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16. ABSTRACT

Rural communication engineering remains a mission critical skill that most engineers in the the state have limited experience with. Lacking these skills, engineers and technicians have a difficult time designing and maintaining reliable and robust 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, two specialized courses were researched and delivered by subject matter experts to train rural engineers and technicians. One course was in Optical Fiber and the other one in Internet Protocol (IP) Networking Fundamentals and Usage (topics included Understanding IP Networks/IP Networking Core, Local Area Networks (LANs), and Wide Area Networks (WAN)). These two 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 2

by

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A report prepared for the

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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 presentation of two training courses. The principal deliverables of this project were the revised Curriculum Scope and Sequence (5), a Subject Matter Expert (SME) List (6), the Optical Fiber Course Summary and Evaluation Report (7), and the IP Networking Fundamentals and Usage Course Summary and Evaluation Report (8).

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

This phase of the project initially focused on plant wired technologies. A formal limited solicitation process was conducted to secure appropriate training providers and deliver courses in Plant Wired Core/xDSL/Serial Connectivity and Optical Fiber. A successful class in optical fiber was delivered by a subject matter expert. The course was 40 hours of training over five days and included a significant number of practical, hands-on activities.

After executing a contract and beginning development of the Plant Wired Core/xDSL/Serial Connectivity class, it was determined that the training provider and the course would not meet the stated objectives and expectations. The contract was terminated prior to course delivery. However, this allowed for the development of a different course and the IP networking subject area was chosen. A successful course that addressed the topics of Understanding IP Networks/IP Networking Core, Local Area Networks (LANs), and Wide Area Networks (WAN) was delivered instead. The course was 40 hours of training over five days, included numerous practical exercises, and was delivered by a subject matter expert.

In order to ensure that the limited solicitation request for bids (RFB) reached the largest possible pool of qualified training providers, and ultimately securing an excellent instructor considered an expert in the field, considerable effort was put into researching and developing a subject matter expert list. As companies and instructors come and go, this is a dynamic document and future work will necessarily include updating this list.

A third phase of this project is anticipated to start in 2014. This will include delivery of a training course addressing one or more topics in the Telco Wireless subject area.

# 1. INTRODUCTION

"A skilled workforce is a critical element in a transportation agency's ability to successfully develop, deliver, operate, and maintain regional and local transportation systems" (1). However, difficulty finding qualified staff, increasing turnover, retention of existing staff with their experience, skill and leadership, and attracting new entrants to the transportation workforce, are all significant challenges faced by transportation agencies around the country. In addition, the American Recovery and Reinvestment Act provided substantial new funding for transportation infrastructure in an effort to put people to work (1).

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

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

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

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

To realize the full benefits of rural ITS, engineers as well as technicians must not only be aware of what technologies are available, but especially how to best select, implement, and maintain

those technologies. Due to challenges presented by rural ITS communications, there is a clear need for an educational curriculum that addresses rural ITS communications engineering across the board with a hands-on approach. The purpose of the Professional Capacity Building for Communications Systems project was to research and develop a comprehensive training curriculum for transportation communication systems that will build the professional capacity of ITS engineers and technicians.

In addition to revising the Curriculum Scope and Sequence, this phase of the project initially focused on providing training for plant wired technologies – plant wiring basics, serial connectivity, xDSL, and optical fiber. A successful training addressing the topic of optical fiber was delivered. After review of the needs assessment and with direction from the Curriculum Review Committee (CRC), a course in IP Networking Fundamentals and Usage was also delivered.

Over the course of this project, several deliverables were completed to address the proposed tasks. For the sake of clarity, these deliverables were left as stand-alone documents. As the final report and to eliminate redundancy, this document includes only critical elements and summarizes the main points from these other deliverables.

