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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 Small Data Center Design, Structured Cabling, and Grounding was researched, developed and delivered by subject matter experts to train rural engineers and technicians. Caltrans procured the following additional courses (developed in previous phases of this project) directly from vendors, with WTI's assistance: Three (3) hands-on classes on Transmission Control Protocol/Internet Protocol (TCP/IP) Fundamentals. Four (4) hands-on classes on Telecom Wireless Fundamentals. One (1) hands-on class on Advanced Internet Protocol(IP)/Networks. All these courses help build the professional capacity of rural ITS engineers and technicians to provide them with 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 4

by

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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, and a final report.

The curriculum consisted of five major subjects: Plant Wireless, Telco Wireless, Plant Wired, Telco Wired, and Internet Protocol (IP) Fundamentals. After the needs assessment and gap analysis conducted in Phase 3, as well as input from the Project Technical Advisory Panel (PTAP), a sixth subject was added to the curriculum during this project phase – Small Data Center Design For Transportation Management Centers (TMC). The topic of Machine to Machine Networks was also added to the IP Fundamentals subject area and the topic of Network Security was further enhanced.

This phase of the project focused on developing and procuring training in data center design for TMCs. A formal limited solicitation process was conducted to secure an appropriate training provider and deliver a course in *Small Data Center Design, Structured Cabling, and Grounding.* A subject matter expert delivered 40 hours of training over five days. 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.

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.

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 (1, 2). 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 (1), 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 (Caltrans Contract Number 65A0500). The subject of Telco Wireless was chosen as the training focus for this phase and a course on Telecom Wireless Fundamentals was delivered. Additionally, since the original needs assessment and gap analysis were conducted in Phase 1, they were updated and repeated within Phase 3's project scope (3). The curriculum scope and sequence were also revised based on development of the Telco Wireless course and results of the needs assessment conducted in Phase 3 (4).

At least 83 percent of the respondents to the Phase 3 Gap Analysis and Need Assessment indicated that training was important or very important for all topics and subtopics with the exception of those covering WiMax, which was removed from the curriculum. Similarly, at least 83 percent indicated a desire for training in all topics and subtopics with the exception of WiMax-related topics and frame relay. There is definitely a desire and need for ongoing training, including more advanced training in topics already offered in the first three phases as well as new topics. Structured cabling and machine-to-machine networks have been suggested both by PTAP members and student participants as additional topics of interest. Data center design as related to transportation management centers is an overarching topic area that deserves attention.

These results substantiated the choice to further investigate training curriculums for at least three more courses in Phase 4 of this project. The overall research problem to be addressed in this study was that of determining the detailed content of prospective courses for ITS engineers, identify suitable contractors to deliver the courses, and evaluate the courses. As these courses fall within a larger curriculum for professional capacity building for communication systems, the scope and sequence of the larger curriculum was revisited in light of the results of the prior three phases to determine the content for the development and delivery of these courses. Two of these courses – *Telecom Wireless Fundamentals* and *Hands-On Advanced IP Networks / Protocols* - were procured directly by Caltrans in order to demonstrate the viability of such procurement and to help transition the overall curriculum to a mainstreamed, internal Caltrans process. One course was procured externally by the project team in the same manner used in the prior three phases – *Small Data Center Design, Structured Cabling, and Grounding*.

Several deliverables were completed to address the proposed tasks of this project. The training course and evaluation summaries 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.

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" (8). 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" (8). 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 (9):

> *"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" (10). 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" (10). 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 fourth 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 training topics, determining which courses would be procured directly by Caltrans and which would be procured through this project, 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 4, several options for training course topics were initially presented and discussed. Three subjects/topics were ultimately selected for training development and delivery – Small Data Center Design as Related to Transportation Management Centers (new), Intermediate IP Fundamentals with Emphasis on Machine to Machine Networks and Security (new), and Optical Fiber. After feedback from Caltrans engineers, Optical Fiber was replaced by Telecom Wireless Fundamentals (updated repeat of course offered in Phase 3). After a search for an appropriate provider and desired course content, Caltrans procured an Advanced IP Networks/Protocols training course. Given the breadth of the machine to machine network topic, it was not included in training during this project phase. The project team procured the Small Data Center Design course.

The project team conducted a thorough search for training providers and available training opportunities that covered data center design, structured cabling, and grounding generally, and also as related to TMCs. Based on the results of this search, the project team developed learning objectives for the proposed course as well as identified potential contractors who may be available to deliver such training.

A limited solicitation and detailed Scope of Work were developed and approved. A Request for Bids (RFB) (Appendix B: Request for Bids) 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. *Small Data Center Design, Structured Cabling, and Grounding* was delivered October 8-12, 2018, at the Ron Le Croix Training Center in Woodland, California. The course was taught by Phil Isaak / Isaak Technologies.

Students completed evaluation forms and a pre- and post-test. Members of the project team and the PTAP attended the course. Evaluations and PTAP feedback were compiled and analyzed by the project team.

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 were conducted as part of Phase 1 of this project (2, 1). A second needs assessment was conducted during project Phase 3 (3). 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 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 surveys and gap analyses to update and revise the curriculum scope and sequence (5).

A sixth subject area was added to the curriculum to address data center design related to transportation management centers. This was the focus for the course procured by the project team/WTI during this phase. Network security objectives were enhanced, and the topic was covered in more depth in the new IP Fundamentals course procured by Caltrans (*Hands-On Advanced IP Networks / Protocols)*.

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 4 Revised)* (5). For quick reference, the subject areas and associated topics are outlined below. Also included are notes indicating the major changes to subject areas and topics as the curriculum evolved.

- Plant Wireless
    - Plant wireless core and RF system design
    - 802.11 (WiFi) and related
    - Microwave
    - Short haul radio
    - ~~Privately owned WiMax~~ (*removed in Phase 3*)
- Telco Wireless
    - Telco wireless core and cellular / PCS basics
    - GSM data, GPRS, 3G and Next Generations
    - CDMA data, 3G and Next Generations
    - ~~Telco owned WiMax~~ (*removed in Phase 3*)
    - LTE (Long Term Evolution), 4G and Next Generations *(added in Phase 2)*
- Plant Wired
    - Plant wired core / plant wiring basics
    - Serial connectivity

  - xDSL
  - Optical fiber

- Telco Wired
  - Telco Wired Core (*added in Phase 3*)
  - POTS
  - Analog data circuits
  - ISDN
  - xDSL
  - DS1/ T1
  - Fractional DS1/T1
  - Frame relay
  - MPLS (*added in Phase 3*)

- IP Fundamentals
  - Understanding IP networks / IP Networking Core
  - Local Area Networks (LANs)
  - Wide Area Networks (WANs)
  - Network security
  - Vendor specific equipment training (e.g., Cisco, Juniper, other)

- Small Data Center Design for Transportation Management Centers (*added in Phase 4*)
  - TMC Overview
  - Data center design short course for TMC managers
  - Data center design for TMC / ITS engineers
  - Site and facility tours

1.2. Identified Training Providers

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 4)*. Because of its length and detail, the list is provided as a stand-alone document (6). Caltrans and the members of the PTAP and project team 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. And in Phase 4, the list was again reviewed and updated with those providers that offered training related to data center design and structured cabling.

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 submitted a bid.

SMALL DATA CENTER DESIGN, STRUCTURED CABLING, AND GROUNDING COURSE DELIVERY

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. **Small Data Center Design For Transportation Management Centers** is a new subject area to be added to the curriculum during this project phase, and it was the focus of the new course developed and procured by the project team.

Training in *Small Data Center Design, Structured Cabling, and Grounding* was delivered at the beginning of October 2018. This section describes the design, content, delivery and evaluation of this course.

1.3. Course Design

The design of the TMC data and communication center itself is critical to effective implementation and operation of rural ITS projects. The Small Data Center Design For TMCs subject area includes numerous topics relevant to designing a new TMC data center or upgrading and retrofitting an existing TMC. Given the complexity of the subject area, this course was designed to first review the major aspects of small data center design, including, but not limited to, scoping, infrastructure and layout, electrical and mechanical systems, structured cabling, communications, video distribution systems, and ancillary systems. The majority of the course would then focus on structured cabling and grounding.

The project team conducted a thorough search for training providers and available training opportunities that covered data center design, structured cabling, and grounding generally, and also as related to TMCs. Based on the results of this search, the project team identified potential contractors for this course. Caltrans, Montana State University, and members of the PTAP neither endorse nor disqualify any vendors on this list. (See Appendix A: List of Identified Training Providers – Small Data Center Design, Structured Cabling, Grounding.)

A limited solicitation and detailed Scope of Work for the course in Small Data Center Design, Structured Cabling, and Grounding was developed and approved. A limited solicitation Request for Bids (RFB) was posted and distributed, and bids were accepted. The responses were evaluated based on an approved scoring rubric – selection included factors other than cost. Phil Isaak / Isaak Technologies was chosen to develop the course materials and deliver the training. Appendix B: Request for Bids includes the scoring factors and the detailed Scope of Work.

With input and review by the PTAP, draft materials were developed by the instructor Phil Isaak. Final course materials were approved, and the course was delivered October 8-12, 2018.

1.4. Content

The project team and the PTAP identified important concepts for the Small Data Center Design subject area. Given the complexity of the subject, these concepts were prioritized to fit a five-day training course. Appropriate learning objectives were developed for the prioritized topics and included in the Request for Bids as required content for the course. 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. Training specific to Transportation Management Center (TMC) design was preferred but not required. However, it was expected that some content specific to TMCs would be incorporated as part of customization of the course.

The approved outline for *Small Data Center Design, Structured Cabling, and Grounding* follows.

Note: The text for Sections 5.2.1 through 5.2.9 is taken from the approved Isaak Technologies course outline, the course syllabus, and/or the RFB. Some formatting has been changed to fit the summary document requirements.

1.4.1. Course Title

Small Data Center Design, Structured Cabling, and Grounding

1.4.2. Course Description

TMCs collect and process data from ITS field elements. That data can be used to make decisions and implement management strategies. The TMC also disseminates traveler information to the public. How all of this is accomplished involves many variables, systems, and sub-systems, and varies considerably depending on the specific purpose of the TMC. With that said, there are several concepts and competencies related to small data centers and TMCs that Caltrans ITS engineers should possess and be able to effectively implement.

This full five-day (40 hours) course will establish the need for utilizing a systems engineering approach when designing a small data center for a TMC. After taking this course, students will understand and be able to apply the fundamental elements of an effective design for a new TMC data center as well as for upgrading and retrofitting an existing TMC. Particular attention will be given to structured cabling and grounding as related to TMC data centers. Students will gain an appreciation for the coordination that is required between all engineering disciplines, and gain knowledge in their specific area of expertise.

The course will be highly interactive with over 30% of instructional time spent on hands-on lab exercises. Content will be directly relevant to TMC systems and applications. Lab exercises will include evaluating multiple structured cabling designs to address various network architectures and topologies, designing a new TMC data center, as well as retrofitting and upgrading an existing TMC.

1.4.3. Learning Objectives

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

- Define and explain terminology and general concepts for small data center design.

- Define and explain terminology and general concepts for data center systems as applied to Transportation Management Centers (TMCs).
- Fully understand the importance and critical need for utilizing a systems engineering approach when planning and designing TMC data centers.
- Describe the need for well-documented data centers and understand the risks associated with inadequate documentation.
- Define and explain terminology and general concepts regarding the levels of redundancy for critical systems within the data center.
- Successfully utilize fundamental planning and design concepts for small data centers, including but not limited to, power system considerations (UPS, back-up generator, etc.), HVAC systems, structured cabling, bonding and grounding, etc.
- Discuss and evaluate techniques and best practices for system, technology, and operational integration in a data center / TMC.
- Assess and incorporate strategies to future-proof the data center's design and operation.
- Describe "crosstalk" interference, the cause, and how to minimize it.
- Understand the benefits of utilizing a structured cabling system and risks associated with a point-to-point cabling system.
- Based on current TIA/EIA standards and telecommunication industry best practices, design and thoroughly document an appropriate structured cabling system for the specific needs of the data center, taking into consideration such factors as cable containment, management, and protection.
- Evaluate current structured cabling systems.
- Effectively upgrade and/or retrofit current cabling systems based on established best practices and telecommunications industry standards (TIA/EIA 568, etc.).
- Assess and compare the pros and cons of using different types of cabling in a data center (i.e., copper UTP, STP, Coaxial, fiber optic, etc.).
- Thoroughly test and certify structured cabling systems used in the data center.
- Describe the various components of a telecommunications bonding and grounding system.
- Analyze and describe issues and symptoms associated with a poorly designed or poorly implemented bonding and grounding system.
- Develop and implement approved bonding and grounding methods based on current telecommunication industry standards (TIA 607-B, etc.) and best practices for new and retrofit installations.
- Thoroughly test and certify the performance of a bonding and grounding system based on current telecommunication industry standards (TIA 607-B) and practices.

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

The course will be highly interactive with over 30% of instructional time spent on realistic, hands-on problem solving and lab exercises.

1.4.7. Course Length

Five (5) days = 40 hours

1.4.8. Course Outline and Schedule

Course Modules

1. Project Process
2. Contract Relationships
3. Applications & Systems
4. Reliability & Redundancy (Risk, Reliability and Class Ranking)
5. Network
6. Structured Cabling
7. Computer Room Layout
8. Racks, Cabinets & Pathways
9. Power & Grounding
10. ITE Power & Grounding
11. Cooling
12. Facility
13. Security & Life Safety Systems
14. Monitoring, Controls & Automation
15. Detailed Computer Room Layout & Structured Cabling Lab
16. Commissioning
17. Final Lab

1.4.9. Equipment

- Laptop computer with Javelin PDF Reader, Microsoft Excel, and modern web browser installed.
- Course content accessible with Javelin PDF Reader
- Lab worksheets

1.5. Logistics and Course Delivery

Small Data Center Design, Structured Cabling, and Grounding was held October 8-12, 2018, 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 near lodging and dining options for those traveling from out of town.

The course was taught by Phil Isaak of Isaak Technologies. This contractor was chosen through a formal request for bids.

The student audience consisted of Transportation Electrical Engineers, ITS Engineers, and Electrical Engineers. Students represented five different Caltrans districts. 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 PTAP also attended to observe, facilitate logistics, and evaluate the course.

Table 1: Small Data Center Design, Structured Cabling, and Grounding course students.

Name	District
Mike Beyer	Caltrans District 2
Lonnie Hobbs	Caltrans District 2
Keith Koeppen	Caltrans District 2
David Busler	Caltrans District 3
Andrew Chang	Caltrans District 3
Gurdeep Sidhu	Caltrans District 3
Steven Gee	Caltrans District 5
Gregory Oviedo	Caltrans District 5
Shima Afshari	Caltrans District 6
Samuel Campos	Caltrans District 6
Michael Djaja	Caltrans District 10
Dung "Dave" Q. Le	Caltrans District 10

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. The instructor also distributed an evaluation form for the overall course. Additionally, members of the PTAP and the project team attended the course to observe and evaluate the presentation methods and content.

To evaluate student learning, students took a short quiz at the start of the training. The same quiz was taken again at the end of the training.

1.6.1. Overall Course Evaluations

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 Isaak Technologies 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 surveys as part of the project and whether this course had met their needs and expectations for communications training in small data center design, structured cabling, and grounding.

The complete evaluation form developed by the project team is included in Appendix C: WTI Course and Instructor Evaluation Form.

At the end of the class, the instructor also distributed an overall course and instructor evaluation form. As this course is part of a larger research project, students completed this form in addition to the form discussed above.

On a scale of one (Poor) to five (Excellent), students rated how well the learning objectives were met, the effectiveness of the slides and visuals, and the appropriateness of the technological equipment. The effectiveness of the lab exercises and the usefulness of the lab worksheets were also rated. Students evaluated the technical accuracy of the materials on the same scale. Finally, the students were asked how well the class met their expectations and to rate the class overall.

Students also evaluated the instructor on a one (Poor) to five (Excellent) scale: enthusiasm for class, knowledge of subject matter, clarity of explanations, delivery and presentation skills, demonstrations, effective use of class time, interaction with students, and quality of personalized feedback.

Space was provided to give an example of any rating below average (below 3).

To generally categorize student learning objectives, students were asked to mark the response(s) that best matched why they were taking the course. Options were:

- Improve existing skills or knowledge
- Gain new skills or knowledge
- Prepare for certification exam
- Continuing education requirements
- Meeting condition of employment
- Achieve professional advancement
- Attaining career change

Students were given ample space to discuss whether the course met their expectations and provide any additional comments.

The evaluation form administered by the instructor is included in Appendix D: Isaak Technologies Course and Instructor Evaluation Form.

1.6.2. Student Learning

A Level II evaluation of student learning was conducted via a pre-test and post-test, oral questioning, review questions, and discussion. The 25-question pre-test and post-test were identical and covered basic concepts of data center design, structured cabling, and grounding. The test was put together by the instructor and approved by the PTAP. It was administered by the instructor in the very beginning of the course and again when the course concluded. (See Appendix G: Pre- and Post-Test, Student Learning Measurement.)

Students also had several opportunities to apply what they learned through small-group exercises and all-class problems. The instructor was cognizant of student progress throughout the course and adjusted the content and presentation as needed. In addition, the PTAP considered that adult

learners voluntarily participating in this type of course would likely take the initiative to learn the material.

1.7. Participant Evaluations

The evaluation forms described in the previous section 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 E: Participant Evaluations (WTI) – Small Data Center Design Course and Appendix F: Participant Evaluations (Isaak Technologies) – Small Data Center Design Course.

1.7.1. WTI Evaluations

The majority of students rated the instructor "Very Good" to "Excellent" in every category (Table 2, Figure 1). Students felt he was extremely knowledgeable and experienced in the subject matter and well-prepared for teaching this course. They appreciated his efforts to familiarize himself with TMC facilities and the differences from data centers in other industries. According to most students, the instructor answered questions completely and thoughtfully, and he positively encouraged them to ask questions and discuss content. He organized the materials and managed class time appropriately to keep students engaged, actively learning, and on task to cover all the course content as expected. All students rated the instructor overall either "Excellent" or "Very Good" and strongly indicated that they would likely attend another course taught by this instructor (Table 3, Figure 2). "Phil is probably one of the better instructors I've come across. Good focus, good pace, and he knows his material."

