Committee for Intelligent Construction Systems and Technology: Program Review Letter Report: May 13, 2013

DETAILS

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Committee for Intelligent Construction Systems and Technology: Program Review

May 13, 2013

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1200 New Jersey Avenue, SE, Room E85-113
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Dear Mr. Mendez:

This is the first letter report of the Transportation Research Board's (TRB's) Committee for Intelligent Construction Systems and Technology: Program Review. The committee was established at the request of the Federal Highway Administration (FHWA) to provide strategic advice and guidance to FHWA concerning the conduct of its Intelligent Construction Systems and Technology (ICST) program. The committee's charge includes reviewing FHWA's ICST program through semiannual meetings with FHWA staff. Specifically, the committee will assess the potential utility of the intelligent or innovative technologies being investigated by FHWA, provide guidance to enhance the effectiveness of deployment and implementation of successful technologies by users, identify and prioritize additional research needs, and make suggestions for future direction of the ICST program. The committee membership has been drawn from the senior professional levels of state highway agencies, private industry, and academia. The committee's collective expertise covers a broad spectrum of scientific and engineering disciplines, including Global Positioning System (GPS) and geographical information system technologies, laser technology, sensors, computer-aided design, artificial intelligence, concrete and asphalt paving, automated quality monitoring, nondestructive testing, data management, and highway construction management. A roster of the committee is provided as Attachment 1.

We acknowledge FHWA's efforts in reaching out to and seeking input from an independent committee of experts and in inviting commentary from external stakeholders. The committee held its first meeting on March 14–15, 2013, in Washington, D.C. All 12 members attended. Because this was the committee's first exposure to FHWA's ICST program, the meeting was mostly a learning experience for the members. Before the committee could comment competently on the program, the members needed to learn more about its basic components. They also needed to gain an understanding of how the program fits within FHWA's overall activities and organizational structure and how it complements and coordinates with other FHWA programs and initiatives, such as the Office of Infrastructure's Bridge and Pavement programs and the Every Day Counts (EDC) initiative. The committee appreciates the efforts of FHWA staff in presenting the information needed to help with this learning process. The initial assessment of the program as presented in this letter report is based on what the committee learned through the presentations and the discussion that followed them.

The committee's assessment was developed in a closed session and completed through correspondence. Its report was reviewed by an independent group of peers according to policies and procedures of the National Research Council. The assessment and recommendations of this letter report represent the committee's best collective judgment at this time.

Overview

The committee's reaction to and assessment of what it learned in the first meeting are described in more detail in the sections that follow. This section provides an overall summary; details and supporting information are included in the relevant sections that follow. In general, the committee supports FHWA's approach as a good starting point and agrees with the program's overarching goals. However, the program's scope needs to be refined or clarified, and this should be reflected in the program's roadmap. The initiatives described by FHWA do not all appear to be consistent with the definition provided for ICST ("collect information, analyze information, make, and execute an appropriate decision during construction"). In addition, the impact of ICST on an agency and how that impact can be enhanced need to be considered. With regard to the individual elements of the program, the committee has the following observations and recommendations:

- The committee needs a better understanding of how each technology listed in FHWA's ICST Strategic Roadmap qualifies as "intelligent" construction, how the various activities are prioritized, and how input from stakeholders is sought in establishing the program's goals and priorities. Development of an overview or matrix of the ICST program will be helpful in demonstrating how all components fit together and how each of the initiatives within the ICST program contributes toward achieving overall program goals.
- The program needs to ensure that it has adequate resources for technology implementation within its proposed time frame and that it has a mechanism for keeping informed of advances in the technology.
- The committee supports FHWA's civil integrated management (CIM) approach, which focuses on integration of technologies into a system, and encourages FHWA to take a lead role in advancing such integration.
- Among alternative contracting methods (ACMs), the construction manager/general contractor (CMGC) method appears to be promising, but FHWA should postpone promoting it until an ongoing National Cooperative Highway Research Program (NCHRP) study on the topic is completed.
- The committee generally supports FHWA's efforts on intelligent compaction (IC) and encourages clarification of priority, cost, and expected duration and interaction of planned implementation activities. The efforts should be expanded to include other scanning technologies, such as paver-mounted infrared temperature bar and ground-penetrating radar (GPR), which would enhance and complement IC technology.
- The committee supports FHWA's efforts to facilitate the use of three-dimensional (3D) engineered modeling among state departments of transportation (DOTs). FHWA should include DOTs that are at the initial as well as advanced implementation levels. Priority should be given to addressing and coordinating issues related to data transfer and sharing as 4D (3D + time component to include scheduling/phasing), 5D (4D + cost element), 6D

(5D + facility management data), and XD (6D + future model elements, for example, carbon footprint/energy sustainability, etc.) are advanced. A careful review of the process should be carried out before expanding the use of 3D engineered models and 4D, 5D, 6D, and XD applications on projects at various jurisdictional levels. FHWA also needs to consider establishing a framework for the implementation of 3D designs at DOTs.