The deliverables include:

- Revised Curriculum Scope and Sequence (5)
- Subject Matter Expert List (6)
- Summary of the Optical Fiber Course (7)
- Summary of the IP Networking Fundamentals and Usage Course (8)

# 2.  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 (9). However, the Framework for Workforce Planning, Development, Management and Evaluation as developed by the Transportation Workforce Development sector of the FHWA OPCD recognizes that a new generation of employees is emerging. This generation of workers brings a different set of priorities to the workplace. They "…grew up in the electronic age, [are] more comfortable with change, have greater expectations for job satisfaction, and are more willing to challenge and to be challenged" (2). How successful they are in meeting the current challenges of the transportation industry "will depend to a great extent on the ability of employers to introduce the emerging workforce to new and innovative approaches in workforce planning and development" (2).

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 its description of this project (4):

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

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

Indeed, an overview for a college graduate level engineering course offered at U.C. Berkeley 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 still ring true.

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 second phase of this project and its results.

# 3. METHODOLOGY

This project consisted of five tasks: *Project Management*, *Review Curriculum Scope and Sequence*, *Plant Wired Course Delivery*, *Evaluation and Feedback*, and *Identification of Next Steps*. This section includes a summary of the methodologies used for each task. More detailed descriptions and plans can be found in the related deliverable documents and 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 Curriculum Review Committee (CRC), 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 involved a review of the Curriculum Scope and Sequence. Some changes were made to the individual topics to reflect current and upcoming technologies used by Caltrans ITS engineers. The project team and the CRC also revised a number of learning objectives in the plant wired and IP networking subject areas to better reflect the practical application of the technologies as well as the need for hands on practice in the training courses (5).

To successfully deliver training courses, the project team first conducted a thorough search for training providers and available training opportunities that covered the stated learning objectives. Based on the results of this search, the project team identified potential contractors for the courses and developed subject matter expert lists (6) for each topic. A limited solicitation and detailed Scope of Work were developed and approved for each course. A Request for Bids (RFB) was posted and distributed, and bids were accepted. The responses were evaluated based on an approved scoring rubric and training providers were selected and contracted.

At the kick-off meeting for the project, it was deemed more practical to split the 10 days of plant wired training into two courses to better address the challenges of continued travel restrictions and work schedules. The first course was to cover the topics of plant wired core / plant wiring basics, serial connectivity, and xDSL. The second course would cover optical fiber.

It should be noted that the vendor contract for the course in plant wiring basics, serial connectivity, and xDSL was terminated prior to course delivery because the project team and CRC felt the planned course would not fulfill the requirements or meet the expectations of the project. This allowed for the development of a different training course. Based on the needs assessment conducted in Phase 1 (11), comments from course participants, and input from the CRC, the IP networking subject area was chosen as the next subject for training.

The project team and the CRC worked with the contracted training providers to customize existing courses to meet the needs and expectations of the project. The project team coordinated logistics and facilitated delivery of two courses. *Mastering Fiber Optic Network Design and Installation*, a five-day hands-on course in optical fiber, was delivered at the end of September 2012 by Eric Pearson and Pearson Technologies. *Hands-On Ethernet and TCP/IP Fundamentals*, a five-day course covering IP networking fundamentals and usage, was delivered at the end of September 2013 by Andrew Walding, CellStream, and Dashcourses. Both courses were taught at the Sacramento Regional Transportation Management Center in Rancho Cordova,

California.  Students completed evaluation forms and members of the project team and CRC attended all or part of the courses.  Evaluations and CRC feedback were compiled and analyzed by the project team.  Complete evaluations for each course can be found in the Optical Fiber and IP Networking Course Summary and Evaluation Reports (7) (8).

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

# 4. REVIEW CURRICULUM SCOPE AND SEQUENCE (TASK 2)

## 4.1. Curriculum Scope and Sequence

A comprehensive literature review and a needs assessment with Caltrans ITS engineers was conducted as part of Phase 1 of this project (12). Five major subjects were identified as important knowledge and skill areas for successful rural ITS implementations. These subject areas are: Plant Wireless, Plant Wired, Telco Wireless, Telco Wired, and IP Fundamentals. The curriculum scope and sequence is based upon these five subject areas and includes descriptions, prerequisites, duration, method of presentation, and specific learning objectives. The target audience includes field engineers and technicians who apply ITS technologies in rural areas to improve transportation safety and operations.