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	9	3	0	0	0	4.8
Presentation skills and delivery	8	3	1	0	0	4.6
Ability to answer questions	9	2	1	0	0	4.7
How well prepared was the instructor?	9	3	0	0	0	4.8
How well did the instructor encourage questions and facilitate discussion?	8	3	1	0	0	4.6
How well did the instructor organize and manage the course to stay on task?	7	3	2	0	0	4.4
Overall rating of instructor	7	5	0	0	0	4.6

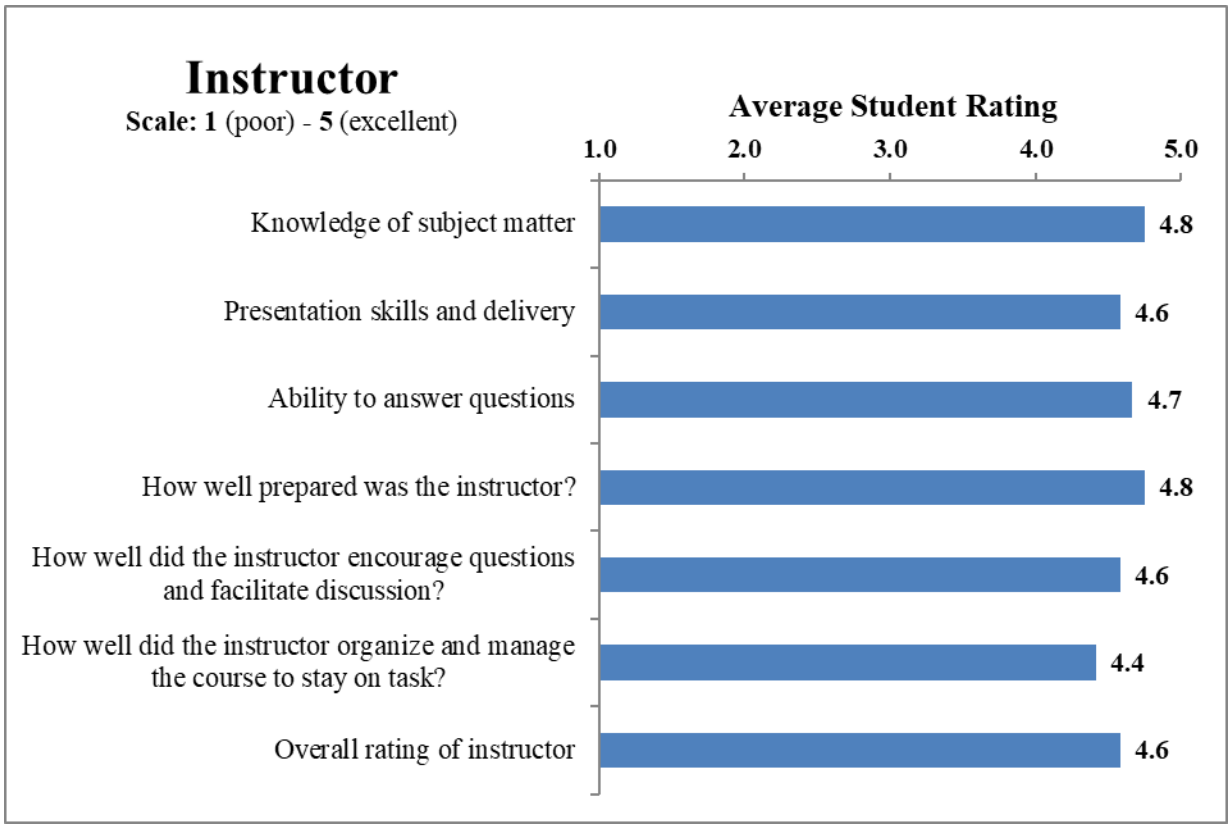

Figure 1: Average instructor ratings.

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
How likely to attend another course by this instructor	7	3	2	0	0	4.4

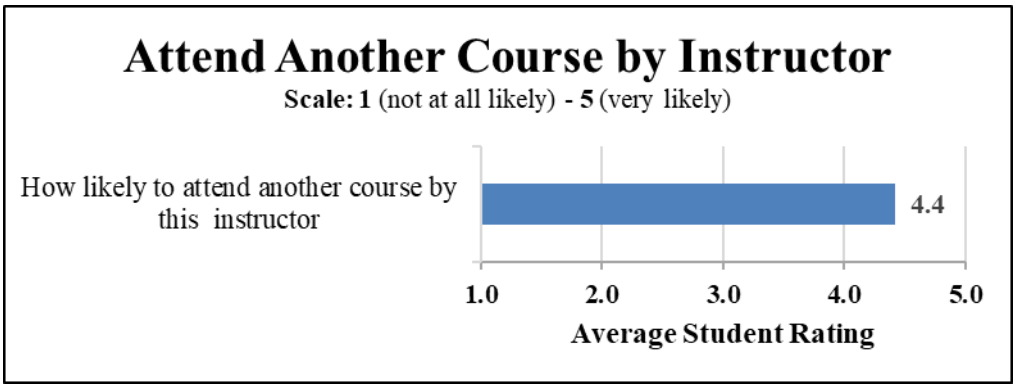

Figure 2: How likely students would attend another course taught by this instructor.

On average, students rated the course organization and structure and how it was delivered between "Very Good" and "Excellent" (Table 4, Figure 3). Students also rated the subject matter and level of detail between "Very Good" and "Excellent." They seemed generally satisfied with the overall content of the course, how easy it was to understand, and how well course objectives were achieved. Students indicated that the course content could be applied to real situations well. "Instructor was very adept at transforming subject matter to meet unique TMC requirements." However, how relevant the course was to students' jobs and whether it met their needs and expectations, were rated slightly lower on average compared to the other ratings for the course. Several students commented that they were expecting more material and hands-on exercises related to structured cabling which could have contributed to slightly lower ratings for the training and content overall. Most students did agree that the correct objectives were targeted and would likely recommend the class to others (Table 5, Figure 4). "It was a great class as far as building a data center but I was expecting more cabling and network design. I learned lots of material that I was not [expecting]." "The course wasn't what I had originally expected, but I learned a lot."

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	4	6	2	0	0	4.2
Subject matter	5	7	0	0	0	4.4
Level of detail	6	6	0	0	0	4.5
Instructional methodology	7	3	2	0	0	4.4
How easy was the course to understand?	5	5	1	1	0	4.2
How relevant was the course to your job?	1	7	3	1	0	3.7
Hands-on activities	4	4	1	2	1	3.7
Application to real situations	5	5	2	0	0	4.3
Presentation structure and organization	7	4	1	0	0	4.5
How well were course objectives achieved?	5	4	3	0	0	4.2
How well did the course meet your expectations?	4	6	1	1	0	4.1
How well did the course meet your needs?	2	5	5	0	0	3.8
Overall quality of course	6	4	2	0	0	4.3

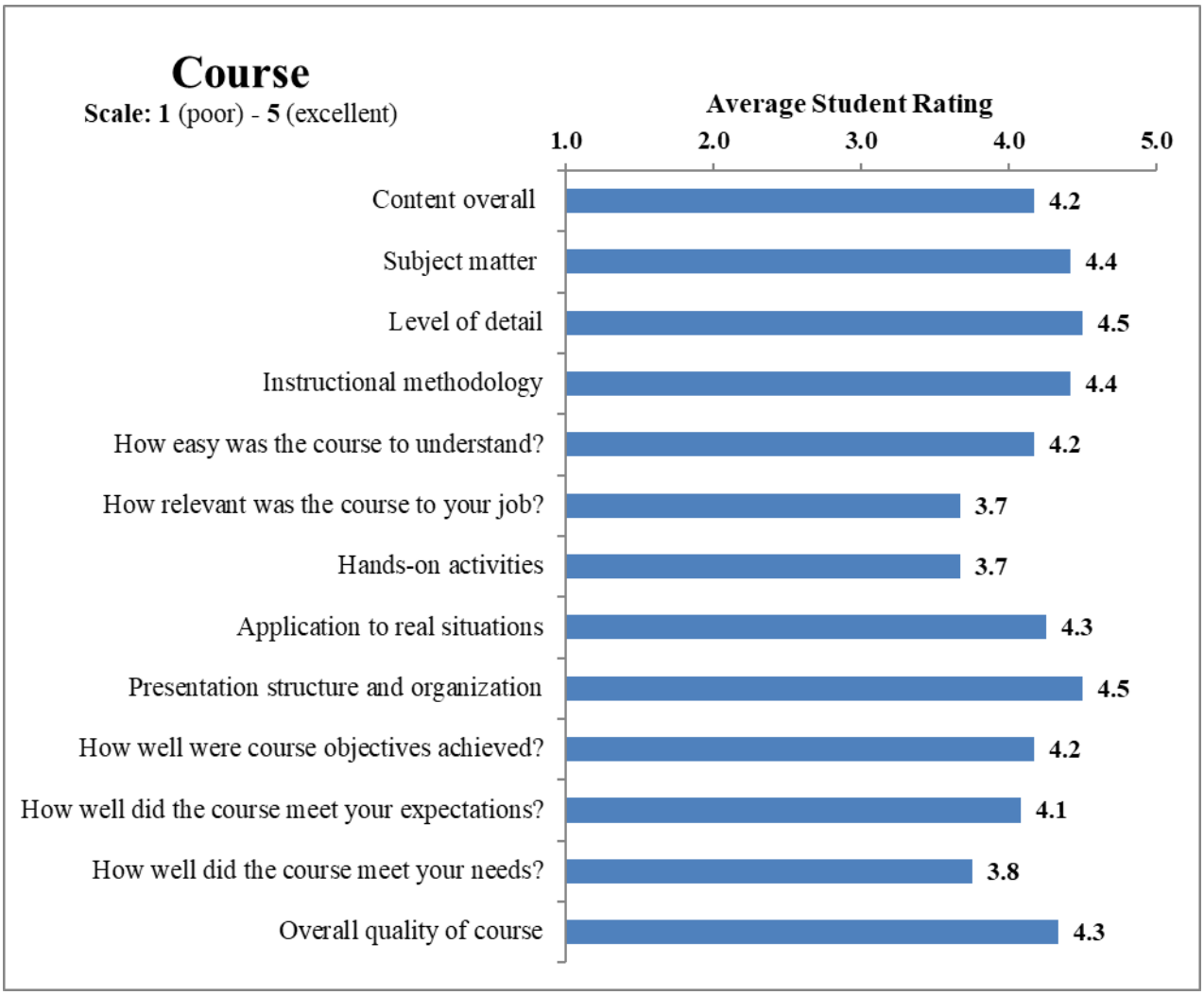

Figure 3: Average course ratings.

Table 5: Number of students agreeing that correct objectives were targeted.

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
Agreement on target objectives	3	7	2	0	0	4.1

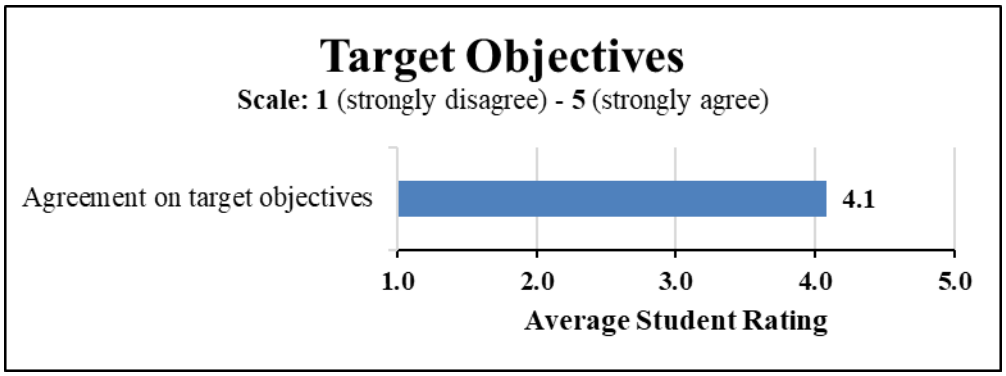

Figure 4: Level of agreement that the correct objectives were targeted.

Hands-on activities have been strongly emphasized throughout all phases of this project. Two-thirds of the students rated the hands-on activities "Very Good" to "Excellent" but one-quarter rated them as "Fair" to "Poor." One student said, "Hands on labs would help to break up the long lectures, but the material did not lend itself too much to that. Perhaps trying to add something related such as Cat 5/6 termination and testing would have been good." Another commented, "The class wasn't what I expected. Could provide more hands-on material."

The class materials received positive ratings, with most ratings at "Very Good." Students indicated they were of overall good quality, easy to understand, well organized and flowed in a logical fashion. They also followed the course presentation well. While 75 percent of the students rated the usefulness and practicality of the materials as "Good" or "Very Good," there was some uncertainty as to the potential value of the materials as future reference material. Based on student comments, this is likely because the materials will only be available electronically versus a printed hard copy or documents that can be printed. "Materials would be better if we had the ability to print or have paper copies." Refer to Table 6 and Figure 5.

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	4	6	2	0	0	4.2
Organization, flow and structure of information	4	6	2	0	0	4.2
How well did the course materials follow the course presentation?	5	6	1	0	0	4.3
Usefulness, practicality of course materials	3	5	4	0	0	3.9
How easy were the materials to understand?	5	5	2	0	0	4.3
Potential value as future reference material	2	5	1	4	0	3.4

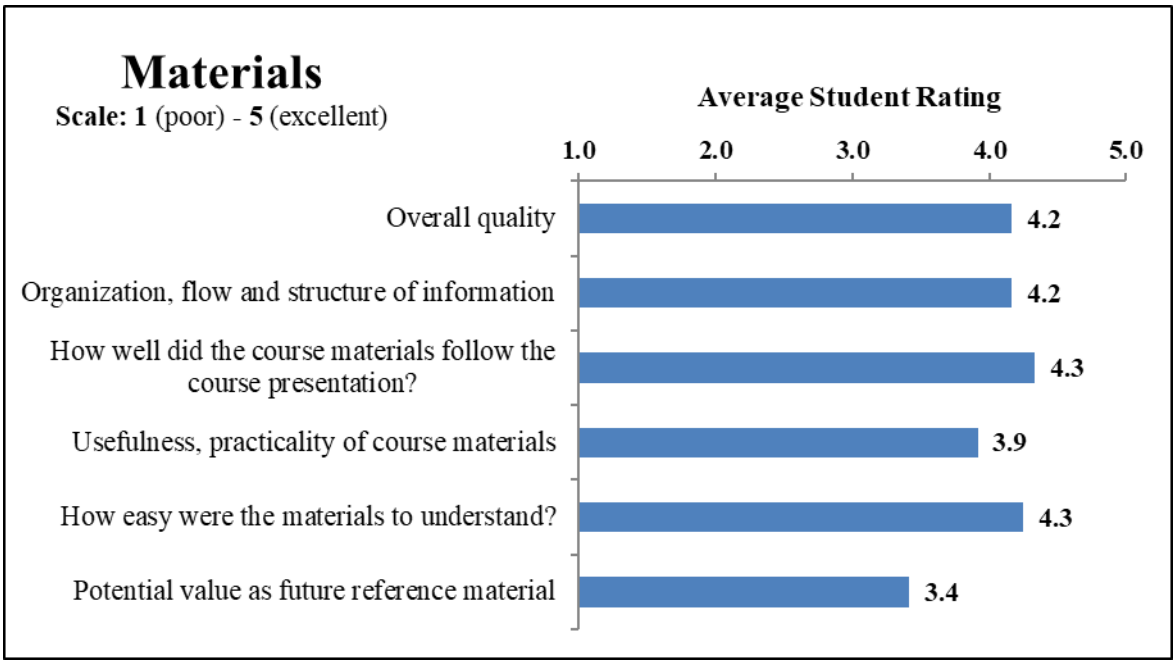

Figure 5: Average ratings for the course materials.

When asked what parts of the course could be applied to students' jobs, the numerous items mentioned covered many aspects of the course. "This course helps identify concerns for reliable

data infrastructure that can be applied across the board in our ITS infrastructure." Rack layout, power and mechanical considerations, cooling, cabling and grounding, UPS upgrades, network room rearrangement, evaluating current capacities, and future capacity planning are some examples of what was learned. The course was timely - one student mentioned that they would be building a TMC in the next five years; another student would be building out and updating existing infrastructure. One student commented, "Collect and log info such as power consumption for network / servers / video systems. This info should come in handy in future design / remodel."

Students mentioned they may have difficulty applying data center design, cooling containment, measurement and placement of rooms/products, and applying large enterprise solutions to the TMC scenario. A couple students indicated that funding resources would make it difficult to make necessary changes and upgrades. One student did comment, "Only because of standard approach used doesn't work as well with ITS/transportation."

Most students were "Satisfied" or "Neutral" regarding the various aspects of course logistics, including location, classroom, course length and pace, and when the course was offered. Students noted that the projector was dim which may have contributed to lower ratings for the classroom. Two students suggested removing some content and providing a three-day course versus five days. See Table 7 and Figure 6.

