taught by Andrew Walding of CellStream, the instructor/vendor for the original *Hands-On Ethernet and TCP/IP Fundamentals* course delivered in September of 2013. These courses may use example equipment from different vendors, but the training is designed to be generic. For training specific to certain vendors, companies such as Cisco, Juniper, etc., offer a variety of learning opportunities for their equipment. No gap exists for training in the IP Fundamentals topics at this time.

As a side note, the only training that could be effectively delivered virtually and still meet the project's expectations are those classes addressing the IP Fundamentals topics. This is important to mention at this time given the ongoing global health pandemic that is restricting in-person, on-site instruction/meetings.[1] While virtual courses can potentially meet the content delivery objectives, hands-on laboratory exercises and in-person interactions / networking, vital pieces of the PCB project, will obviously be very limited to non-existent. Still, since IP Fundamentals training is a priority and it can be effectively delivered virtually, high-quality training can continue to be delivered. As mentioned above, both *Hands-On Ethernet and TCP/IP Fundamentals* and *Hands-On Advanced IP Networks/Protocols* will be delivered multiple times to meet this training need.

Optical Fiber training was also designated a high priority. Two courses in *Mastering Fiber Optic Network Design* will be taught by Eric Pearson / Pearson Technologies. Mr. Pearson taught the original optical fiber course of the same name in September of 2012. There is no gap for fiber optics training at this time.

Training needs for LTE, 4G and Next Generations, Data Center Design for TMC / ITS Engineers, and 802.11 were rated highly important and of top or near top priority among the topics in their respective subject areas. LTE, 4G and Next Generations technology is covered in depth in the course *Telecom Wireless Fundamentals* (Scott Baxter, TONEX), which was first delivered in 2015 and has since been delivered multiple times to Caltrans ITS engineers and technicians. The objectives for Data Center Design for TMC / ITS Engineers were covered in the *Small Data Center Design, Structured Cabling, and Grounding* course delivered by Philip Isaak of Isaak Technologies in October 2018. While this course hasn't yet been procured again, the opportunity exists to update and deliver it again if desired. Finally, training that addresses 802.11 (WiFi) and

[1] As of this writing, the United States and the global community are battling the coronavirus COVID-19 pandemic. Travel and in-person gatherings are severely restricted which limits the options for training.

Related technologies objectives is offered by several vendors, including some familiar to Caltrans. However, most courses are being delivered online and/or in a virtual classroom. No gap exists for training in LTE, 4G and Next Generations technology or Data Center Design for TMC / ITS Engineers. For 802.11 (WiFi) and Related technology training, a small gap could be present due to the potential difficulty in securing live, on-site training.[1]

Generally, training in the core and overview topics for all the subject areas was rated as important and of priority. IP Fundamentals Core / Understanding IP Networks is covered completely in the courses mentioned above. Similarly, Telco Wireless Core / Cellular/PCS Basics is adequately addressed in *Telecom Wireless Fundamentals*. The objectives for a TMC Overview were included in the course *Small Data Center Design, Structured Cabling, and Grounding* delivered in 2018 through project phase 4. No gaps exist for training in the core topics for the IP Fundamentals, Telco Wireless, and Small Data Center Design for TMCs subject areas.

The pilot course for this project was *RF System Design* and a syllabus was established based on the learning objectives in the curriculum. However, after the course was delivered, the PTAP agreed that the course content and delivery had not met expectations and was subsequently not recommended for continuation at the time. Plant Wireless Core and RF Systems Design objectives are included in coursework from a few vendors, including vendors familiar to Caltrans and the PTAP. Relatively few vendors advertised on-site (in California), hands-on, customizable training though. A potential gap for training in Plant Wireless Core and RF Systems Design appears if no suitable vendor/instructor can be found and/or hands-on training can't be delivered in Caltrans locations.

The Plant Wired Core and Plant Wiring Basics topic addresses important knowledge and skill sets for different wire types, connectors, and installation of wired communication systems. Hands-on training exercises are essential. As mentioned in the previous section, a course in Plant Wired Core / Plant Wiring Basics, serial connectivity, and xDSL was cancelled when it became clear the selected contractor would not be able to deliver the course as expected. Structured cabling from a design perspective was included in the *Small Data Center Design, Structured Cabling, and Grounding* course objectives. The topic is addressed by some vendors and that training appears to adequately cover the core Plant Wired objectives listed in the Curriculum Scope and Sequence. However, with some exceptions, available training is largely online versus in person, on-site, and hands-on. It is unclear whether training opportunities in these topics are generally limited by the global health pandemic[1] at this time or indeed very few training opportunities exist for these objectives even without the constraints of the pandemic. As with the Plant Wireless Core topic, a potential gap exists for training in Plant Wired Core and Plant Wiring Basics if no qualified instructor/vendor can be secured to deliver on-site, hands-on training.