The project team reviewed the needs assessment from Phase 1 (11), considered comments from the students in the courses, and consulted with the CRC to update and revise the curriculum scope and sequence (5). While the main subject areas remained the same, some changes were made to the topics to be addressed in each subject area. The topics in the telco wired subject area were revised to eliminate discussion of ADN and switched 56 as Caltrans districts are no longer using these technologies. LTE (Long Term Evolution), 4G and Next Generations was added to the telco wireless subject area. In the process of facilitating the two courses, a number of revisions were also made to the specific learning objectives for the plant wired and IP networking topics.

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* (Revised) (5). For quick reference, the subject areas and associated topics are outlined below:

A. Plant Wireless

    a. Plant Wireless Core and RF Systems Design

    b. 802.11 (WiFi) and Related

    c. Microwave

    d. Short Haul Radio

    e. Privately Owned WiMAX

B. Telco Wireless

    a. Telco Wireless Core and Cellular/PCS Basics

    b. GSM Data, 3G and Next Generations

    c. CDMA Data, 3G and Next Generations

    d. LTE (Long Term Evolution), 4G and Next Generations

    e. Telco Owned WiMAX

C. Plant Wired

    a. Plant Wired Core / Plant Wiring Basics

      b.   Serial Connectivity

      c.   xDSL

      d.   Optical Fiber

D.  Telco Wired

      a.   POTS

      b.   ISDN

      c.   xDSL

      d.   DS1/T1

      e.   Fractional DS1/T1

      f.   Frame Relay

      g.   Analog Data Circuits

E.  IP Networking Fundamentals and Usage

      a.   Understanding IP Networks/IP Networking Core

      b.   Local Area Networks (LANs)

      c.   Wide Area Networks (WANs)

      d.   Network Security

      e.   Vendor Specific Equipment Training

## 4.2.    Subject Matter Expert List

One of the core tenets for this project was to develop training that would be presented by experts in their field.  Phase 1 identified several potential subject matter experts (SME) that could provide training in the ITS communications topics listed above.  Phase 2 expanded the list of SMEs with a particular focus on training offerings in plant wired and IP fundamentals topics.

The SME list is a dynamic document.  It includes identified vendors and training providers that appear to have 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 CRC 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 CRC 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.

The updated Subject Matter Expert 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 solicitations distributed in Phase 2 are marked along with those who actually submitted a bid.

Because of its length and detail, the Subject Matter Expert list is a stand-alone document titled *Subject Matter Expert List, Professional Capacity Building for Communications (Phase 2) (6).*

# 5.  PLANT WIRED COURSE DELIVERY

A training course in optical fiber was delivered at the end of September 2012.  Taught by Eric Pearson of Pearson Technologies, the course lasted 40 hours over 5 days and was held at the Sacramento Regional Transportation Management Center in Rancho Cordova, California. Twelve students from 6 Caltrans districts participated.

The project team felt it would be useful to keep the summary and review of the plant wired course as a separate document for easy reference.  Therefore, to eliminate redundancy, the review report can be found in the document titled *Optical Fiber Course Summary and Evaluation Report, Professional Capacity Building for Communications (Phase 2) (7)*.

To summarize, the project team made the following recommendations based on the planning, delivery, and evaluation of the plant wired course:

- The time of year the course was held seemed appropriate.  However, the time frame was 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 delivery.  As previously mentioned, the project team chose to present a large amount of information in this course.  While students might not master all content within the training period, they are provided with sufficient resources and references to allow them to review and expand their understanding of the content after the course is completed.

- 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.

- The materials for this course were very professional, clear, and easy to follow.  They will also be a valuable reference for the students beyond the course.  Therefore, if students did not pick up on something during course delivery because too much information was presented, they will be able to refer back to course materials and find what they need.

- The location of the training course was also a good choice.  The Sacramento Regional TMC has further potential for case studies and field trips as well.  Consideration should be given to similar locations in different regions of the state if multiple iterations of an identical course are offered.