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	2	4	5	1	0	3.6
Facility/Classroom	2	6	2	1	1	3.6
Course length	2	5	4	1	0	3.7
Pace of course	3	8	1	0	0	4.2
Time of year course was offered	3	6	3	0	0	4.0

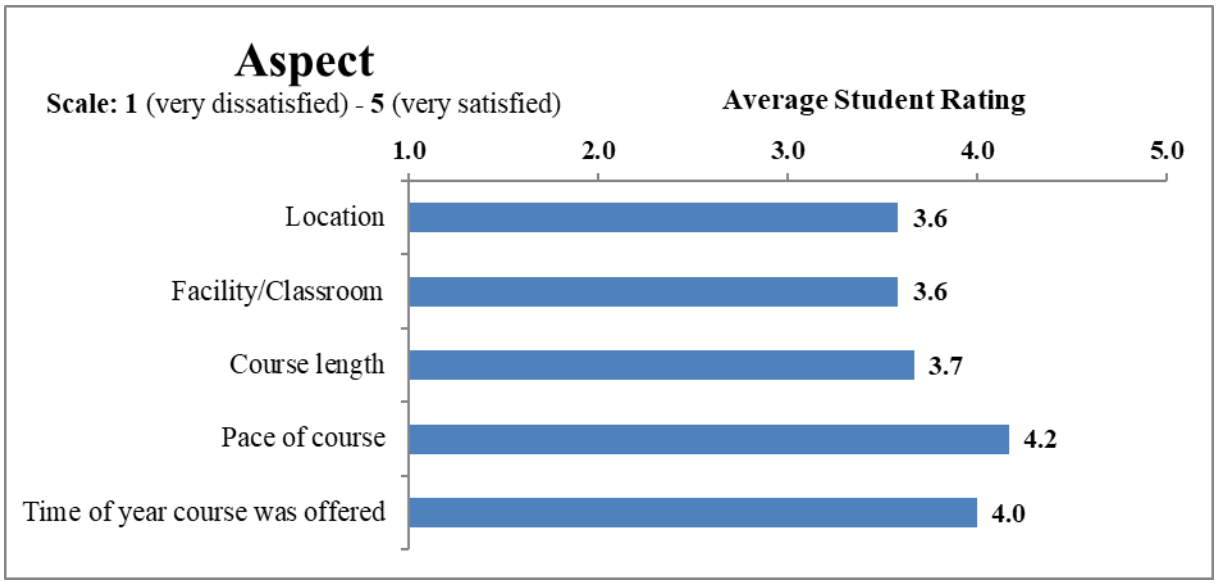

Figure 6: Level of satisfaction with different aspects of course logistics.

All the students indicated they did not or were unsure whether they had participated in either of the needs assessment surveys. The course did meet the expectations of some students who commented, "Yes. Many aspects of the course material were directly applicable; IF, UPS, GenSet, cooling, grounding;" and "Yes, [it applies] to our TMC and ITS server room." A few students indicated that the training only partially met their expectations for communications and TMC design: "Yes – partially. If this was for new Data Center consideration, then my answer would be yes. If looking at it from [the] perspective of existing Data Centers, and specifically being able to improve them, then not really." "Mostly. Expected more on structured cabling and best practices." And one student stated flatly, "This course did not meet my expectations because the material did not have much of a hands-on activity to correlate to." Of note relevant to topic selection for the PCB courses, one student did say, "[It] is good to know about data center design but I am not sure if I [will] even use the knowledge at work." The majority of students said they would be "Very Likely" to participate in another training as part of the Professional Capacity Building for Communications project (Table 8, Figure 7).

Table 8: Number of students likely to participate in another PCB training.

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
	8	2	2	0	0	4.5

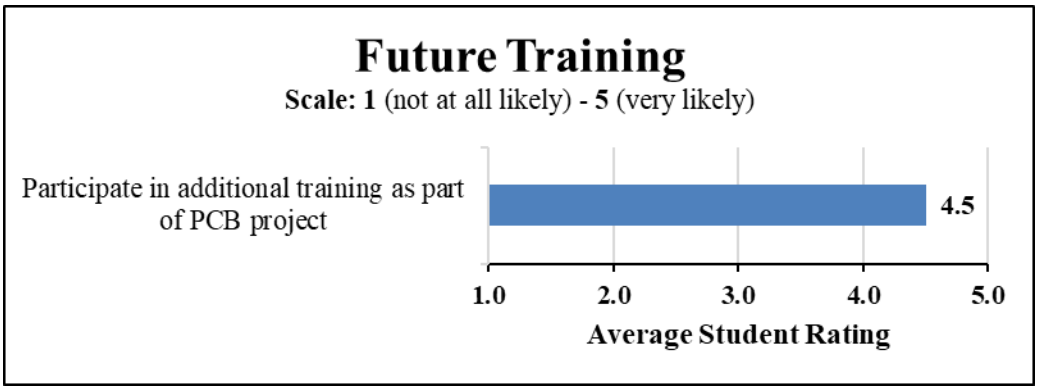

Figure 7: Average ratings for how likely students would participate in another PCB training.

Students also listed ITS communications topics for which they were interested in receiving more training. One student listed hands-on training for "data center creation" while another student suggested "1 to 2-day courses on basics like ideas on network redundancy, remote management; with everything solution-specific and minimum of theory." Other topics listed included: managing ITS elements – database, Wireshark, backbone fiber from the field to the TMC (wireless, microwave), RF / microwave, networking and cabling (more network training, video encoding / decoding technologies, and software programming such as Python.

In summary, ten of the twelve students indicated they would "Likely" or "Definitely" recommend this course to others. (See Table 9, Figure 8.) "Yes, but mostly to someone who may likely be involved in some aspect of a TMC build-out or remodel." Comparatively, "If the course was shorter and more concentrated. Course was too broad." "For many, this may not be an appropriate course. Very good for anybody involved in managing [a] raised-floor environment; which is a lot of senior IT and IT managers [~~do~~]." As final comments, one student said, "Good job is being done putting on these types of training courses." Another student concluded, "Overall good class. Very difficult to approach TMC/Telcom data centers from typical IT enterprise background, but was well done."

Table 9: 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	2	8	2	0	0	4.0

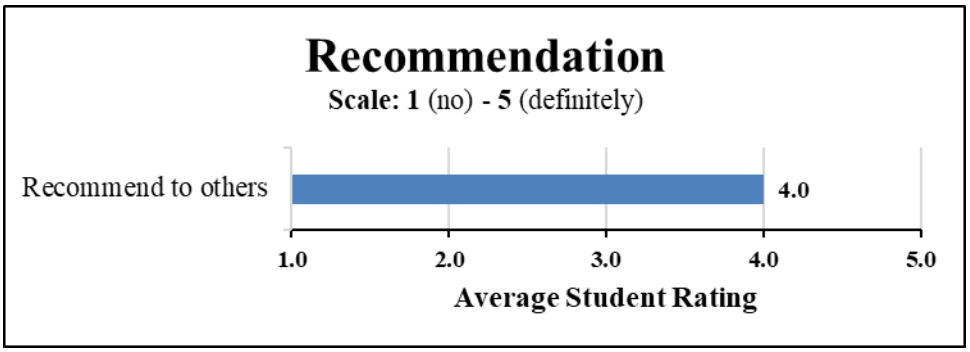

Figure 8: How likely students were to recommend this course to others.

The average rating for each evaluation category are summarized in Figure 9. The full evaluations are in Appendix E: Participant Evaluations (WTI) – Small Data Center Design Course.

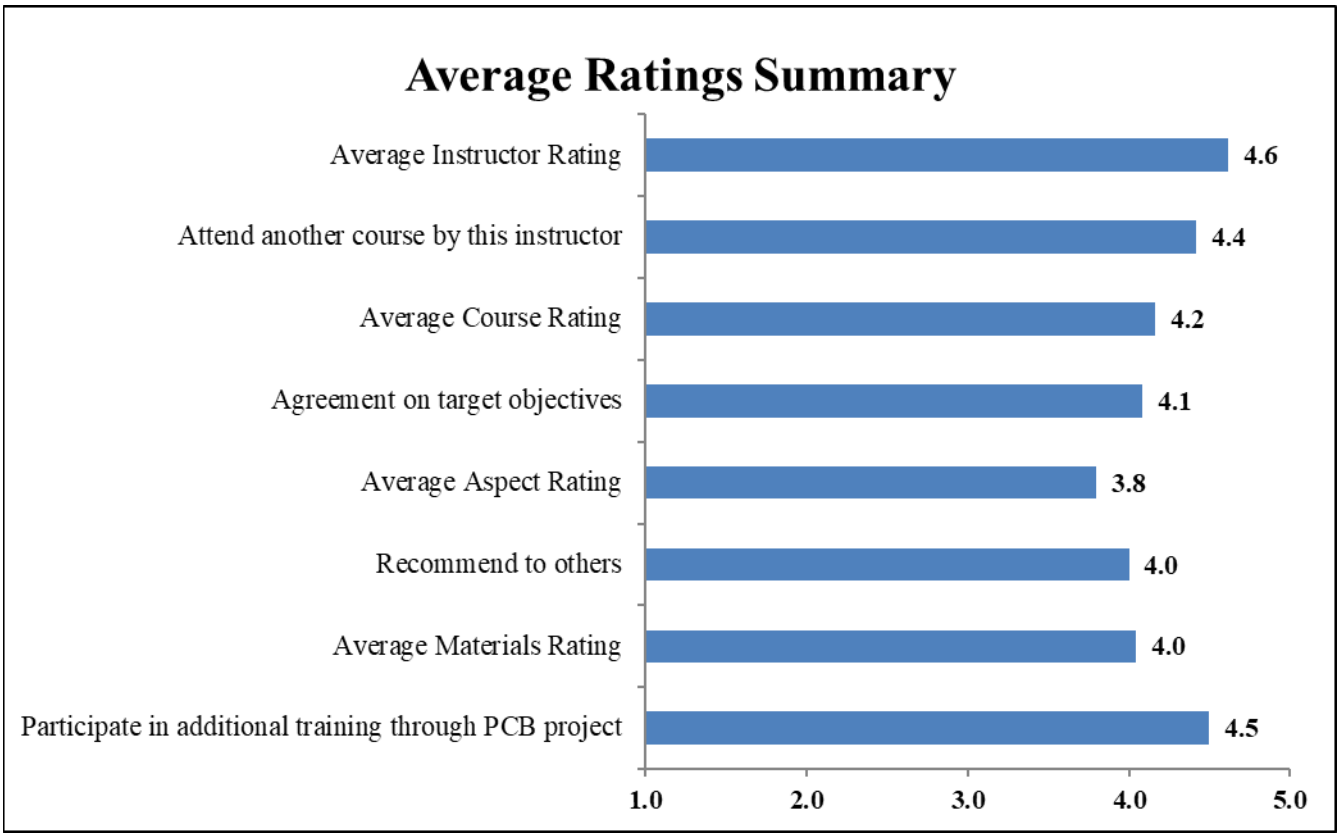

Figure 9: Average student ratings summary.

1.7.2. Isaak Technologies Evaluations

Questions, ratings, and comments were similar to the evaluations described above. Students indicated the instructor was highly knowledgeable, gave clear explanations for methodologies, and provided feedback to students that was relevant to their individual situations. Two-thirds of the

students rated the instructor's enthusiasm, teaching skills, and interaction with them as "Excellent."

The instructor's demonstrations of the lab exercises rated slightly lower on average, but ten of twelve students still rated the demonstrations "Above Average" or "Excellent." Students rated the instructor's use of class time similarly. Refer to Table 10 and Figure 10 below.

The various course ratings for aspects including materials, achieving learning objectives and meeting expectations, were marked "Excellent" by about half of the students and "Above Average" by the other half of the group, with the other one or two ratings at average. The lab exercises showed a slight exception with a few more students rating their effectiveness as "Average." Comments were naturally similar to those on the WTI evaluation forms, but one student did add the following regarding the materials and lab exercises, "Excel sheets can be improved. Maybe use remote access so everyone can see changes."

The overwhelming majority of students rated the class "Excellent" or "Above Average." Three-fourths of the students indicated the course met their expectations. "It was a great class as far as building a data center but I was expecting more cabling and network design. I learned lots of material that I was not [expecting]." See Table 11 and Figure 11 below.

Table 10: Number of students who rated the instructor at each level (Isaak Technologies evaluation).

Instructor	*Number of students who rated the item at each level*						
	5	4	3	2	1	N/A	
	Excellent	Above Average	Average	Below Average	Poor		Average Rating
Enthusiasm for class	8	3	1	0	0	0	4.6
Knowledge of subject matter	10	2	0	0	0	0	4.8
Clarity of explanations	9	3	0	0	0	0	4.8
Delivery and presentation skills	8	3	1	0	0	0	4.6
Exercise demonstrations	6	4	2	0	0	0	4.3
Effective use of class time	7	4	1	0	0	0	4.5
Interaction with students	8	3	1	0	0	0	4.6
Quality of personalized feedback	9	3	0	0	0	0	4.8

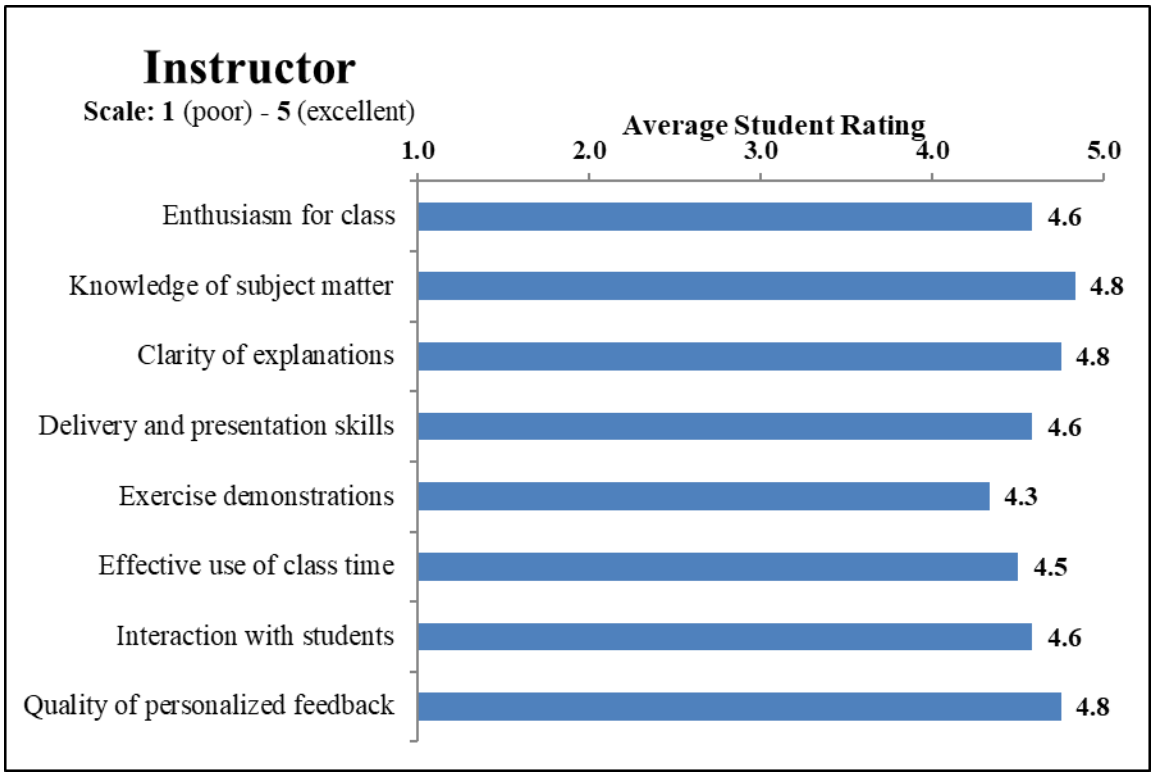

Figure 10: Average instructor ratings (Isaak Technologies evaluation).

Table 11: Number of students rating the course at each level (Isaak Technologies evaluation).

Course	*Number of students who rated the item at each level*						
	5	4	3	2	1	N/A	
	Excellent	Above Average	Average	Below Average	Poor		Average Rating
How well were stated learning objectives met	5	6	1	0	0	0	4.3
How effective were the slides & visuals	6	5	1	0	0	0	4.4
How appropriate was the technological equip	4	5	2	0	0	1	4.2
How effective were the lab exercises	5	3	4	0	0	0	4.1
How useful were the lab worksheets	5	5	2	0	0	0	4.3
How technically accurate were the materials	6	5	0	0	0	1	4.5
How well did the class meet your expectations	5	5	2	0	0	0	4.3
Overall class rating	5	6	1	0	0	0	4.3

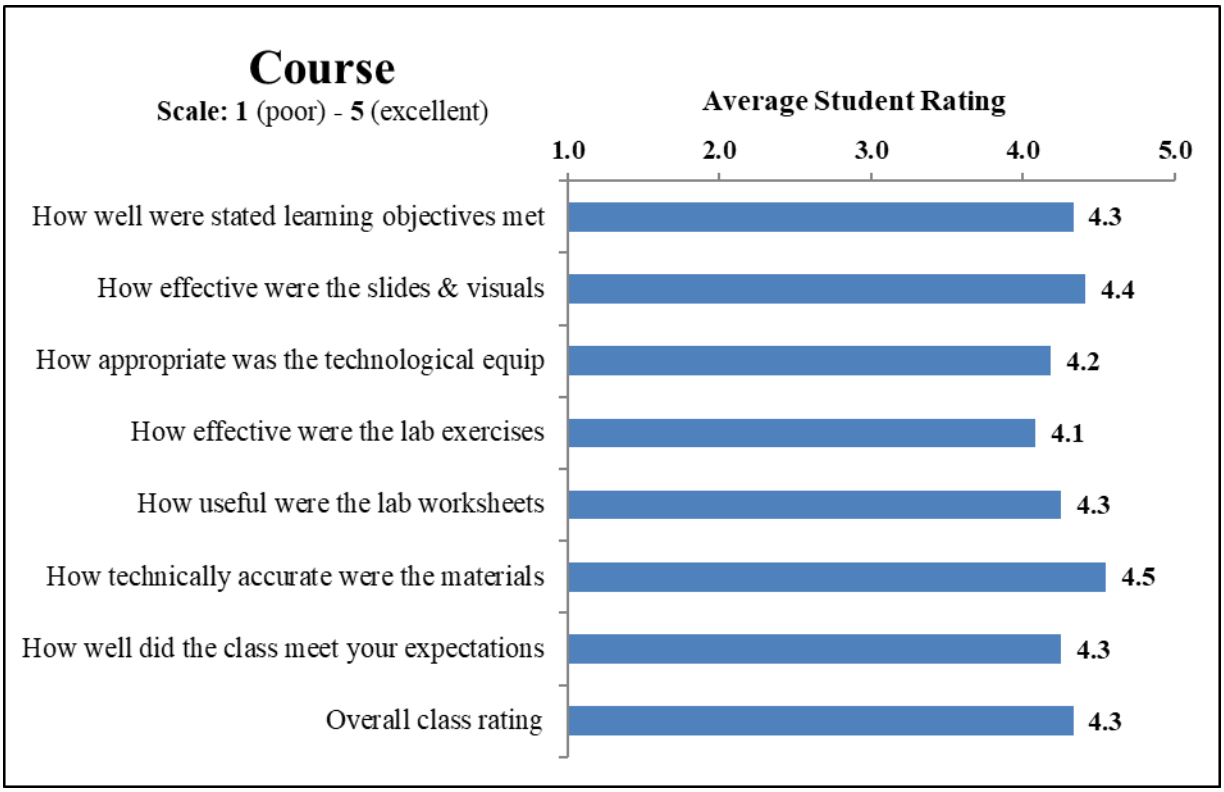

Figure 11: Average course ratings (Isaak Technologies evaluation).