- The committee supports FHWA's accelerated bridge construction (ABC) activities. These activities could be expanded to include bridge system moves other than slide-in technology. The committee encourages additional technical support for bridge owners and collaboration with other stakeholders in the adoption of ABC methods.
- With regard to ICST research at FHWA, the committee needs more information on how projects are selected and how they contribute to ICST. Development of a framework is suggested showing how new projects are determined and how they relate to ICST objectives and are coordinated with other related activities elsewhere.
- The method of geosynthetic reinforced soils (GRS) is not intelligent construction, but it is a useful technique in bridge construction and should be encouraged.
- The committee supports the development of technical briefs and training programs at various levels of detail and of durations appropriate to specific audiences with the timeline for the courses matching the rate at which DOTs are willing to attempt change. A plan on how to update the technical briefs and training courses as the various technologies advance is also needed.

ICST Program

The committee needs a better understanding of what constitutes the ICST program and what qualifies as intelligent construction. The primary reasons for the committee's lack of clarity may be the definition of ICST, which has evolved to incorporate more than just intelligent systems, and parallel, apparently complementary programs, such as the EDC and CIM initiatives, which appear to overlap with the ICST program. The topics of the presentations at the meeting were broad. In view of FHWA's current interpretation of the vision and purpose of the ICST program, "innovative" rather than "intelligent" might be a more inclusive word for the program presented to the committee.

In addition, the committee needs to understand how the ICST program fits in with other similar efforts within FHWA, particularly how it relates to the EDC and the Highways for LIFE programs, the Technology Implementation Group (TIG) of the American Association of State Highway and Transportation Officials (AASHTO), and the Strategic Highway Research Program 2.

ICST Strategic Roadmap

FHWA's ICST Strategic Roadmap is a crucial document that establishes the program's goals as well as milestones to help gauge progress toward reaching the goals. The roadmap consists of short-term activities for implementation of existing technologies and long-term activities for conceptual and emerging technologies. Short-term activities involve training and technology transfer to the construction industry for specific individual technologies. Long-term activities include development of guidance specifications and standards for technologies grouped into domains (some of which overlap). Technologies are divided into seven disciplines: general and common technologies, surveying, earthworks, pavements, structures, construction and project management, and traffic management and work zones. A project statement for each technology provides the current status, identified needs, description, objective, tasks, final product or deliverables, and project budget and duration.

The roadmap emphasizes the need to refine the scope of the program. The roadmap implies that all technologies (whether "intelligent" or not) are included as long as they accelerate construction, improve quality, reduce cost, or improve safety. Under these criteria, many other technologies qualify for the ICST program, although they would not be considered "intelligent." Two such examples are recycled pavement materials and GRS abutments for bridges, and there are many more not listed in the roadmap. Therefore, information about how each technology listed in the roadmap qualifies as intelligent construction will be helpful.

Preparation of an overview or matrix of the program to demonstrate how all components fit together might be helpful. However, it is important to decide beforehand which objectives, technology areas, ICST categories, and so forth should be depicted. For example, the five "classified ICST activities" listed in the research presentation are different from the seven "disciplines" listed in the ICST Strategic Roadmap. In addition, "ICST program objectives" as described in the introductory presentation are different from "infrastructure R&T strategic plan objectives" as described in the research presentation. This in itself is not an issue as long as the manner in which they fit together is clear. The overview will help in demonstrating how each of the initiatives within the ICST program contributes toward achieving overall program goals.

The roadmap does not make clear whether FHWA has established a mechanism adequate for monitoring the status of each technology in the industry. For example, NCHRP is close to releasing specifications for automated machine guidance. However, the roadmap shows this as a long-term goal (which may no longer be needed). A mechanism is needed at FHWA for reporting and communicating with organizations such as AASHTO's TIG, TRB's NCHRP, and professional associations to keep abreast of the state of technology transfer and progress in each specific technology or domain area to avoid duplication of effort.