- The contractor was selected from a number of bids through a formal limited solicitation process.  This process allowed the project team to set clear expectations and standards for the instructor, content, materials, delivery, and logistics, and have the leverage to hold the contractor accountable through the duration of the contracted services agreement (CSA). It is highly recommended that a similar process and Request for Bids be used for future training opportunities.

- The Scope of Work for the CSA should include a timeline and deadlines for various steps in course development and delivery (i.e., due dates for draft materials, final materials, equipment list, evaluations, etc.) This establishes accountability, but also provides the opportunity to review, evaluate, and approve content, materials, presentation, and activities to ensure the course and its delivery will meet the needs of the students and expectations for the project.

- The one hour "dry run" presentation, which included a description of a hands-on activity, was helpful to confirm the pedagogy of the upcoming course.

- As mentioned 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 CRC/project team/selection committee to determine levels of knowledge and experience.

- It is recommended that instructors be included in course curriculum development from the beginning and throughout the preparation. For this course, the instructor was also the company owner and signatory on the CSA which insured that CRC review and expectations were received and translated correctly. 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 CRC and project team.

- It is recommended that direct means for communication with the instructor be provided to the CRC.

- It is recommended that further consideration be given to administering an assessment of learning. Student perception of the effectiveness of the course and instructor may not match the expectations of the CRC, and high evaluation marks may not equate to the course meeting its intended objectives. Thus, course evaluations alone may not give a sufficient indication of course effectiveness.

- It is further recommended that the CRC contemplate the opportunity to facilitate student certification if the topic and training are appropriate. For example, this instructor was certified by the Fiber Optic Association and after taking this course, students were well-prepared to take the Certified Fiber Optic Technician exam.

- Class size should be about 10 to 12 students to ensure quality of student and teacher interactions.

- It is recommended that the CRC consider different options for course presentation. One idea may be to conduct two or three days of training with a trainer such as Mr. Pearson and then do a practical field experience with nearby ITS installations or case studies, or some combination thereof. The field experience may be led by a Caltrans engineer or other subject matter expert.

- It is further recommended that the CRC 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 CRC members attend the course was valuable and should be continued in some capacity for future training classes.

- Regarding logistics, it is preferable to have the course materials and equipment set up at least the day prior to the start of the course.

# 6. IP NETWORKING FUNDAMENTALS AND USAGE COURSE DELIVERY

A training course in IP networking fundamentals and usage was delivered at the end of September 2013. Taught by Andrew Walding of CellStream Inc./Dashcourses, the course was 40 hours over 5 days and was held at the Sacramento Regional Transportation Management Center in Rancho Cordova, California. Eleven students from 7 Caltrans districts participated.

The project team felt it would be useful to keep the summary and review of the IP fundamentals course as a separate document for easy reference. Therefore, to eliminate redundancy, the review report can be found in the document titled *IP Networking Fundamentals and Usage Course Summary and Evaluation Report, Professional Capacity Building for Communications (Phase 2) (8).*

To summarize, the project team made the following recommendations based on the planning, delivery, and evaluation of the IP fundamentals course:

- 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 location of the training course was also a good choice. The Sacramento Regional TMC has further potential for case studies and field trips as well. Consideration should be given to similar locations in different regions of the state if multiple iterations of an identical course are offered.

- 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.

- The skill level of the students varied considerably as did their job responsibilities regarding IP communications. It is recommended that the project team and CRC consider additional means of communicating course expectations, including attendance, skill level, and relevancy, to those choosing which students should participate in a particular training course.

- It is critical to maintain the high standards set forth in this project regarding the content and delivery of these courses – that high quality technical content be delivered in a challenging environment by an expert in the field. The curriculum and presentation should not be "dumbed down" but instead students should be "brought up" to a higher level of expertise. Students should come out of a course challenged but with a solid understanding of the material and the different options available for solving a

communications problem.  Furthermore, the instructor must have practical, hands-on experience in the field for a length of time necessary to be considered an expert, in addition to being a quality instructor.

- The contractor was selected from a number of bids through a formal limited solicitation process.  This process allowed the project team to set clear expectations and standards for the instructor, content, materials, delivery, and logistics, and have the leverage to hold the contractor accountable through the duration of the contracted services agreement (CSA).  It is highly recommended that a similar process and Request for Bids be used for future training opportunities.