Most students hoped to gain new skills or knowledge or improve upon what they already knew. A few came to advance their professional career and one attended as a condition of employment. The following chart (Figure 12) shows some of the reasons students participated in the training course.

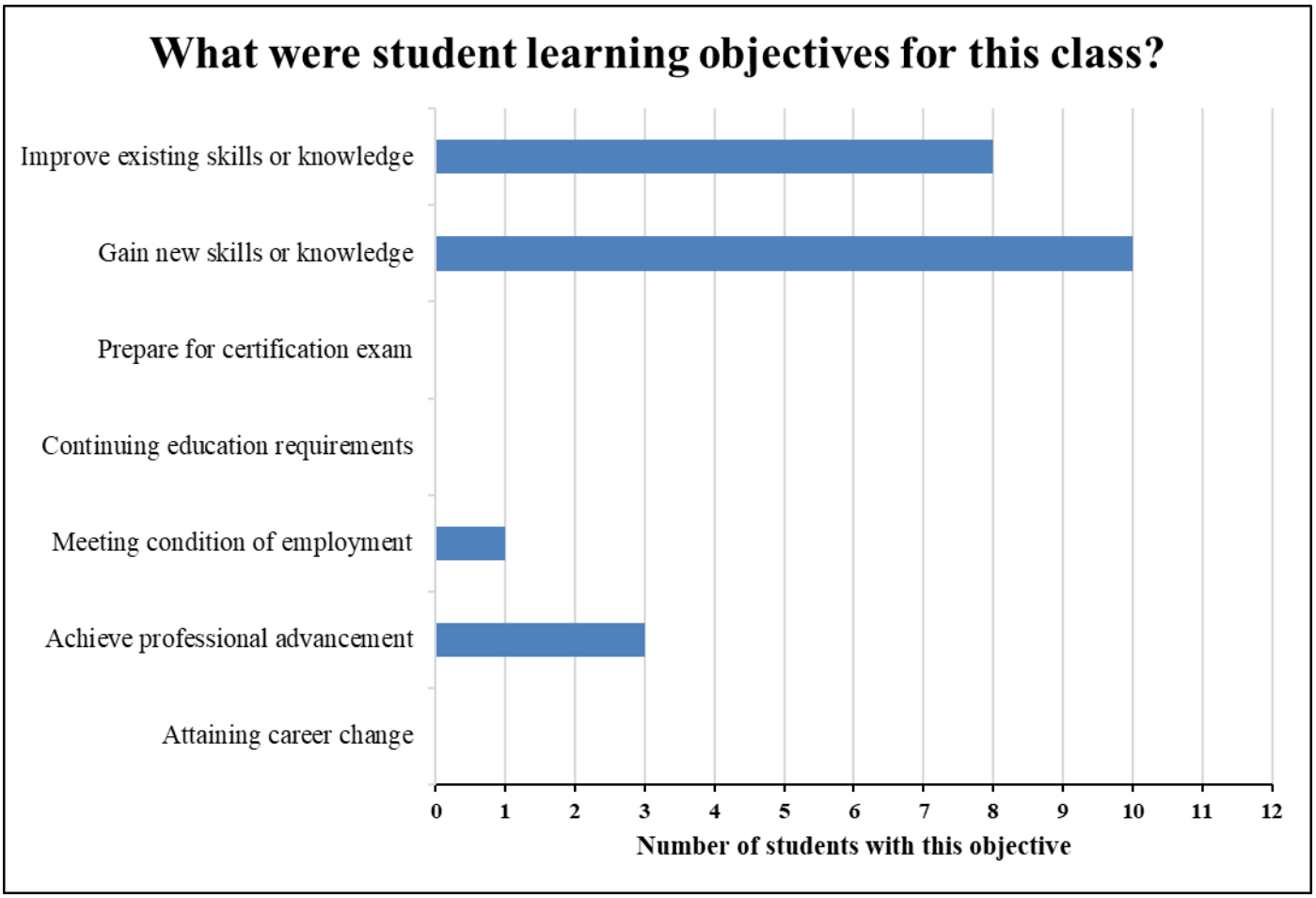

Figure 12: Reasons students participated in the training course based on Isaak Technologies evaluation.

The full evaluations are in Appendix F: Participant Evaluations (Isaak Technologies) – Small Data Center Design Course.

1.8. Project Technical Advisory Panel (PTAP) Evaluation

While participant evaluations were important and provided beneficial feedback, it was very valuable to have members of the PTAP and project team attend the class in a review capacity.

Overall, the PTAP felt the course was very well-received and the entire process of procurement to course delivery went smoothly. The instructor concurred commenting that he would absolutely teach the course again.

- The group was pleased with the amount and level of interaction and discussion. The instructor commented it was more than expected based on his experience with different disciplines.
- A few comments were made relative to the length and overall content of the course:
    - A large amount of content was presented on an aggressive timeline. Acknowledging the instructor's feeling and that of some students that five days was a long time to be in such a class, the PTAP noted that these courses have been purposely designed with a "firehose" effect in mind – 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. Indeed, the courses are designed such that students would be challenged, learn the foundational skills to solve a problem, and leave with the desire, resources, and ability to go back and learn more about topics relevant to their particular challenges.
    - The PTAP chose to focus on data center engineering and design. With that said, a PTAP member indicated that more hands-on activities to "break up the seat time" would be good (e.g., terminating cables, etc.).
    - The instructor mentioned that he felt the final lab exercise could have been improved, perhaps with additional time spent on alternatives and students separated into more groups. Less time could have been spent on lower priority topics to allow additional time for the final exercise and/or structured cabling topics.
    - Other curriculum adjustments discussed were:
        - Spending more time on installation techniques.
        - Reinforcing cabling, installation, maintenance, and operations concepts.
        - Cutting back on chiller system coverage and staying with air cooled systems, mechanical.
        - Further discussion on UPS back-up and related.
- The PTAP indicated that the course was customized appropriately to transportation and TMCs. They appreciated the "on-the-fly" adjustments made by the instructor as needed. Several students validated the amount of customization with comments like, "Yes very pleased to see the level of understanding and modification of course material to our unique infrastructure." On the other hand, some students felt the course was not customized enough, "Courses should be designed more for TMC angle."

- The instructor felt that the TMC tours were very helpful in preparing to teach the course and that they were an overall positive experience. The PTAP agreed. A student commented, "Phil was very knowledgeable in data centers, and I appreciate that he took the time to visit a couple TMCs prior to the class."
- The instructor indicated that the RFB was one of the clearest he had come across regarding expectations and necessary information.
- The time of year the course was delivered was appropriate given work schedules and seasons.
- The course materials were well-organized, detailed, and easy to use. However, the PTAP agreed that a hard copy is preferred. Students appreciated the notepad and pen given the materials were only available electronically. "…Providing a notepad for each class is great, very useful for class."
- The facility and training room were adequate for the course. The PTAP agreed with the students that the projector was dim.
- The instructor commented that he would consider partnering with another instructor to more thoroughly address structured cabling topics. He also indicated that he was aware of individuals who teach this content.

1.9. Student Learning

To get a feel for the effectiveness of the training, students took a 25-question test at the beginning of the course and repeated the same test at the end of the training. The quiz is in Appendix G: Pre- and Post-Test, Student Learning Measurement.

In general, the PTAP felt the pre-test was indicative of the overall lack of knowledge on the topic and underscored the need for the training. The instructor added that the first scores were very typical and he was actually surprised they weren't lower.

Most of the students increased their score from the pre-test to the post-test. (See Figure 13.) Indeed, some students doubled their score which the instructor indicated was not common. This supports the student and PTAP evaluations indicating that the course successfully met the expectations of the training.

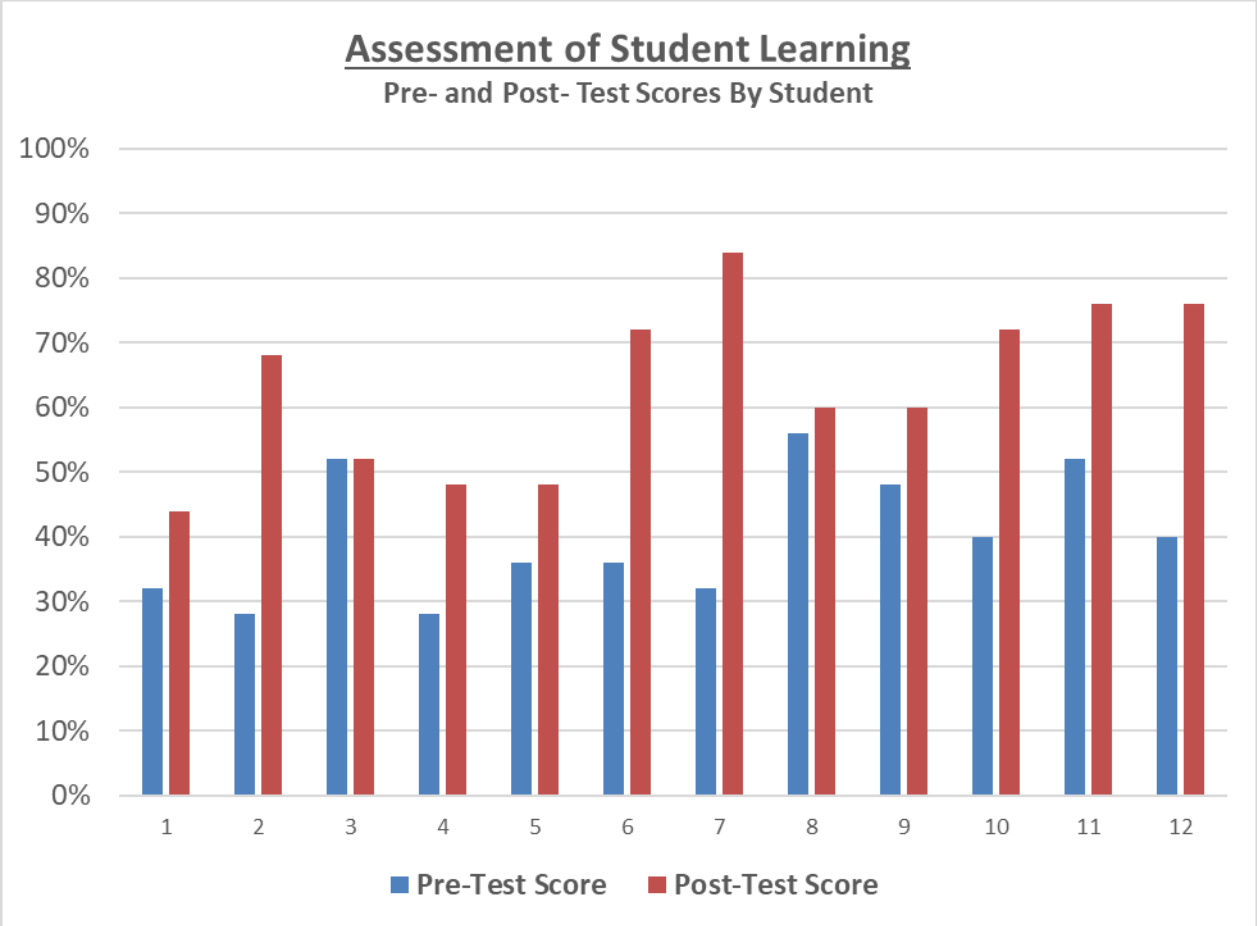

Figure 13: Assessment of student learning, Pre- and Post-Test Scores by student.

1.10. Recommendations

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

- The time of year the course was held seemed appropriate and is likely the best choice. Consistently holding training at this time of year is beneficial. However, the time frame is very close to the end of summer construction season and many rural districts are busy with end of season wrap up on projects. 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. Mid to late April is another option that has been suggested.
- The full week length of the course was appropriate and necessary for this topic and course presentation. Consideration should be given to shifting the start time on the first day of the course to a little later in the morning to accommodate those traveling from longer distances.
- The requirement for a minimum of 25 percent of class time devoted to hands-on activities helped ensure that the course was practical and applicable and not limited to lecture and slide presentations.
- 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 comments and feedback from the course from all perspectives provide evidence that more intense, hands-on structured cabling training is needed, potentially as a separate, direct follow on to this course. Alternatively, the curriculum for this course could be adjusted to 2 - 2.5 days spent on data center design and 2.5 - 3 days addressing structured cabling. If training on this topic is offered again, the PTAP should consider adjusting the course curriculum to better address structured cabling and related content.
- Course materials (i.e., student materials) should be provided in printed form, in color and appropriately bound. Alternatively, course materials should be provided in an electronic format that allows printing and is easily accessible in the future.
- The contractor was selected from several 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 "preview" presentation, which included a description of a hands-on activity, was helpful to confirm the pedagogy of the upcoming course.
- As mentioned above, this instructor's level of knowledge, experience, and ability to deliver were keys to the success 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.
- 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 further recommended that the PTAP contemplate the opportunity to facilitate student certification if the topic and training are appropriate.
- Class size should be about 10 to 12 students to ensure quality of student and teacher interactions. A more effective means of utilizing a waiting list should be implemented.
- It is recommended that the PTAP consider different options for course presentation. One idea may be to conduct three or four days of training with a trainer such as Mr. Isaak and then do a tour(s) or practical field experience at an operational data center, or some combination thereof. The field experience may be led by a Caltrans engineer or other subject matter expert. Tours could be at a rural TMC, urban TMC, or a data center in another industry that was either similar to a TMC or that had a feature or features of particular interest.
- When choosing PCB training offerings, the PTAP might consider additional training presentations. For example, one student from this course suggested, "1 to 2 day courses on basics like ideas on network redundancy, remote management. With everything solution-specific and minimum of theory."
- 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.
- Having project team and PTAP members attend the course was valuable and should be continued in some capacity for future training classes.
- Regarding logistics, 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. Projectors and network connectivity should also be tested in advance and backup arrangements made if needed.

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 4, a new course was developed, procured, and successfully delivered. Caltrans demonstrated the feasibility of the solicitation process by procuring several classes separately, including one with new content. The comprehensive curriculum was also revised. 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 through 4. One aspect that may merit consideration is further specification of the target audience (i.e., repair/maintenance, system implementation, system design, system administration, operations, etc.). The expectation is to continue to deliver relevant, high quality technical content in a challenging environment.
- Five training courses have been developed and delivered to date through this project. Competent instructors and subject matter experts have already been identified and content is well established. Caltrans has used those instructors and course content to procure additional training for ITS engineers. How best to utilize what has already been done and not "reinvent the wheel" is still an important consideration for continued professional capacity building for communications.
- 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 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, structured cabling for TMCs – 3 days, etc.).
- If additional training is developed through a future project phase, the PTAP has several options to consider in terms of content: a) repeat a previously offered course in full or go into more depth on a particular topic(s) from a previous course; b) offer more intermediate or possibly advanced training in topics already addressed (i.e., RF Engineering, IP fundamentals); c) try again to secure a subject matter expert and deliver a course in Plant Wired core / plant wiring basics, serial connectivity, xDSL; and/or d) develop a course in a new subject / topic. This decision should be guided by the needs of Caltrans engineers.
- 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 – SMALL DATA CENTER DESIGN, STRUCTURED CABLING, GROUNDING

The following list is a dynamic document. It includes identified vendors and training providers that appear to have the qualifications listed in the 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. It should be noted that this list represents a best effort and that 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.

1.11. BICSI

Name:	BICSI					
Address:	BICSI 8610 Hidden River Parkway Tampa, FL 33637					
Telephone:	813.979.1991					
Website:	https://www.bicsi.org					
Individual Contact:	Michele Sidlasky, Training Sales Manager msidlasky@bicsi.org sales@bicsi.org +1 813.979.1991					
Topics:	*Plant Wireless*	*Telco Wireless*	*Plant Wired*	*Telco Wired*	*IP Networking*	*Small Data Center Design for TMCs*
			✓			✓
Notes:	5.2.9					
	RF System Design	*Optical Fiber*	*Plant Wired Core/Serial/ xDSL*	*IP Networking*	*Telco Wireless*	*SDC Design, Cabling*
Received RFB?		✓	✓			✓
Submitted Bid?		✓				

1.12. Capitoline

Name:	Capitoline
Address:	
Telephone:	
Website:	https://www.capitoline.org/

Individual Contact:	Matt Flowerday, Director, mflowerday@capitoline.org					
Topics:	*Plant Wireless*	*Telco Wireless*	*Plant Wired*	*Telco Wired*	*IP Networking*	*Small Data Center Design for TMCs*
						✓
Notes:	RFB Sent					
	RF System Design	*Optical Fiber*	*Plant Wired Core/Serial/ xDSL*	*IP Networking*	*Telco Wireless*	*SDC Design, Cabling*
Received RFB?						✓
Submitted Bid?						

1.13. CNet Training

Name:	CNet Training
Address:	Park Farm Business Centre Fornham St Genevieve Suffolk IP28 6TS United Kingdom
Telephone:	+44 (0)1284 767100
Website:	http://cnet-training.com
Individual Contact:	Matt Hawkins, Global Account Director MHawkins@cnet-training.com Sales: CourseAdmin@cnet-training.com; sales@cnet-training.com; info@cnet-training.com

Topics:	*Plant Wireless*	*Telco Wireless*	*Plant Wired*	*Telco Wired*	*IP Networking*	*Small Data Center Design for TMCs*
	✓	✓	✓	✓	✓	✓
Notes:						
	RF System Design	*Optical Fiber*	*Plant Wired Core/Serial/ xDSL*	*IP Networking*	*Telco Wireless*	*SDC Design, Cabling*
Received RFB?						✓
Submitted Bid?						