In the Curriculum Scope and Sequence, Telco Wired Core includes understanding terminology and general concepts, technology trends, and characterization of relevant systems. The Telco Wired subject area includes eight other specific technologies. Of the 13.5 days of training outlined for the subject, a ½ day is allotted to Telco Wired Core. As of now, training in Telco Wired topics has not been pursued because other subjects/topics have been deemed higher priority. However, in this needs assessment the Core area was rated important and top priority for training compared to the other topics in the Telco Wired subject area. Some limited training opportunities for Telco Wired Core objectives are available. Like the discussion above, most if not all training is being offered virtually versus on-site; there is coursework online, self-paced and live instructor led. While the overall aim is to deliver hands-on, in-person training, for a ½ day covering objectives

that would likely be delivered in a simple lecture format, virtual live instructor led training could be acceptable. With all this said, a small gap could be said to exist for the Telco Wired Core objectives.

As has been noted in previous needs assessments, the goal of this project is to meet the professional capacity building needs of Caltrans personnel for rural ITS data communications. One way to do this could be simply utilizing existing training opportunities. In most cases, a gap doesn't exist. However, the task for the project team then becomes how to effectively incorporate existing training opportunities into the Curriculum Scope and Sequence that meet the objectives set forth.

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, many providers do allow flexibility in course content and will customize their training to meet specific learning objectives established by the client.

6. CONCLUSIONS

The subjects and topics addressed in the Curriculum Scope and Sequence 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.

Overall, the group said that training for ITS data communications is important and of priority. Training addressing IP Fundamentals topics is of highest priority both now and in the future. Training for optical fiber and LTE technologies is of high priority as well. The group also indicated that data center design training for TMC / ITS engineers and training addressing core skills in all subjects were of importance.

Several of the higher priority needs for ITS data communications training are currently being met with the existing PCB courses. However, potential gaps open up with challenges securing qualified subject matter experts to deliver on-site courses.

The subjects and topics in the Curriculum generally reflect the state of the practice in regard to ITS data communications. However, the results of the needs assessment indicate that some of the older technologies could potentially be phased out of the Curriculum or training duration reduced. Similarly, some new topics and learning objectives could be added to the Curriculum to accurately reflect the current and future ITS data communications field.

The courses that have been developed and delivered through the project are perceived as useful. The PTAP has already acknowledged that the courses receiving relatively lower perceived usefulness scores need to be revised to better meet training needs. The *Hands-On Ethernet and TCP/IP Fundamentals* course is considered quite important based on current and future project work. The same can be said for *Telecom Wireless Fundamentals* and *Hands-On Advanced IP Networks / Protocols. Mastering Fiber Optic Network Design and Installation* was also rated important based on project work.

Finally, the interactive meeting format was well-received and garnered good responses and participation. The group agreed that it was a good use of time and appreciated seeing the real-time results to the survey questions.

7. NEXT STEPS

This project continues to be a positive step towards providing critical professional capacity building to Caltrans ITS engineers and technicians by way of advanced, technical training. Based on the results of the needs assessment working meeting, the research team suggests the following next steps:

- Share the detailed results of the needs assessment and subsequent gap analysis with the functional managers within the Caltrans Districts and relevant offices. Follow-up discussions may be conducted as needed. The project team should determine if any additional needs assessment should be conducted with District staff and if so what the objectives for the assessment would be. This may include further characterization of the target audience (i.e., repair/maintenance, system implementation, system design, system administration, operations, etc.). Taking a quote from the last needs assessment survey, "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."
- Thoroughly review the Curriculum Scope and Sequence and take an in-depth look at the state of the practice for ITS data communications. The project team could consider compiling a list of technologies being used and the extent of implementation within each District. The Curriculum should be revised based on the current and future ITS data communications technologies of interest to Caltrans. Older technologies (i.e., GSM, GPRS, and CDMA, ISDN, Frame Relay, etc.) could be phased out of the curriculum or the recommended time spent on these topics could be reduced. At the same time, topics and objectives could be added and/or revised to enhance the existing curriculum (i.e., Linux, virtual machine environments, 5G and related technologies, emphasis on network management and security, more troubleshooting skills, scripting languages, etc.).
- Determine the subject/topic for another training course to be developed, procured, and delivered during project phase 5.
- Carefully evaluate how 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 feasible option for developing shorter trainings on a core or specific topic (e.g., Plant Wired Core / Plant Wiring Basics – 2 days, structured cabling for TMCs – 3 days, Plant Wireless Core – 1 day, Telco Wired Core – ½ day, etc.).
- Delivering hands-on and practical, relevant training is of crucial importance. While alternative delivery mechanisms have been considered, the experiences of the PTAP and delivery of the courses to date indicate that on-site delivery by industry recognized experts is the most effective and preferable to such methods as web-based, independent study, or condensed versions. However, given the current circumstances[1], the project team concedes that the IP Fundamentals courses can still be effectively delivered in a virtual environment and should be pursued.

8. REFERENCES

[1] Koon, Leann A.F. and Doug Galarus. *Identified Training Providers, Professional Capacity Building for Communications (Phase 4).* Bozeman, MT: Western Transportation Institute, College of Engineering, Montana State University-Bozeman. Document prepared for the California Department of Transportation, Division of Research, Innovation, and System Information.