Whether adequate resources are available to FHWA to implement the roadmap within the self-imposed time frames is also unclear. For example, the barriers to the use of 3D and 4D engineered models by DOTs are listed as resistance to change; misperception of cost; and lack of understanding between designers and contractors about the 3D data requirements for major uses, such as automated machine guidance. The tasks to be accomplished are then described as identifying the requirements, investigating the status of standardized data transfer, and developing guidance and training. The tasks are reasonable but will take much more time and effort than envisioned here.

In addition, FHWA needs to consider establishing a framework with regard to the implementation of 3D design at the DOTs. Such an implementation framework may consist of work-flow process maps which display the order and sequence of utilizing technologies within an entity in order to achieve goals more efficiently (such as delivery of projects, design-procurement-construction, maintenance/operation of a facility, etc.). If this is done, most of the ICST technologies that are now addressed separately will fall into the framework at the appropriate level or location. Assisting and enabling DOTs (and the contractors and consultants) in embracing a new way of thinking and working in cooperation will not be an easy task, but it is doable and necessary. The committee would like FHWA to take the lead, with the realization that successful implementation may take a decade or longer. It will involve policies, procedures, and legal issues unique to each of the 50 DOTs and other transportation agencies.

CIM and ICST

CIM was described in the presentation as "intelligent construction + partnering" and as consisting of the following: project management systems with legal considerations, information modeling and utilities, surveying, and ACMs. The concept was communicated with a diagram depicting the components overlaid on an image of clouds (which is representative of the networked interoperability of various systems and the "smart job site").

The committee agrees that FHWA should direct its efforts toward an integrated approach, as opposed to its current focus on individual technologies. The consensus at the fall 2011 St. Louis ICST workshop concerned integration of the individual technologies into systems. The CIM concept does just that—it integrates individual technologies into a framework. The framework is where FHWA should provide leadership and direction to all stakeholders involved in the construction of transportation infrastructure. The DOTs need as much guidance as the contractors.

The vertical construction industry has embraced and implemented a similar framework of technology integration: building information modeling (BIM), based on 3D computer-aided design, is becoming mainstream in certain types of projects. The industry has developed new owner procurement delivery systems and standard contract forms for integrated project delivery (IPD). The industry is assisting users with standards and implementation through buildingSMART International and research project deliverables at Pennsylvania State University such as *BIM Project Execution Planning Guide* and *BIM Planning Guide for Facility Owners*. The committee would like to see FHWA provide leadership in research, training, technology transfer, and development of standards in implementing the CIM concept. Partnering is an integral component of CIM that is missing in the BIM and IPD models: even if stakeholders are contractually required to cooperate in these new delivery systems, teamwork is required for the systems to realize a return on investment. The human element of cooperation, which is just as crucial as the technology side with regard to implementation, is still needed for the systems to function properly.

Implementation of ACMs

The ICST initiative seeks to promote mechanisms to improve project delivery performance. While design–build (DB) is the predominant ACM for federally-funded construction projects, ACMs that incorporate contractor involvement in the design phase offer advantages for certain types of projects.

A significant number of state DOTs have used ACMs to achieve accelerated project delivery. The data presented at the meeting indicated that 39 DOTs have full authority to use DB contracting, while three have limited authority for its use. In addition, 26 DOTs have used alternative technical concepts (ATCs) with their DB projects. Twelve DOTs have full authority and six have limited authority to use the CMGC method of contracting. FHWA has been encouraging the use of DB, ATCs, and CMGC because these methods help accelerate project delivery.

AASHTO's *Primer on Construction Contracting for the 21st Century* focuses on 17 ACMs and lists five with the highest potential for accelerating project completion. In order of highest relative potential, they are DB, incentives and disincentives, cost-plus-time bidding, interim completion dates, and no-excuse incentives. All five methods reduce duration, and three (cost-plus-time, incentives and disincentives, and DB) reduce duration by more than 10 percent of the planned value. However, they do not differ substantially in their impact on project cost; cost performance for all five methods generally varies by ±5 percent from budget.