1.14. CTS – Cabling and Technology Services

Name:	CableCTS CTS
Address:	2720 S Ash St. Tacoma, WA 98409
Telephone:	206-686-2000
Website:	http://cablects.com/
Individual Contact:	customerservice@cableCTS.com

Topics:	*Plant Wireless*	*Telco Wireless*	*Plant Wired*	*Telco Wired*	*IP Networking*	*Small Data Center Design for TMCs*
			✓			✓
Notes:	RFB Sent					

	RF System Design	*Optical Fiber*	*Plant Wired Core/Serial/ xDSL*	*IP Networking*	*Telco Wireless*	*SDC Design, Cabling*
Received RFB?						✓
Submitted Bid?						

1.15. DC Professional

Name:	DC Professional (DCPRO)
Address:	
Telephone:	(212) 404-2378
Website:	https://www.dc-professional.com/ https://www.dcpro.training/in-house-training
Individual Contact:	Liam Moore liam.moore@dc-professsional.com customer-service@dc-professional.com

Topics:	*Plant Wireless*	*Telco Wireless*	*Plant Wired*	*Telco Wired*	*IP Networking*	*Small Data Center Design for TMCs*
						✓
Notes:	RFB Sent					

	RF System Design	*Optical Fiber*	*Plant Wired Core/Serial/ xDSL*	*IP Networking*	*Telco Wireless*	*SDC Design, Cabling*
Received RFB?						✓
Submitted Bid?						

1.16. ENO.com

Name:	ENO.com
Address:	E&A Information Services Inc. 6 St. Charles Ct Stafford, VA 22556 USA
Telephone:	(540) 720-9660
Website:	http://www.eno.com
Individual Contact:	Jim Cummings eainfo@eno.com Janey Sears salesinfo@eno.com Ph. 540-720-9660 Fax: 540-720-9664 Andrew Russell Email: corporateinfo@eno.com Ph. 540-720-9660 Fax. 540-720-9664

Topics:	*Plant Wireless*	*Telco Wireless*	*Plant Wired*	*Telco Wired*	*IP Networking*	*Small Data Center Design for TMCs*
	✓	✓	✓	✓	✓	✓

Notes:

	RF System Design	*Optical Fiber*	*Plant Wired Core/Serial/ xDSL*	*IP Networking*	*Telco Wireless*	*SDC Design, Cabling*
Received RFB?			✓	✓	✓	✓
Submitted Bid?						

1.17. EPI

Name: EPI

Address:	P O Box 548 3510 Viola Drive Aromas, CA 95004 The United States of America
Telephone:	+1-877-318-5344; +1 877 318 534
Website:	http://www.epi-ap.com/
Individual Contact:	David Montalbano, President, EPI-USA, david@epi-ap.com

Topics:	*Plant Wireless*	*Telco Wireless*	*Plant Wired*	*Telco Wired*	*IP Networking*	*Small Data Center Design for TMCs*
						✓
Notes:	RFB Sent					

	RF System Design	*Optical Fiber*	*Plant Wired Core/Serial/ xDSL*	*IP Networking*	*Telco Wireless*	*SDC Design, Cabling*
Received RFB?						✓
Submitted Bid?						

1.18. Fast Lane

Name:	Fast Lane
Address:	Grove Business Park Waltham Road, White Waltham SL6 3LW Maidenhead United Kingdom
Telephone:	612-205-9052
Website:	www.fastlaneus.com
Individual Contact:	Dan Walser, Director Strategic Accounts dan.walser@fastlaneus.com enquiries@flane.co.uk

Topics:	*Plant Wireless*	*Telco Wireless*	*Plant Wired*	*Telco Wired*	*IP Networking*	*Small Data Center Design for TMCs*
			✓	✓	✓	✓
Notes:	RFB Sent, Bill, Swiss, training mostly for their products, but potential for other. Contact maybe. Looks like a distribution/Sales spot relatively close to here and of course in CA.					

	RF System Design	*Optical Fiber*	*Plant Wired Core/Serial/ xDSL*	*IP Networking*	*Telco Wireless*	*SDC Design, Cabling*
Received RFB?			✓	✓		✓
Submitted Bid?						

1.19. Huber+Suhner

Name:	Huber+Suhner
Address:	8530 Steele Creek Place Drive Suite H NC 28273 Charlotte
Telephone:	612-205-9052
Website:	https://www.hubersuhner.com/
Individual Contact:	Amy Dunton, Data Center Regional Account Manager amy.dunton@hubersuhner.com (612) 205-9052 info.na@hubersuhner.com

Topics:	*Plant Wireless*	*Telco Wireless*	*Plant Wired*	*Telco Wired*	*IP Networking*	*Small Data Center Design for TMCs*
			✓	✓	✓	✓
Notes:						

	RF System Design	*Optical Fiber*	*Plant Wired Core/Serial/ xDSL*	*IP Networking*	*Telco Wireless*	*SDC Design, Cabling*
Received RFB?			✓			✓
Submitted Bid?						

1.20. International Data Center Authority (IDCA)

Name:	International Data Center Authority (IDCA)
Address:	7300 Calhoun Pl., Suite 100 Rockville, MD 20855, USA
Telephone:	+1 (866) 422 1971
Website:	https://www.idc-a.org/
Individual Contact:	Subhan Jahromi, Public Relations Director subhan@idc-a.org

Topics:	*Plant Wireless*	*Telco Wireless*	*Plant Wired*	*Telco Wired*	*IP Networking*	*Small Data Center Design for TMCs* ✓
Notes:						

	RF System Design	*Optical Fiber*	*Plant Wired Core/Serial/ xDSL*	*IP Networking*	*Telco Wireless*	*SDC Design, Cabling*
Received RFB?						✓
Submitted Bid?						✓

1.21. Isaak Technologies, Inc.*

Name:	Isaak Technologies, Inc.
Address:	
Telephone:	1 (888) 838-0411
Website:	http://www.isaaktech.com/home.html
Individual Contact:	Phil Isaak, President phil.isaak@isaaktech.com support@isaaktech.com

Topics:	*Plant Wireless*	*Telco Wireless*	*Plant Wired*	*Telco Wired*	*IP Networking*	*Small Data Center Design for TMCs* ✓
Notes:						

	RF System Design	*Optical Fiber*	*Plant Wired Core/Serial/ xDSL*	*IP Networking*	*Telco Wireless*	*SDC Design, Cabling*
Received RFB?						✓
Submitted Bid?						✓

*Winning bidder for Small Data Center Design, Structured Cabling, and Grounding training course.

1.22. New Instruction, LLC

Name:	New Instruction, LLC
Address:	New Instruction, LLC 615 Valley Road Montclair, NJ 07043
Telephone:	(973) 746-7010
Website:	http://www.newinstruction.com
Individual Contact:	Maria Esteves Director of Training maria@newinstruction.com 973-744-3339

Topics:	*Plant Wireless*	*Telco Wireless*	*Plant Wired*	*Telco Wired*	*IP Networking*	*Small Data Center Design for TMCs*
	✓	✓	✓	✓	✓	✓
Notes:						

	RF System Design	*Optical Fiber*	*Plant Wired Core/Serial/ xDSL*	*IP Networking*	*Telco Wireless*	*SDC Design, Cabling*
Received RFB?		✓	✓			✓
Submitted Bid?		✓				

1.23. Option Train College

Name:	Option Train College
Address:	20 Eglinton Ave East, Suite 390 Toronto,ON M4P1A9
Telephone:	(416) 486-6555
Website:	https://www.optiontrain.com/index.php
Individual Contact:	info@optiontrain.com

Topics:	*Plant Wireless*	*Telco Wireless*	*Plant Wired*	*Telco Wired*	*IP Networking*	*Small Data Center Design for TMCs*
						✓
Notes:						

	RF System Design	*Optical Fiber*	*Plant Wired Core/Serial/ xDSL*	*IP Networking*	*Telco Wireless*	*SDC Design, Cabling*
Received RFB?						✓
Submitted Bid?						

1.24. Perpetual Solutions

Name:	Perpetual Solutions
Address:	Perpetual Solutions Tuition House 27-37 St Georges Road, London SW19 4DS
Telephone:	(408) 759-5074
Website:	http://www.perpetual-solutions.com
Individual Contact:	Juan Calvo juan.calvo@perpetual-solutions.com Constantine Galatis constantine.galatis@perpetual-solutions.com Sam Hurrell Senior Account Manager Telephone: + 44 (0) 207 620 0033 Ext: 2126542 Fax: + 44 (0) 207 620 0055 Email: sam.hurrell@perpetual-solutions.com Address: Tuition House, 27-37 St Georges Road, Wimbledon, London, SW19 4DS

Topics:	*Plant Wireless*	*Telco Wireless*	*Plant Wired*	*Telco Wired*	*IP Networking*	*Small Data Center Design for TMCs*
	✓	✓	✓	✓	✓	✓

Notes:

	RF System Design	*Optical Fiber*	*Plant Wired Core/Serial/ xDSL*	*IP Networking*	*Telco Wireless*	*SDC Design, Cabling*
Received RFB?		✓	✓	✓	✓	✓
Submitted Bid?						

1.25. Society of Cable Telecommunications Engineers

Name:	Society of Cable Telecommunications Engineers (SCTE)
Address:	140 Philips Road Exton, PA 19341-1318
Telephone:	1- 800-542-5040
Website:	https://www.scte.org/
Individual Contact:	Steve Harris Senior Director – Technical Education sharris@scte.org profdev@scte.org

Topics:	*Plant Wireless*	*Telco Wireless*	*Plant Wired*	*Telco Wired*	*IP Networking*	*Small Data Center Design for TMCs*
		✓	✓		✓	✓

Notes:

	RF System Design	*Optical Fiber*	*Plant Wired Core/Serial/ xDSL*	*IP Networking*	*Telco Wireless*	*SDC Design, Cabling*
Received RFB?						✓
Submitted Bid?						

1.26. Tavcom Training

Name:	Tavcom Training
Address:	Unit 10 Claylands Park Claylands Road Bishops Waltham, Hampshire SO32 1QD
Telephone:	+44 (0)1489 895099
Website:	http://www.tavcom.com
Individual Contact:	Andrew Saywell, Business Development Manager andrew@tavcom.com sales@tavcom.com

Topics:	*Plant Wireless*	*Telco Wireless*	*Plant Wired*	*Telco Wired*	*IP Networking*	*Small Data Center Design for TMCs*
					✓	✓

Notes:

	RF System Design	*Optical Fiber*	*Plant Wired Core/Serial/ xDSL*	*IP Networking*	*Telco Wireless*	*SDC Design, Cabling*
Received RFB?						✓
Submitted Bid?						

1.27. TechSherpas

Name:	TechSherpas
Address:	5404 Cypress Center Drive Suite 125 Tampa, FL 33609
Telephone:	(866) 704-9244
Website:	https://www.techsherpas.com/
Individual Contact:	info@techsherpas.com

Topics:	*Plant Wireless*	*Telco Wireless*	*Plant Wired*	*Telco Wired*	*IP Networking*	*Small Data Center Design for TMCs*
						✓

Notes:

	RF System Design	*Optical Fiber*	*Plant Wired Core/Serial/ xDSL*	*IP Networking*	*Telco Wireless*	*SDC Design, Cabling*
Received RFB?						✓
Submitted Bid?						

1.28. TONEX

Name:	TONEX
Address:	1400 Preston Rd., Suite 400 Plano, Texas 75093
Telephone:	1-972-665-9786
Website:	http://www.tonex.com
Individual Contact:	Howard J Gottlieb Phone: 214-762-6673 Fax: 972-692-6829

hgottlieb@tonex.com

Simone Giacometti
Tonex, Inc.
+1-310-622-9362 Direct
+1-972-692-7492 Fax
sgiacometti@tonex.com
www.tonex.com

Topics:	*Plant Wireless* ✓	*Telco Wireless* ✓	*Plant Wired* ✓	*Telco Wired* ✓	*IP Networking* ✓	*Small Data Center Design for TMCs* ✓
Notes:	Provide many training courses covering most subjects for each topic with hands on activities. Delivered Telco Wireless course.					

	RF System Design	*Optical Fiber*	*Plant Wired Core/Serial/ xDSL*	*IP Networking*	*Telco Wireless*	*SDC Design, Cabling*
Received RFB?	✓	✓	✓	✓	✓	✓
Submitted Bid?	✓				✓	✓

1.29. TRA

Name: TRA

Address:

Telephone:

Website: https://www.tra.com/

Individual Contact: Steve Wages
swages@tra.com

Topics:	*Plant Wireless* ✓	*Telco Wireless* ✓	*Plant Wired*	*Telco Wired*	*IP Networking*	*Small Data Center Design for TMCs* ✓
Notes:	RFB Sent, Email sent to Steve Wages, some network security match					

	RF System Design	*Optical Fiber*	*Plant Wired Core/Serial/ xDSL*	*IP Networking*	*Telco Wireless*	*SDC Design, Cabling*

Received RFB?	✓
Submitted Bid?	

1.30. Webucator

Name:	Webucator
Address:	Webucator, Inc. 201 West Genesee Street Suite 113 Fayetteville, NY 13066-1313 USA
Telephone:	1-877-932-8228
Website:	http://www.vdvacademy.com/
Individual Contact:	Allison Kenien, Sales and Marketing Manager akenien@webucator.com sales@webucator.com

Topics:	*Plant Wireless*	*Telco Wireless*	*Plant Wired*	*Telco Wired*	*IP Networking*	*Small Data Center Design for TMCs*
						✓

Notes:

	RF System Design	*Optical Fiber*	*Plant Wired Core/Serial/ xDSL*	*IP Networking*	*Telco Wireless*	*SDC Design, Cabling*
Received RFB?						✓
Submitted Bid?						

APPENDIX B: REQUEST FOR BIDS

PD-46
Rev 11/12/13

REQUEST FOR WRITTEN BIDS

State of Montana **LIMITED SOLICITATION FORM** **AGENCY** **Montana State University**	Solicitation Number: _____414030-1402_____ Solicitation Title: Professional Capacity Building for Communication System Course Delivery - Small Data Center Design, Structured Cabling, and Grounding Training MSU Dept. Contact: Leann Koon 1-406-994-7643, leann.koon@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: _____

Signed W-9 is required prior to any award.

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@montana.edu** until **2:00 pm (Bozeman time) on May 15, 2018**. The following documents are attached to this solicitation and will be applicable to the resultant contract: **Exhibit A Requirements and Scope of Services; Deliverables, Due Dates, Payment; Standard Terms and Conditions**; **and Exhibit B Blank Contracted Services Agreement.**

Instructions and Requirements/ Scope of Services are stated on pages 3-11.

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 _____

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PD-46
Rev 11/12/13

SEE STANDARD TERMS AND CONDITIONS ON PAGES 12 AND 13

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
3. Section 3.3 Instructor – 25 points
4. Section 3.4 Company Qualifications – 25 points
5. 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 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.

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EXHIBIT A
REQUIREMENTS AND SCOPE OF SERVICES

Professional Capacity Building for Communications Systems
Phase 4

Small Data Center Design, Structured Cabling, and Grounding Training

1. BACKGROUND AND REQUIREMENTS

MSU is seeking to purchase the delivery of a training course in Small Data Center Design, Structured Cabling, and Grounding for Rural Intelligent Transportation Systems (ITS) 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 will be delivered by an experienced instructor(s) with hands-on design and implementation experience in the technologies to be presented.

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. The design of the TMC data and communication center itself is critical to effective implementation and operation 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. For this course, special emphasis will be placed on the design of rural TMCs and their integration with rural communication networks.

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. **Small Data Center Design as Related to Transportation Management Centers** is one subject area and is the focus of this solicitation. This course is intended to first review the major aspects of small data center design, including, but not limited to, scoping, infrastructure and layout, electrical and mechanical systems, structured cabling, communications, video distribution systems, and ancillary systems. The majority of this course will focus on structured cabling and grounding.

This solicitation document defines the scope and sequence for **one course** that provides training for **small data center design, structured cabling, and grounding**. Training specific to Transportation Management Center (TMC) design is preferred but not required. However, it is expected that some content specific to TMCs will be incorporated as part of customization of the course.

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 Small Data Center Design as Related to TMCs subject area includes numerous topics relevant to designing a new TMC data center or upgrading and retrofitting an existing TMC. This course will establish the need for utilizing a systems engineering approach when designing a small data center. After taking this course, students will understand the fundamental elements of an effective data center design. Given the complexity of small data centers, this course will then focus on structured cabling and grounding.

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 small data center design as applied to TMCs.

2.5.1. Small Data Center Design, Structured Cabling, and Grounding

A TMC is a central focal point through which traffic challenges may be mitigated, while the quality and safety of the traveling experience may be improved through more efficient management of the roadway system. TMCs collect and process data from ITS field elements. That data can be used to make decisions and implement management strategies. The TMC also disseminates traveler information to the public.

How all of this is accomplished involves many variables, systems, and sub-systems, and varies considerably depending on the specific purpose of the TMC. With that said, there are several concepts and competencies related to small data centers and TMCs that Caltrans ITS engineers should possess and be able to effectively implement. For this course, it is anticipated that approximately ½ day will be spent on the fundamentals of small data center design, three days addressing structured cabling, and the remainder working with proper grounding methods.

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

- Define and explain terminology and general concepts for small data center design.
- Define and explain terminology and general concepts for data center systems as applied to Transportation Management Centers (TMCs).
- Fully understand the importance and critical need for utilizing a systems engineering approach when planning and designing TMC data centers.
- Describe the need for well-documented data centers and understand the risks associated with inadequate documentation.
- Successfully utilize fundamental planning and design concepts for small data centers, including but not limited to, power system considerations (UPS, back-up generator, etc.), HVAC systems, structured cabling, bonding and grounding, etc.
- Discuss and evaluate techniques and best practices for system, technology, and operational integration in a data center / TMC.
- Assess and incorporate strategies to future-proof the data center's design and operation.