- The Scope of Work for the CSA should include a timeline and deadlines for various steps in course development and delivery (i.e., due dates for draft materials, final materials, equipment list, evaluations, etc.)  This establishes accountability, but also provides the opportunity to review, evaluate, and approve content, materials, presentation, and activities to ensure the course and its delivery will meet the needs of the students and expectations for the project.

- The one hour "dry run" presentation, which included a description of a hands-on activity, was helpful to confirm the pedagogy of the upcoming course.

- As mentioned 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 CRC/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 CRC and project team.

- It is recommended that direct means for communication with the instructor throughout the process be provided to the CRC. (We note this because the CRC was not given direct access to an instructor in the course offered in Phase 1, and there were resulting challenges.)

- It is recommended that further consideration be given to administering an assessment of learning.  Student perception of the effectiveness of the course and instructor may not match the expectations of the CRC, and high evaluation marks may not equate to the course meeting its intended objectives.  Thus, course evaluations alone may not give a sufficient indication of course effectiveness.

- It is further recommended that the CRC 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 CRC consider different options for course presentation.  One idea may be to conduct two or three days of training with a trainer such as Mr. Walding

and then do a practical field experience with nearby ITS installations or case studies, or some combination thereof. The field experience may be led by a Caltrans engineer or other subject matter expert.

- It is further recommended that the CRC 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 CRC 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. Network connectivity should also be tested in advance and backup arrangements made if needed.

- Finally, it is recommended that the project team conduct another needs assessment and gap analysis comparing the ITS communications skills of Caltrans ITS engineers and training available in the different subject areas.

## 7. EVALUATION AND FEEDBACK (TASK 4)

The deliverables for this task were a course evaluation form to be distributed and collected for each course and a summary of evaluation report.  Students in both courses completed evaluation forms.  Members of the CRC and the project team attended both trainings to evaluate the instructors, materials, content, and delivery.  Additionally, after each course, an overall course evaluation was held with the project team, the CRC, the instructor, and the contractor.

A summary of the planning, delivery, and evaluations of each course was compiled to complete this task.  The recommendations made as a result of the course deliveries are presented in this document in Section 5 Plant Wired Course Delivery and Section 6 IP Networking Fundamentals and Usage Course Delivery. For more details about each of the training courses provided in this project phase, refer to the complete summary documents:  *Optical Fiber Course Summary and Evaluation Report, Professional Capacity Building for Communications (Phase 2) (7), IP Networking Fundamentals and Usage Course Summary and Evaluation Report, Professional Capacity Building for Communications (Phase 2) (8).*

# 8. NEXT STEPS

This project was another positive step towards providing critical professional capacity building training to Caltrans ITS engineers and technicians. The comprehensive curriculum was revised and updated and two successful training courses were delivered. The results of the second phase of this project have shown enough potential for Caltrans to contract a third phase.

Based on the experiences completing Phase 2 of this project and with significant input from the CRC, the project team suggests the following next steps:

- Further detailed development of the curriculum in future project phases should continue similar to what has been done for Phase 1 and Phase 2. The expectation is to deliver high quality technical content in a challenging environment.

- Optical fiber was only one of four topics in the plant wired subject area. Similarly, the IP networking fundamentals course focused on three of the five topics in that subject area. Further consideration should be given to the other topics in these subject areas, as well as the potential for offering these two courses on more occasions.

- The needs assessment and gap analysis that have driven curriculum development for this project were conducted in Phase 1. To ensure the curriculum is current and applicable to the needs of the target audience, the needs assessment and a subsequent gap analysis should be repeated.

- Carefully evaluate how best to approach securing subject matter experts who can deliver quality training that is hands-on and applicable to rural ITS engineering. Although outside the scope of the proposed project phases, further consideration should be given to sabbatical programs for the development of curricula by expert Caltrans personnel.

- 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 CRC and delivery of these 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, future research should investigate opportunities to sustain the program as well as probe prospective "sponsor" organizations (e.g., FHWA, IEEE, ITSA).

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