The CMGC method appears to show promise to bring about change in construction practice. CMGC is similar to construction manager at risk (CMR) but allocates risk more reasonably among the owner, the contractor, and the designer. The risk component and the benefit gained by early contractor input are two reasons for using CMGC. On the basis of building industry experience, CMGC may also help speed delivery of more complicated and difficult urban environment projects while better aligning project risk. An NCHRP study, Design–Management Guide for Design–Build and Construction Manager/General Contractor Projects (15-46), is under way, and the Florida DOT has been evaluating the use of CMR at the Miami Airport. Additionally, various state DOTs are applying modified versions of CMGC or CMR that do not conform to the strict definition of each practice. Hopefully these will be included in the NCHRP study and provide data points. FHWA is advised to wait until the completion of the NCHRP study before promoting CMGC. The metrics for evaluating any ACM should be time to project delivery, construction project duration (impact on the public), and project delivery cost. The number of projects using a particular method should not guide the decision making.

IC Initiative

Uniform compaction of soils, aggregate base materials, and asphalt paving materials is critical to the performance of the pavement structure. The IC process uses construction equipment, sensors, GPS technology, and specialized software to monitor compaction efforts continuously and provide coverage and stiffness data to the operator in a real-time format. IC-equipped rollers also provide color-coded plan view plots that help guide the compaction operation and identify "weak" and missed areas and other anomalies that may require more investigation. The continuous compaction control provided by IC systems will improve quality control/quality assurance approval processes that rely exclusively on a variety of spot-testing methods.

FHWA's plan to expand and implement IC appears well developed. The plan builds on the work done across the United States over the past several years, especially that performed in a recent pooled-fund study. Page 11 of the EDC-2 report sets forth a detailed implementation plan listing all of the categories and related activities that need to be performed. The plan could be further strengthened by clarifying the following:

- The items considered to have highest priority and the items that need to be funded first,
- Estimated cost for each activity (at the meeting, FHWA informed the committee that it had $1.2 million for the entire effort), and
- The expected duration for each activity and for the whole effort along with a flowchart and timeline showing how all activities fit together.

IC could fundamentally change the way roadways are built. Properly used, IC will improve the overall performance of the highway network. To help FHWA achieve these goals, the committee makes a few suggestions. The IC technology should not be oversold. Like any technology, IC has strengths and weaknesses, and they should be listed in a straightforward manner. Page 10 of the EDC-2 report is a start. The committee also recommends that FHWA include related scanning technologies that would enhance and complement the IC technology. The paver-mounted infrared temperature bar shows great promise for improving compaction. In addition, GPR has been used successfully to correlate GPR-measured surface dielectric with in-place hot-mix asphalt density. These technologies could significantly improve the overall quality of pavements at a reasonable cost. Each technology should be fully interactive with the others. Data management for IC and related scanning technologies is the key to success.

3D Engineered Models for Construction

The committee was briefed on FHWA's efforts to foster wider use of 3D engineered models among state DOTs in the construction of highway facilities. The models are stated to offer multiple benefits to DOTs: clash detection, coordination of various disciplines on the job, earthwork quantity computations, facilitation of automated machine guidance, facilitation of the use and organization of data from light detection and ranging data collection systems, and a means of maintaining the location of subsurface geophysical features and utilities. The plan for achieving wider use comprises three elements: (*a*) an understanding of the current level of implementation of 3D engineered models in the DOTs and their concerns with regard to the use of these models; (*b*) different deployment strategies (vetted with public and private experts) for new, recent, and advanced implementers of this technology; and (*c*) performance measurement, which involves determination of the levels in the implementation process (initiation, development, execution, assessment, and integration) a DOT was able to achieve as a result of the program. The key deployment strategies were (*a*) development of case studies, marketing documents, and best practice documents; (*b*) provision of training and guidance for project implementation; and (*c*) development of best practice guidelines and modeling requirements and model state laws related to digital signature. FHWA also reported experiencing challenges due to the need for return on investment information, for guidance concerning the level of detail and the level of accuracy required in models, and for data transfer standards. Although the construction industry has been using 3D modeling sporadically in support of automated machine guidance and underground utility location for at least 10 years, it does not appear from the information presented at the meeting that anything significant related to 3D engineered models is under way at FHWA, but a number of research areas were listed as potential activities, including the modeling of workflow processes, the modeling of standards and processes, quality assurance and quality control of 3D models, data exchange standards, data storage, and security.