- Describe "crosstalk" interference, the cause, and how to minimize it.
- Understand the benefits of utilizing a structured cabling system and risks associated with a point-to-point cabling system.
- Based on current TIA/EIA standards and telecommunication industry best practices, design and thoroughly document an appropriate structured cabling system for the specific needs of the data center, taking into consideration such factors as cable containment, management, and protection.
- Evaluate current structured cabling systems.
- Effectively upgrade and/or retrofit current cabling systems based on established best practices and telecommunications industry standards (TIA/EIA 568, etc.).
- Assess and compare the pros and cons of using different types of cabling in a data center (i.e., copper UTP, STP, Coaxial, fiber optic, etc.).
- Thoroughly test and certify structured cabling systems used in the data center.
- Describe the various components of a telecommunications bonding and grounding system.
- Analyze and describe issues and symptoms associated with a poorly designed or poorly implemented bonding and grounding system.
- Develop and implement approved bonding and grounding methods based on current telecommunication industry standards (TIA 607-B, etc.) and best practices for new and retrofit installations.
- Thoroughly test and certify the performance of a bonding and grounding system based on current telecommunication industry standards (TIA 607-B) and practices.

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 small data center design, structured cabling, and grounding shall address the topics including but not limited to, those listed in section *2.5 Learning Objectives (Small Data Center Design, Structured Cabling, and Grounding)*. 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:
    - Cable management techniques
    - Design a retrofit ground system
    - Splice ground wire using exothermic welds and compression lugs
    - Terminate Cat5e cable to a 110 punch down RJ-45 patch panel
    - Install an RJ-45 connector
    - Use a cable tester to test and accept installed cables
    - Install an RG-59 coax connector (BNC type connector versus typical F type connector)
    - Use string and lashing to lace and secure backbone cable bundles and explore other cable grooming alternatives.
    - Terminate microwave antenna cabling

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 building data centers, implementing structured cabling systems, and utilizing proper grounding techniques. The instructor(s) must be knowledgeable and current in small data center design and technologies and demonstrate the ability to adapt course materials to the knowledge, interest, and skill level of the students. Given the diversity and complexity of topics associated with small

data center design, one or multiple qualified instructors (team teaching) would be acceptable.

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 related to data centers, structured cabling, and grounding methods.
- 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 data center design, structured cabling, and grounding methods.

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 data center design and structured cabling 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)

The Vendor will provide a list of at least three (3) references specific to data center design and structured cabling 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 deliver the course October 8-12, 2018, 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 northern or central California 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.	**July 11th, 2018, or before**	Course outline will be approved by the PTAP.
2. Course materials drafts (Small Data Center Design, Structured Cabling, and Grounding) • 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 activities. General course evaluation instruments will be included.	**August 7th, 2018**	Draft versions of course materials will be reviewed and approved by the PTAP.

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• 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**	**August 24th, 2018**	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.	**August 31st, 2018**	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.	**August 31st, 2018**	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 or via WebEx 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.	**Week of September 17th, 2018**	PTAP will approve the pedagogy and the amount and level of hands-on/laboratory activities intended for the course delivery.
7. **Course delivery**	**October 8th – 12th, 2018**	Contractor shall deliver five days of training as developed. The training shall be at the Caltrans Sacramento Regional Transportation Management Center or Caltrans' Ron LeCroix

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		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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APPENDIX C: WTI COURSE AND INSTRUCTOR EVALUATION FORM

Course and Instructor Evaluation

Course: *Small Data Center Design, Structured Cabling, and Grounding* Professional Capacity Building for Communications	**Instructor:** Phil Isaak Isaak Technologies, Inc.
Training Location: Ron Le Croix Training Center, Woodland, CA	**Date:** October 8-12, 2018
Student Name (*optional*):	**Caltrans District (*optional*):**

Thank you for participating in the *Small Data Center Design, Structured Cabling, and Grounding* course presented by Isaak Technologies, 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 *Small Data Center Design, Structured Cabling, and Grounding* 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 *Small Data Center Design, Structured Cabling, and Grounding* 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 *Small Data Center Design, Structured Cabling, and Grounding* 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 4 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 parts of Phase 1 and 3 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 one or both of the Needs Assessment surveys? (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 Small Data Center Design, Structured Cabling, and Grounding? 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: ISAAK TECHNOLOGIES COURSE AND INSTRUCTOR EVALUATION FORM

Bicsi CONTINUING EDUCATION CREDIT PROVIDER

ISAAK TECH

Course: _____ Location: _____

Instructor: Phil Isaak Date: _____

Please rate the course	Excellent	Above Ave	Average	Below Ave	Poor	N/A
How well were stated learning objectives met	5	4	3	2	1	n/a
How effective were the slides & visuals	5	4	3	2	1	n/a
How appropriate was the technological equip	5	4	3	2	1	n/a
How effective were the lab exercises	5	4	3	2	1	n/a
How useful were the lab worksheets	5	4	3	2	1	n/a
How technically accurate were the materials	5	4	3	2	1	n/a
How well did the class meet your expectations	5	4	3	2	1	n/a
Overall class rating	5	4	3	2	1	n/a

Please rate the instructor	Excellent	Above Ave	Average	Below Ave	Poor	N/A
Enthusiasm for class	5	4	3	2	1	n/a
Knowledge of subject matter	5	4	3	2	1	n/a
Clarity of explanations	5	4	3	2	1	n/a
Delivery and presentation skills	5	4	3	2	1	n/a
Exercise demonstrations	5	4	3	2	1	n/a
Effective use of class time	5	4	3	2	1	n/a
Interaction with students	5	4	3	2	1	n/a
Quality of personalized feedback	5	4	3	2	1	n/a

Please provide an example for any rating below average. _____

What were your learning objectives for this class?

- ☐ Improve existing skills or knowledge
- ☐ Gain new skills or knowledge
- ☐ Prepare for certification exam
- ☐ Continuing education requirements
- ☐ Meeting condition of employment
- ☐ Achieve professional advancement
- ☐ Attaining career change

1.) Did the course meet your expectations? _____

2.) Additional Comments: _____

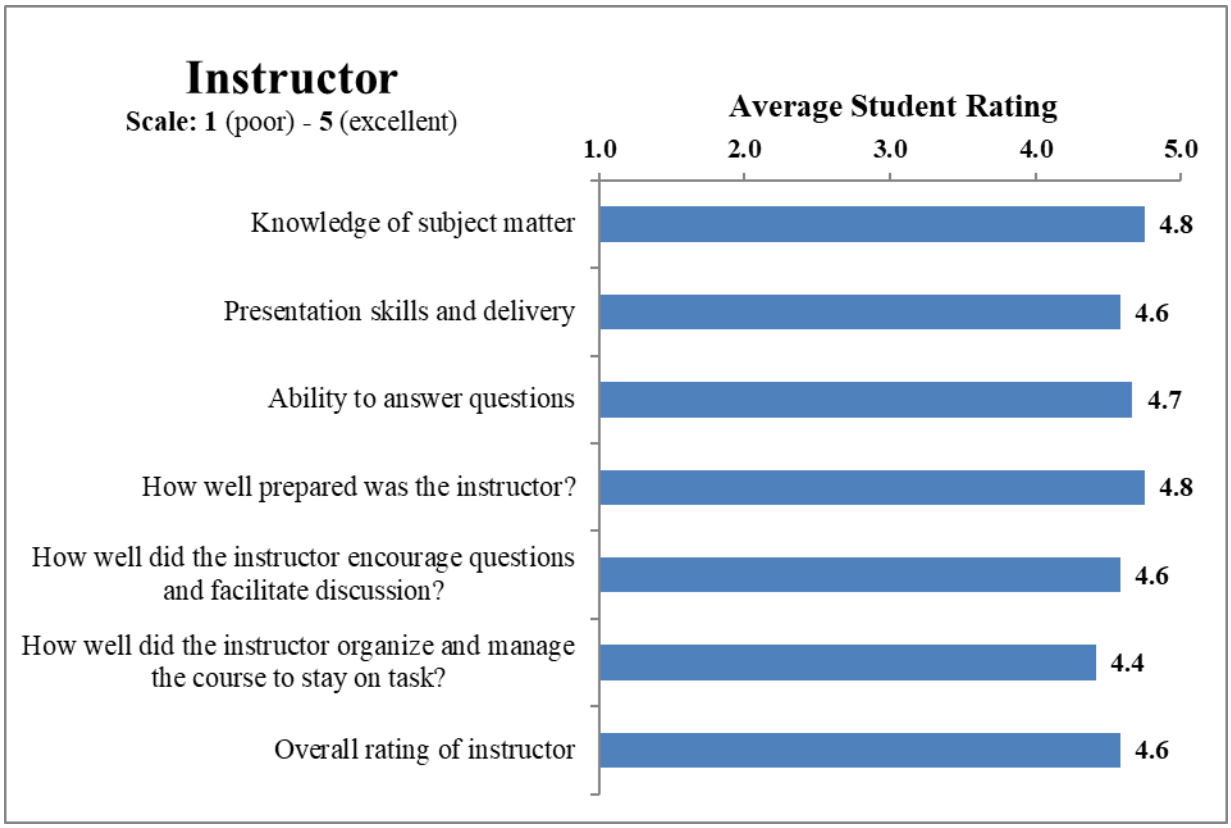
APPENDIX E: PARTICIPANT EVALUATIONS (WTI) – SMALL DATA CENTER DESIGN COURSE

Overall Course Evaluation
WTI Project Team

The overall evaluation was developed by WTI and administered to the students at the conclusion of the 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*					Average Rating
	5	4	3	2	1	
	Excellent	Very Good	Good	Fair	Poor	
Knowledge of subject matter	9	3	0	0	0	4.8
Presentation skills and delivery	8	3	1	0	0	4.6
Ability to answer questions	9	2	1	0	0	4.7
How well prepared was the instructor?	9	3	0	0	0	4.8
How well did the instructor encourage questions and facilitate discussion?	8	3	1	0	0	4.6
How well did the instructor organize and manage the course to stay on task?	7	3	2	0	0	4.4
Overall rating of instructor	7	5	0	0	0	4.6

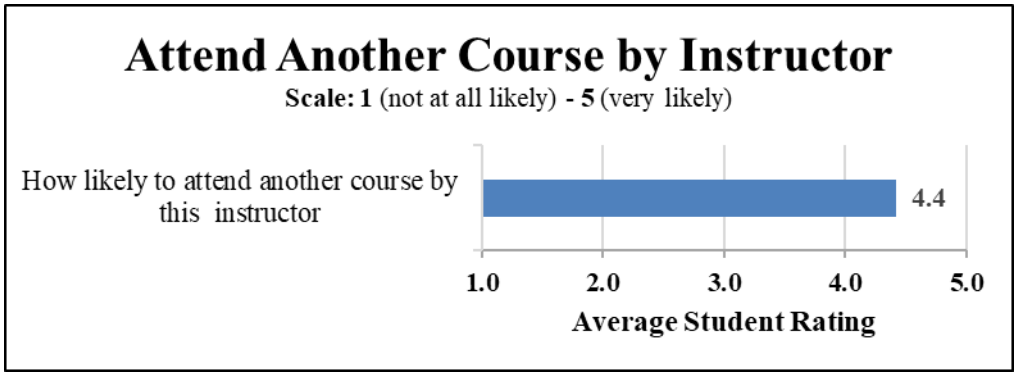


Comments:

- *"Phil was very knowledgeable in data centers, and I appreciate that he took the time to visit a couple TMCs prior to the class."*
- *"The instructor was very knowledgeable. I was expecting more cabling and networking than how to do data centers. I learned a lot of what I was not expecting but not what I thought the class will be about. I general of give 4 to overall class. Thank you for putting this class together."*
- *"Phil was able to tailor parts of the training to meet TMC needs which are very different from the typical data center."*
- *"Instructor was very adept at transforming subject matter to meet unique TMC requirements."*
- *"Well prepared, but went on a tangent occasionally. A lot of material in 5 days. Breaks needed on timed basis."*
- *"Very well done, especially in modifying course content on the fly to address the differences between "data centers" and TMC infrastructure."*
- *"Phil is probably one of the better instructors I've come across. Good focus, good pace, and he knows his material."*

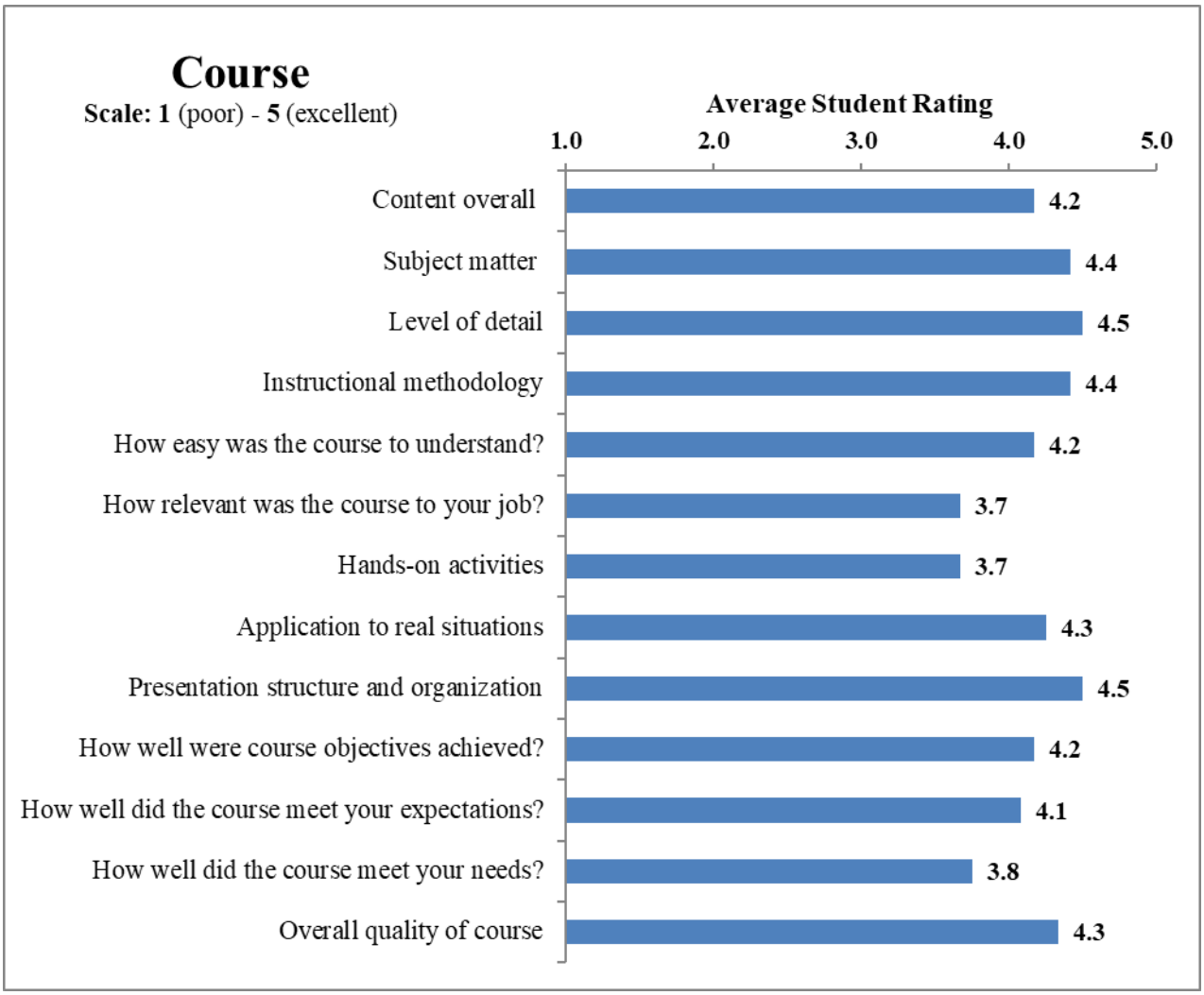
2. How likely would you be to attend another course taught by this instructor? Circle one rating.

Likely attend another course by this instructor	*Number of students who rated the item at each level*					Average Rating
	5	4	3	2	1	
	Very Likely		Neutral		Not At All Likely	
	7	3	2	0	0	4.4



3. Please evaluate the *Small Data Center Design, Structured Cabling, and Grounding* course and circle one rating for each characteristic.

Course	*Number of students who rated the item at each level*					Average Rating
	5	4	3	2	1	
	Excellent	Very Good	Good	Fair	Poor	
Content overall	4	6	2	0	0	4.2
Subject matter	5	7	0	0	0	4.4
Level of detail	6	6	0	0	0	4.5
Instructional methodology	7	3	2	0	0	4.4
How easy was the course to understand?	5	5	1	1	0	4.2
How relevant was the course to your job?	1	7	3	1	0	3.7
Hands-on activities	4	4	1	2	1	3.7
Application to real situations	5	5	2	0	0	4.3
Presentation structure and organization	7	4	1	0	0	4.5
How well were course objectives achieved?	5	4	3	0	0	4.2
How well did the course meet your expectations?	4	6	1	1	0	4.1
How well did the course meet your needs?	2	5	5	0	0	3.8
Overall quality of course	6	4	2	0	0	4.3

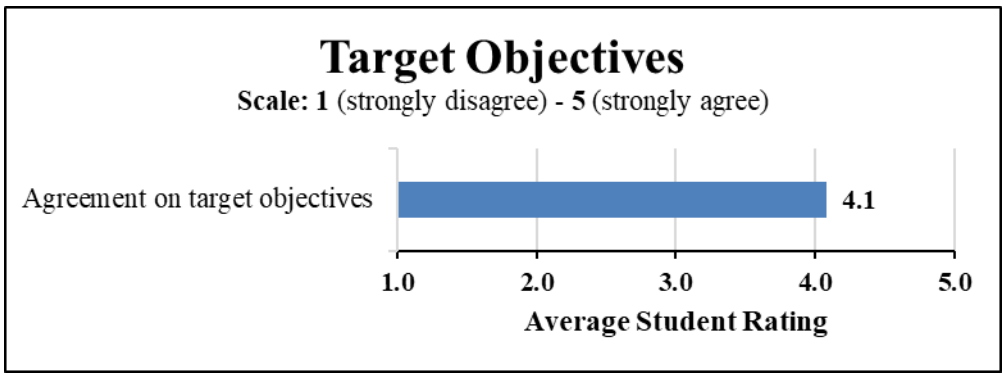


Comments:

- *"Hands on labs would help to break up the long lectures, but the material did not lend itself too much to that. Perhaps trying to add something related such as Cat 5/6 termination and testing would have been good."*
- *"This class was very good teaching how a Data Center is designed. It showed me that all of the Caltrans Data Center (TMC) need major improvement."*
- *"Overall good class. Very difficult to approach TMC/Telcom data centers from typical IT enterprise background, but was well done."*
- *"Could be three day class for future."*
- *"The class wasn't what I expected. Could provide more hands-on material."*

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
	3	7	2	0	0	4.1

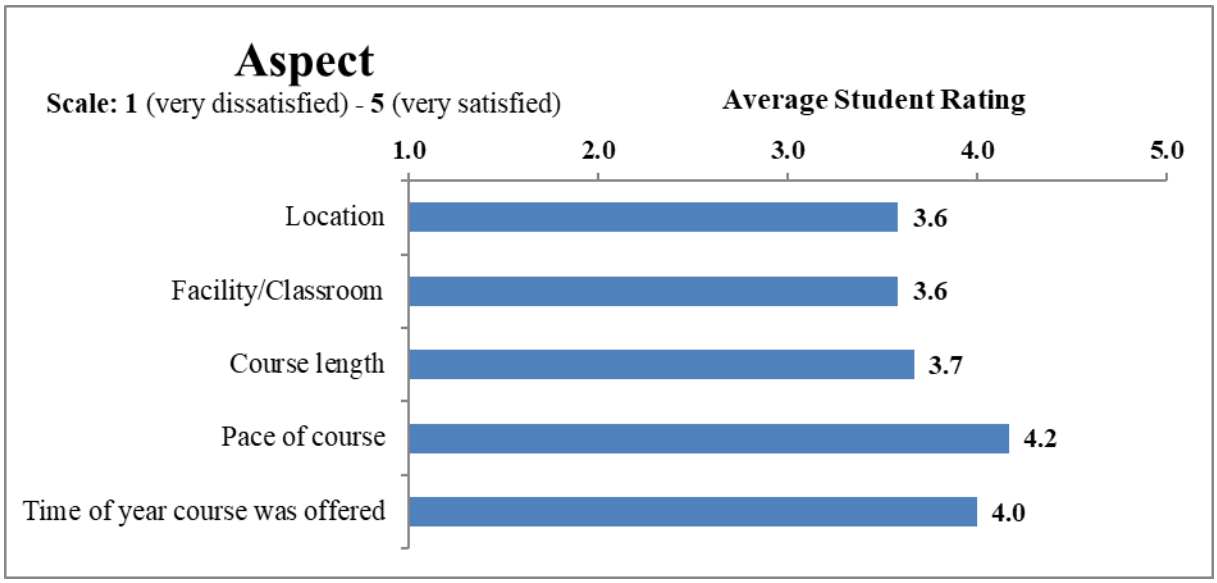


Comments:

- *"Instructor tried to understand and target the needs of the TMC facilities."*
- *"If target was new TMC data center, then yes. I was expecting some more of the structured cabling part per the course description."*
- *"The class was very good but I thought it's mostly about cabling and network design."*
- *"For TMC support."*
- *"While most objectives were targeted some were not focused/emphasized."*

5. How satisfied were you with the following aspects of the *Small Data Design, Structured Cabling, and Grounding* course? Please circle one level of satisfaction for each category.

Aspects	*Number of students who rated the item at each level*					Average Rating
	5 Very Satisfied	4 Satisfied	3 Neutral	2 Dissatisfied	1 Very Dissatisfied	
Location	2	4	5	1	0	3.6
Facility/Classroom	2	6	2	1	1	3.6
Course length	2	5	4	1	0	3.7
Pace of course	3	8	1	0	0	4.2
Time of year course was offered	3	6	3	0	0	4.0

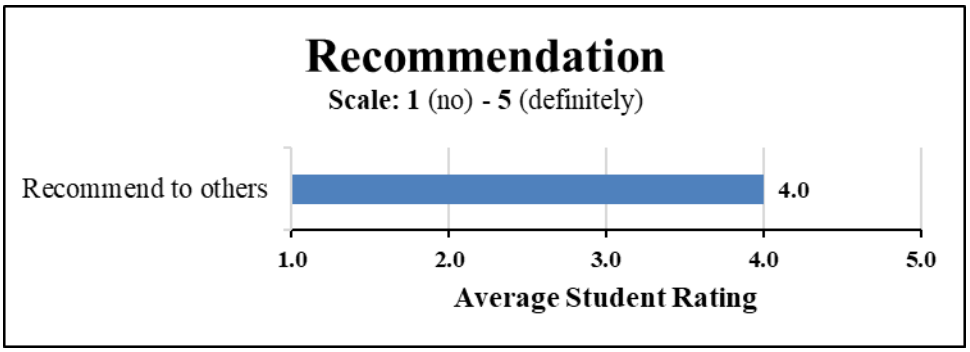


Comments:

- *"If possible to remove some content, a 3-day course should work."*
- *"I think the best length for a class is 3 days so the student still have the energy to absorb the knowledge."*
- *"Chairs are tough to sit in for long periods."*
- *"Classroom has a projector that is hard to read/see."*
- *"Need brighter projector, stronger internet connection. Excellent water and food provided. Light food should always be offered."*

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
	2	8	2	0	0	4.0

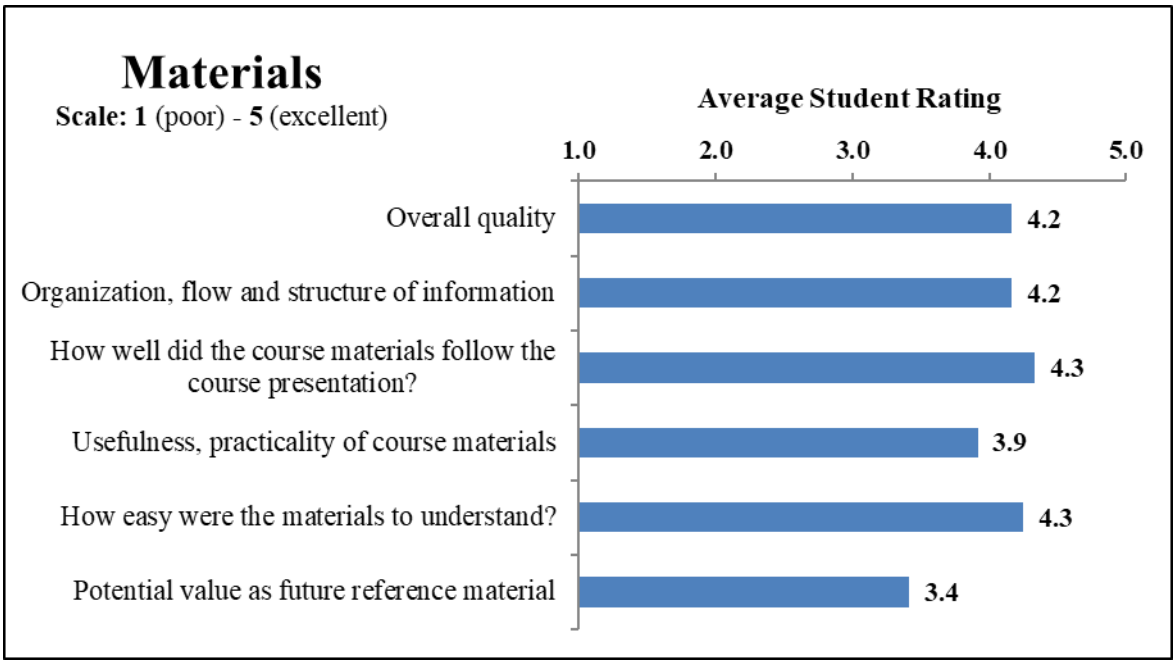


Comments:

- *"Yes, but mostly to someone who may likely be involved in some aspect of a TMC build-out or remodel."*
- *"I learned a lot about creating data center which I hope I get a change to use the knowledge."*
- *"Great course for understanding data centers."*
- *"If the course was shorter and more concentrated. Course was too broad."*
- *"For many, this may not be an appropriate course. Very good for anybody involved in managing raised-floor environment. Which is a lot of senior IT and IT managers do."*

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*					Average Rating
	5	4	3	2	1	
	Excellent	Very Good	Good	Fair	Poor	
Overall quality	4	6	2	0	0	4.2
Organization, flow and structure of information	4	6	2	0	0	4.2
How well did the course materials follow the course presentation?	5	6	1	0	0	4.3
Usefulness, practicality of course materials	3	5	4	0	0	3.9
How easy were the materials to understand?	5	5	2	0	0	4.3
Potential value as future reference material	2	5	1	4	0	3.4



Comments:

- *"Some slides had dark images. Materials handed out are not printable or searchable so reference value is questionable."*

- *"My only reason for low rating is that I wish the course material would be given in pdf or other Microsoft file for future use."*
- *"Materials would be better if we had the ability to print or have paper copies."*
- *"Course material was specific at times and could only be applied in certain situations."*
- *"The future value of the course material is excellent. Having had the experience of this class makes planning all aspects of TMC infrastructure more complete and efficient."*
- *"We were actually not planning to attend and did not know this training was available. We had heard at last minute that openings were available, (so this was a pleasant surprise)."*

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

- *"Cooling system, power requirements, design, sizing of data center, etc."*
- *"Collect and log info such as power consumption for network / servers / video systems. This info should come in handy in future design / remodel."*
- *"Structured cabling - network design and probably I get a chance to use grounding."*
- *"If we have a new data center I will be prepared to give some solid input to the design. Also how to manage a data center."*
- *"Rack layout, cabling, and grounding. Power and mechanical considerations."*
- *"Will be building out small telcom and refreshing main equipment room."*
- *"Yes, we will build TMC in the next five years."*
- *"Knowledge of TMC / Data Center materials / rules for design and development."*
- *"This course helps identify concerns for reliable data infrastructure that can be applied across the board in our ITS infrastructure."*
- *"Planning techniques. Documentation."*
- *"Power per row, cooling recommendations, future capacity planning, evaluating current capacities."*
- *"Data center upgrades for UPS and network room rearrangement."*

9. **I will have difficulty applying the following to my job:**
    - *"There are many areas that our current TMC / data center fall short of standards and it will be very difficult to change due to funding."*
    - *"Data center design."*
    - *"Cooling containment."*
    - *"Only because of standard approach used doesn't work as well with ITS / transportation."*
    - *"Measurement and placement of rooms / products."*
    - *"Implementing dual generator, dual UPS, changing the cooling infrastructure, etc. etc. - $$."*
    - *"Large enterprise solutions towards TMC."*

10. ***This course was offered as part of Phase 4 of the Professional Capacity Building for Communications project. The project team is investigating and developing a comprehensive training curriculum for communication as applied to Intelligent Transportation Systems (ITS). As parts of Phase 1 and 3 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

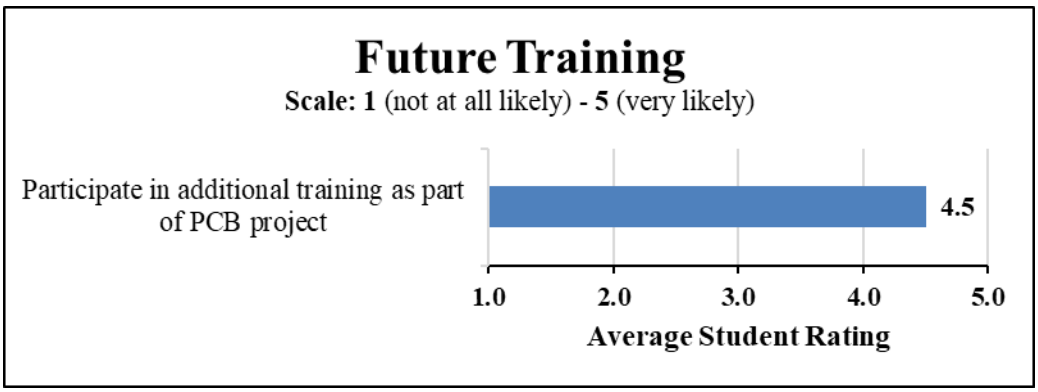
Were you able to participate in the Needs Assessment survey?	Number
Yes	0
No	4
Not Sure	8

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 Small Data Center Design, Structured Cabling, and Grounding? Please explain.

- *"Yes, the course did cover topics that were relevant."*
- *"Yes - partially. If this was for new Data Center consideration, then my answer would be yes. If looking at it from perspective of existing Data Centers, and specifically being able to improve them, then not really."*
- *"It is good to know about data center design but I am not sure if I even use the knowledge at work."*
- *"Yes. The instructor has designed, built, and been a consultant on many projects and was able to communicate his vast experience to the class."*
- *"Mostly. Expected more on structured cabling and best practices."*
- *"Yes, it's apply to our TMC, and ITS server room."*
- *"This course did not meet my expectations because the material did not have much of a hand-on activity to correlate to."*
- *"Yes. Many aspects of the course material were directly applicable. IF, UPS, GenSet, cooling, grounding."*
- *"Yes. Some excellent ideas were presented and, believe it or not, are already being implemented at some Caltrans locations."*
- *"Yes, intro to data center design high level decision making and planning."*

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
	8	2	2	0	0	4.5



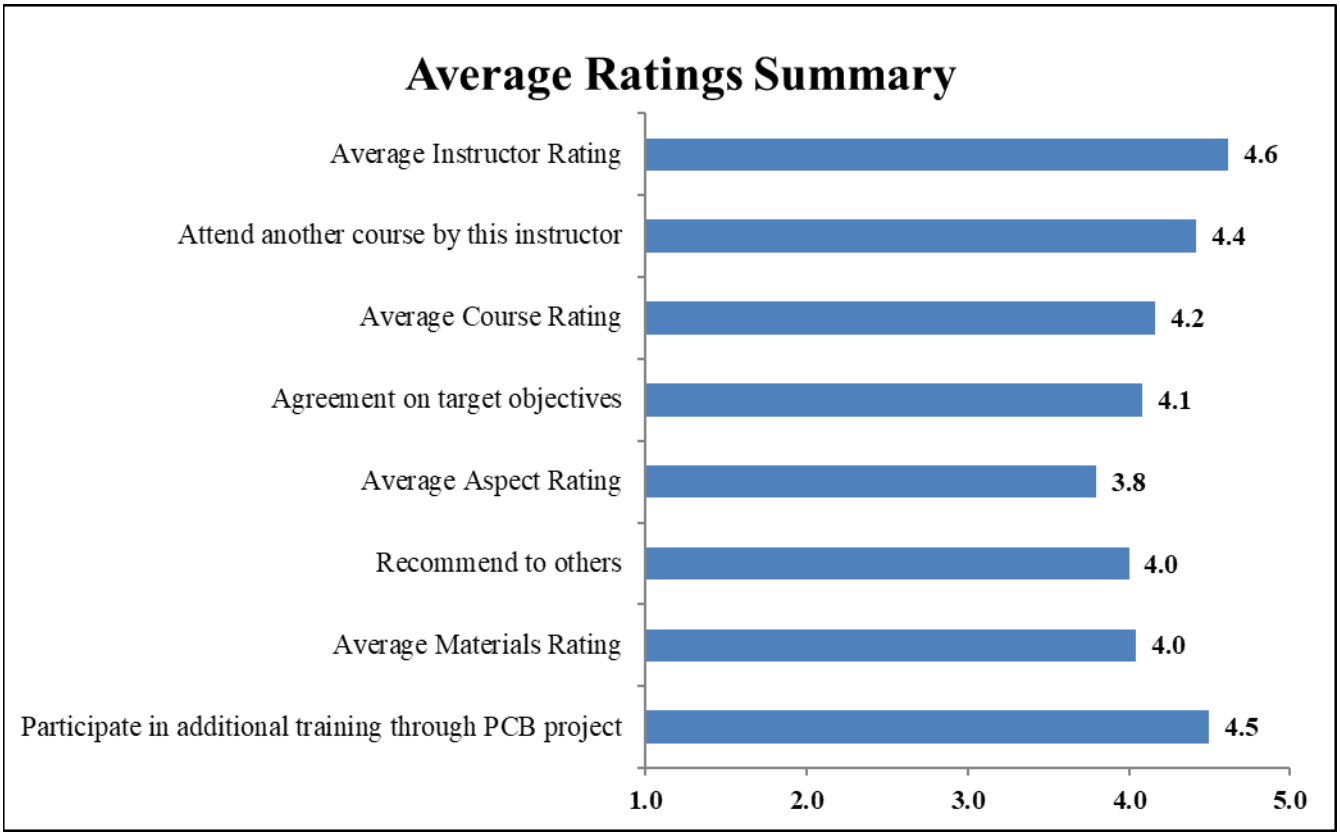
12. In what other subject areas related to ITS communications would you be interested in receiving training?

- *"Video encoding / decoding technologies."*
- *"Software programming such as Python, that would help in writing programs to accomplish certain tasks."*
- *"Networking and cabling."*
- *"More network training."*
- *"RF / microwave"*
- *"Backbone fiber from field to TMC."*
- *"Wireless, microwave network."*
- *"Wireshark"*
- *"Managing ITS elements - database."*
- *"1-2 day courses on basics like ideas on network redundancy, remote management. With everything solution-specific and minimum of theory."*
- *"Hands on training of data center creation."*

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

- *"Good job is being done on putting on these types of training courses."*
- *"Thank you for snacks. That help[ed] a lot to stay on task."*
- *"K and on"*
- *"N/A"*
- *"Good! But class information should have open access. Providing a notepad for each class is great, very useful for class."*

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



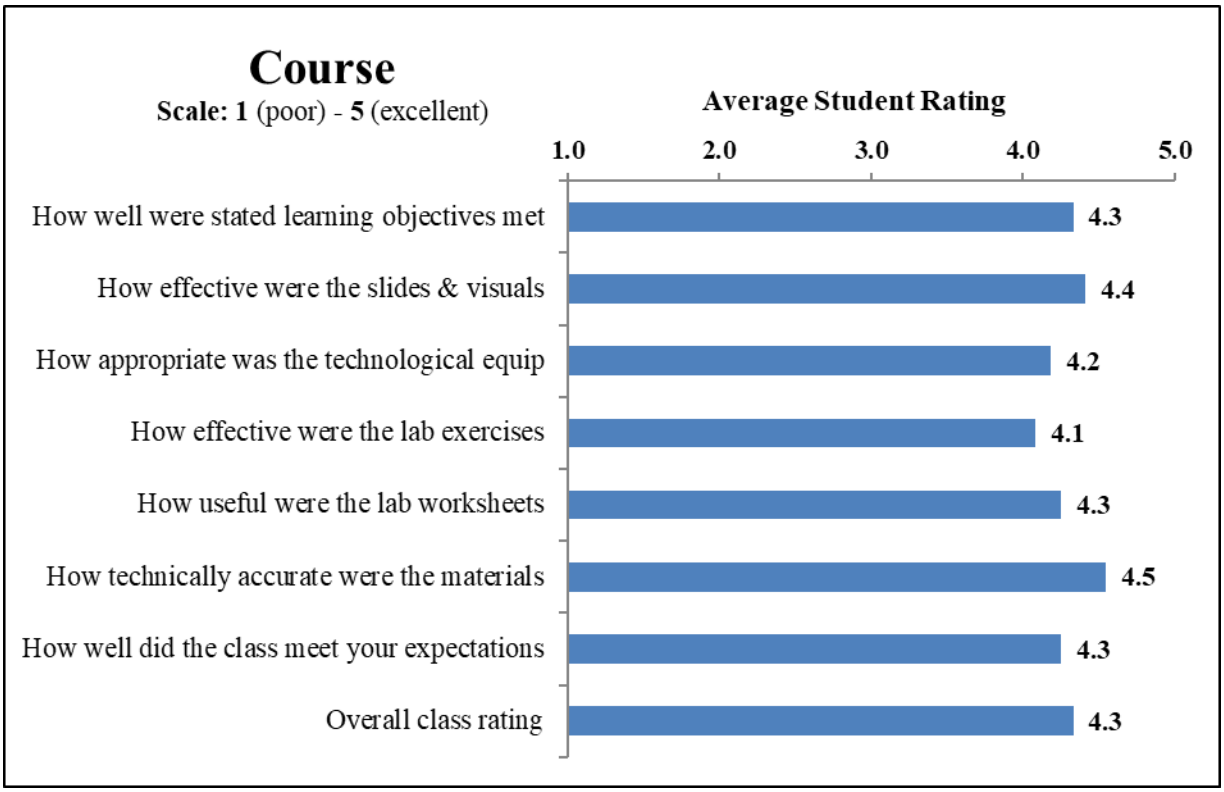
APPENDIX F: PARTICIPANT EVALUATIONS (ISAAK TECHNOLOGIES) – SMALL DATA CENTER DESIGN COURSE

Course Evaluation
Isaak Technologies

This course evaluation was administered to the students at the conclusion of the course. The results are below.

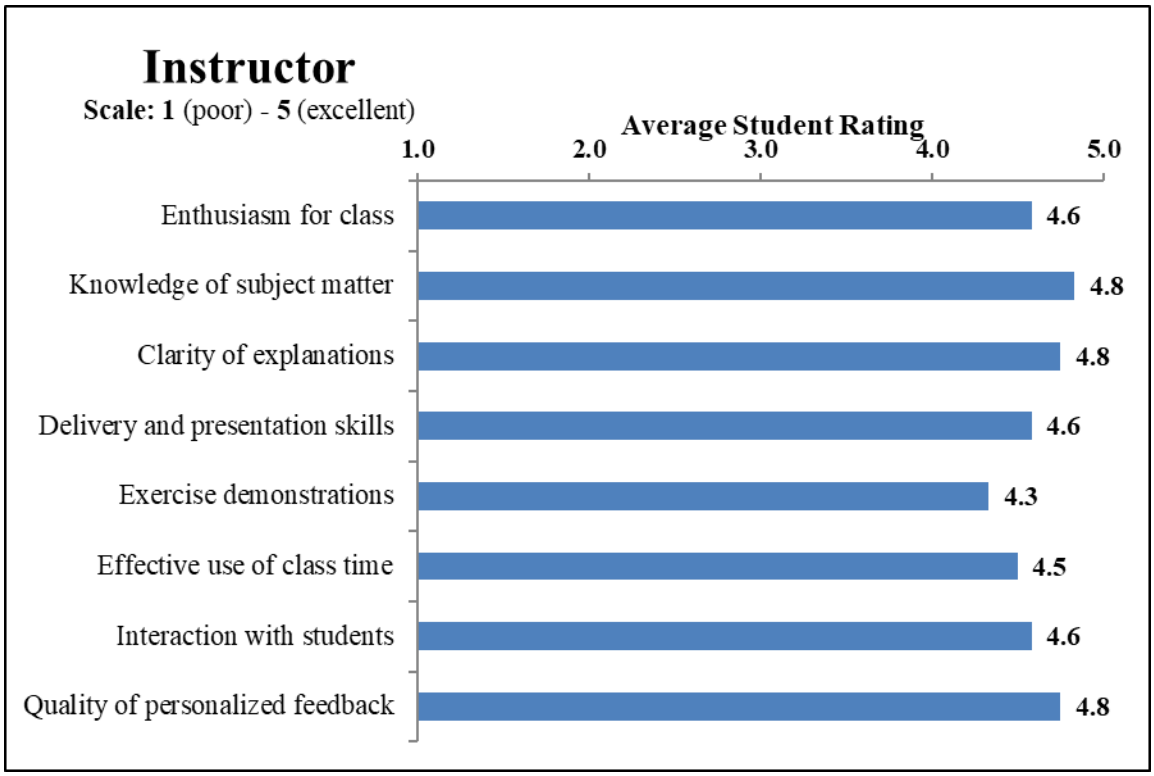
Please rate the course.

Course	*Number of students who rated the item at each level*						
	5	4	3	2	1	N/A	
	Excellent	Above Average	Average	Below Average	Poor		Average Rating
How well were stated learning objectives met	5	6	1	0	0	0	4.3
How effective were the slides & visuals	6	5	1	0	0	0	4.4
How appropriate was the technological equip	4	5	2	0	0	1	4.2
How effective were the lab exercises	5	3	4	0	0	0	4.1
How useful were the lab worksheets	5	5	2	0	0	0	4.3
How technically accurate were the materials	6	5	0	0	0	1	4.5
How well did the class meet your expectations	5	5	2	0	0	0	4.3
Overall class rating	5	6	1	0	0	0	4.3



Please rate the instructor.

Instructor	*Number of students who rated the item at each level*						
	5	4	3	2	1	N/A	
	Excellent	Above Average	Average	Below Average	Poor		Average Rating
Enthusiasm for class	8	3	1	0	0	0	4.6
Knowledge of subject matter	10	2	0	0	0	0	4.8
Clarity of explanations	9	3	0	0	0	0	4.8
Delivery and presentation skills	8	3	1	0	0	0	4.6
Exercise demonstrations	6	4	2	0	0	0	4.3
Effective use of class time	7	4	1	0	0	0	4.5
Interaction with students	8	3	1	0	0	0	4.6
Quality of personalized feedback	9	3	0	0	0	0	4.8

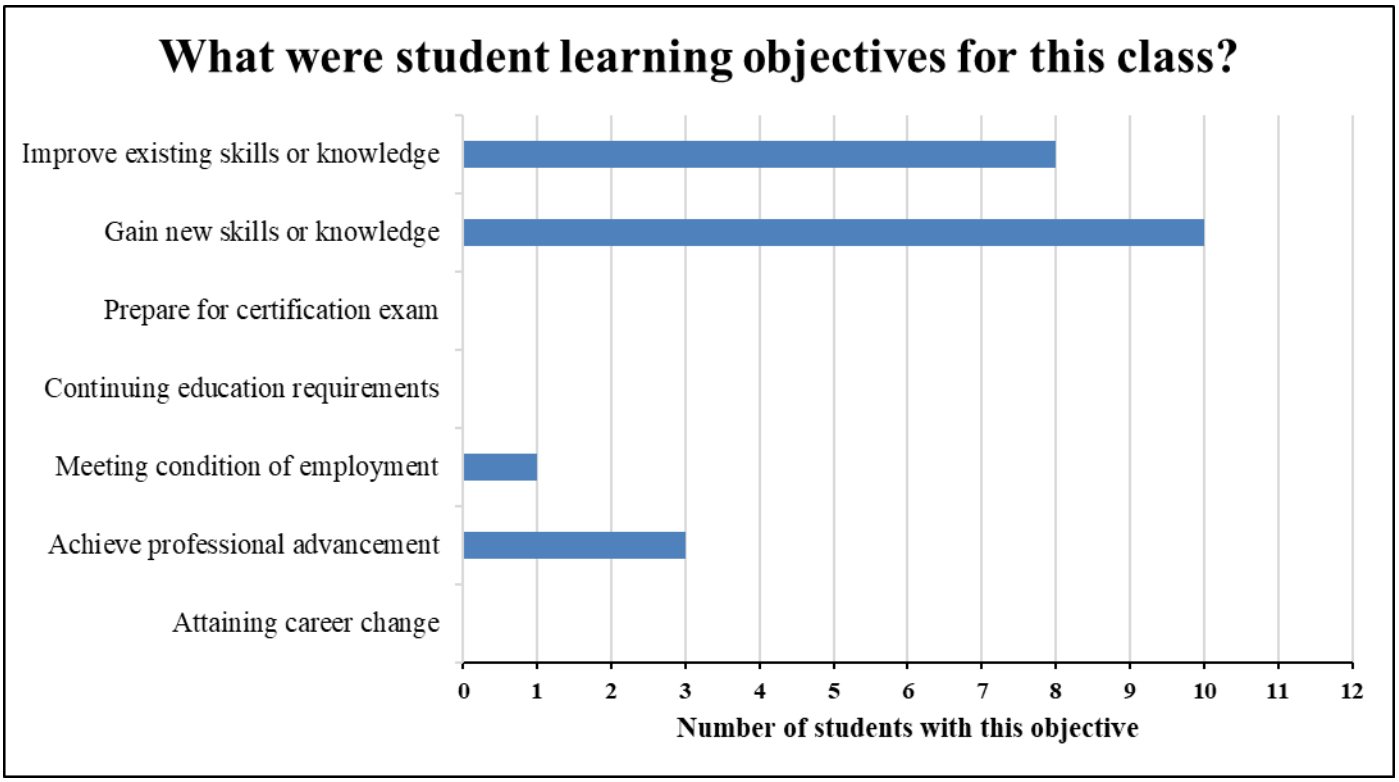


Please provide an example for any rating below average.

- Excel sheets can be improved. Maybe use remote access so everyone can see changes.

What were your learning objectives for this class?

Objectives	Number of students with this objective
Improve existing skills or knowledge	8
Gain new skills or knowledge	10
Prepare for certification exam	0
Continuing education requirements	0
Meeting condition of employment	1
Achieve professional advancement	3
Attaining career change	0



1. **Did the course meet your expectations?**

Did course meet expectations	Number of students
Yes	9
No	0
Did not answer yes or no	3

- *"It was a great class as far as building a data center but I was expecting more cabling and network design. I learned lots of material that I was not [expecting]."*
- *"The course wasn't what I had originally expected, but I learned a lot."*
- *"Yes very pleased to see the level of understanding and modification of course material to our unique infrastructure."*
- *"And Phil did a great job, even though he's a Canuck."*

2. **Additional comments:**
    - *"I was expecting more on structured cabling, but overall, I received a lot more info than I expected."*
    - *"Three day course."*
    - *"Class is very broad and is quite long."*
    - *"Great presentations, more structured work book like now but more could be helpful."*
    - *"Courses should be designed more for TMC angle."*

APPENDIX G: PRE- AND POST-TEST, STUDENT LEARNING MEASUREMENT

California Department of Transportation DRAFT v2
Evaluation Quiz

1) Which topology uses the least amount of cable? [14-40-101]
   a) Centralized
   b) End-of-Row
   c) Top-of-Rack

2) The latest network design architecture is referred to as a: [18-01-01]
   a) Spine & Leaf Network
   b) 2-Tier Network
   c) 3-Tier Network

3) A 100G Ethernet optical interface requires _____ strands of fiber optic cable. [18-01-02]
   a) 2
   b) 8
   c) 20
   d) 2, 8 or 20

4) A 110 Block is primarily used for _____. [18-01-03]
   a) Terminating copper cables on equipment racks
   b) Terminating copper cables on the wall
   c) Providing ground protection for telco circuits
   d) Terminating fiber optic cables

5) OM5 Multimode cable supports _____ wavelengths over a single pair of fibers. [18-01-04]
   a) 2
   b) 3
   c) 4
   d) 5

6) Which one of the following MPO connector designations is NOT available? [18-01-05]
   a) MPO6
   b) MPO12
   c) MPO16
   d) MPO24
   e) MPO32

7) Which of the following is currently the most common fiber optic connector used on server I/O interfaces? [18-01-06]
   a) ST
   b) SC
   c) LC
   d) MPO

8) What is the recommended minimum distance between the telecom access entrance and other utility service entrance feeds? [14-24-118]
   a) 0.9 m (3 ft)
   b) 1.2 m (4 ft)
   c) 1.4 m (4.5 ft)
   d) 1.6 m (5 ft)
   e) 1.8 m (6 ft)

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California Department of Transportation DRAFT v2
Evaluation Quiz

9) What is the preferred location of Power Distribution Units (PDUs) feeding the Remote Power Panels (RPPs)? [14-21-104]
   a) In an adjacent space outside the computer room
   b) In the computer room
   c) At one or both ends of each row of cabinets

10) What is the preferred width for the cold aisle? [14-21-108]
   a) 1.0 m (3 ft)
   b) 1.2 m (4 ft)
   c) 1.4 m (4.5 ft)
   d) 1.8 m (6 ft)
   e) 2.0 m (6.5 ft)

11) What is the recommended maximum number of racks to have side-by-side in a row? [14-21-109]
   a) 10
   b) 15
   c) 20
   d) 25
   e) 30

12) What is the minimum spacing between a rack and a wall? [14-21-113]
   a) 0.9 m (3 ft)
   b) 1.2 m (4 ft)
   c) 1.5 m (4.9 ft)
   d) 1.8 m (6 ft)
   e) 2.0 m (6.5 ft)

13) Under-floor power cabling should be routed in which aisle? [14-21-116]
   a) Hot
   b) Cold

14) Under-floor telecommunications cabling should be routed in which aisle? [14-21-117]
   a) Hot
   b) Cold

15) What is the minimum recommended height between the computer room ceiling and the raised-floor (or floor if non-raised floor computer room)? [14-22-108]
   a) 3.1 m (10.2 ft)
   b) 3.8 m (12.5 ft)
   c) 3.0 m (10 ft)
   d) 4.5 m (15 ft)
   e) 5.0 m (16 ft)

16) What is one of the primary downsides to 'open-transition' transfers from Backup Generator to Utility Power? [14-25-124]
   a) Requires more controls
   b) Requires close monitoring
   c) Electricity providers are reluctant to allow
   d) Additional cooling systems restart cycle and reduced UPS battery life

p. 2

California Department of Transportation DRAFT v2
Evaluation Quiz

17) Each equipment rack/cabinet requires _____. [14-25-154]
   a) Its own grounding connection to the supplementary ground grid
   b) A ground connection to adjacent racks or cabinets
   c) Two separate grounding connections to the equipment ground bus

18) Which of the following is NOT a method used to bond the ITE chassis to the rack? [14-25-156]
   a) Manufacturer provided grounding location
   b) Grounding via mounting system
   c) Grounding via the power cord

19) Battery rooms are typically required by local code to have a dedicated exhaust system to limit hydrogen gas concentration to _____. [14-26-107]
   a) 1%
   b) 2%
   c) 3%
   d) 4%
   e) 5%

20) What is the recommended temperature range for a data center computer room per ASHRAE? [14-26-109]
   a) 15.2° C - 32.3° C (59.4° F - 90.1° F)
   b) 20° C - 25° C (68.0° F - 77.0° F)
   c) 18.3° C - 26.7° C (64.4° F - 80.6° F)
   d) 21.5° C - 28.6°C (70.7° F - 83.5° F)
   e) 17° C - 30°C (62.6° F - 86.0° F)

21) In a computer room designed in accordance with the hot/cold aisle method of equipment layout, what does the front of a server face? [14-26-139]
   a) The cold aisle
   b) The hot aisle
   c) It may face either the hot or cold aisle

22) Which type of fire detection system is recommended for the computer room? [14-27-110]
   a) Incipient/Early Warning
   b) Ionization
   c) Photoelectric
   d) Thermal
   e) Flame Detector

23) The recommended number of conduits in the telecommunications duct bank from the property line to the building is: [14-30-114]
   a) Four 100 mm (4 in) conduits
   b) One 100 mm (4 in) conduit
   c) Four 100 mm (4 in) conduits, plus one spare
   d) One 100 mm (4 in) conduit for each anticipated access provider, plus one spare (minimum of four conduits)

California Department of Transportation DRAFT v2
Evaluation Quiz

24) What is the maximum depth of cable in a cable tray? [14-30-116]
   a) 50 mm (2 in)
   b) 100 mm (4 in)
   c) 150 mm (6 in)
   d) 200 mm (8 in)
   e) 250 mm (10 in)

25) What is the minimum distance below the access floor and the top of the cables in an underfloor cable tray? [14-30-119]
   a) 30 mm (1.2 in)
   b) 40 mm (1.5 in)
   c) 50 mm (2 in)
   d) 60 mm (2.4 in)
   e) 65 mm (2.6 in)

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