At the fall 2011 St. Louis ICST workshop, the conclusion was that 3D engineered models were still emerging and were not greatly used by DOTs at that time. The committee considers FHWA's activities in encouraging more DOTs to use full 3D design to be important and necessary. FHWA's efforts to promote 3D engineered models appear to focus mostly on DOTs that are already at an advanced implementation level; involvement of states less far along in the process would be helpful. Involving states less advanced in the use of 3D models will keep them informed of the implementation progress and provide them with a better understanding of what is involved in the implementation. As a result, these states will have a higher comfort level when initiating their own implementation. The committee also believes that priority should be given to addressing and coordinating issues related to data transfer and sharing. Contractors in many states have been requesting 3D model data for grading control instead of, or as a supplement to, conventional survey staking, and these requests do not seem to be related to the size of the contractors. Even though this 3D model may include only the roadbed prism, it can be used successfully for automated machine guidance.

No data were presented at the meeting concerning which states were participating in this program or where they are on the implementation spectrum. The committee is not sure how effective the key deployment strategies will be if they are created with help only from the advanced implementers of 3D engineered models. Feedback from DOTs that are in the early stage of implementation or that have yet to implement anything is also needed. A survey of DOTs would be useful in determining whether this program helped them or whether they made the change for some other reason. Two maps of all 50 states, with one of five levels of implementation depicted for each state (i.e., five colors, one for each level, with each state having one color), would be helpful. The first map should show what the situation was when this project started, and the second would show the situation at the time of reporting.

FHWA also indicated its intent to proceed beyond 3D design deployment to 4D, 5D, and XD deployment and to use the data for long-term asset monitoring and management. FHWA appears hesitant to drive data transfer standardization, although this appears to be an area where FHWA could assist in taking the technology forward. The technical briefs and web-based training need to articulate that the 3D engineered model forms the foundation on which the 4D, 5D, and so forth components are built and that state DOTs need to master 3D design capabilities before they take on these added components. A careful review of the process should be carried out before expanding the use of 3D engineered models and 4D, 5D, and XD applications on projects at various jurisdictional levels. In particular, its impact on small contractors should be taken into consideration since their means and methods may not be able to accommodate equipment required for this technology.

ABC and Slide-In Bridge Technology

Slide-in technology is one of a suite of bridge system move technologies significantly reducing mobility impacts that otherwise would occur when a bridge is replaced. Bridge system move technologies may include fit-up, twist, and other real-time monitoring systems that would place the technologies under the intelligent construction umbrella. The "slide-in" or "lateral slide" technology, as defined by FHWA, is accomplished by constructing a new bridge on temporary supports parallel to the existing structure. Once the new bridge is ready, the road is closed and the existing structure is demolished or slid out of the way and the new bridge is slid into position. This technology is a part of FHWA's EDC-2 initiative. From several summits that FHWA held across the country to facilitate knowledge exchange on ABC, it became apparent that bridge owners wanted assistance with cost data, decision making related to when and which type of ABC to use, and technical details such as case studies and lessons learned. To address these needs, FHWA is planning workshops that showcase slide-in demonstration projects in addition to presentations, technical information on the website, and training. Slide-in bridge construction has been used in the United States since at least the early 1990s on a limited project-by-project basis but not as a program of work. The number of projects using this technology is increasing as the states must replace their substandard bridges while maintaining traffic. However, application of slide-in technology is limited to bridge sites that are conducive to the building of temporary substructure alongside the existing bridge. The temporary substructure must be able to resist the significant lateral forces that are applied during the move.

FHWA has advanced slide-in technology through the EDC-2 initiative. This appears to be effective as a starting point. Since site constraints may preclude the use of slide-in technology in some places, expansion of FHWA's assistance to bridge owners to include other bridge system moves would be helpful in minimizing mobility impacts. Promotion of a "bridge system moves" suite of products could encompass technologies such as self-propelled modular transporter bridge moves and longitudinal launches.

The committee suggests that FHWA consider, in addition to activities planned to address bridge owners' needs, helping owners develop detailed specifications for the initial application of the technology in a state, followed by performance-based specifications in subsequent projects to allow contractor options within the owners' construction timeline. Use of AASHTO's TIG lead states team process could increase implementation of the suite of available bridge system move products. FHWA is advised to collaborate internally and with the states and industry to accomplish these tasks.

ICST Research Under Way or Planned at FHWA

The research component of the program has a broad array of current and planned projects. The research appears to be wide-ranging, and FHWA appears to have done a good job of leveraging the limited funds available. The method for determining which new research projects should be started was discussed briefly, but it did not appear to follow a standard framework. The connection between the projects and ICST objectives is not clear. Furthermore, the process for determining how overlaps with parallel efforts by other agencies are avoided is not formalized. The following questions arise:

- How do the ICST research activity classifications and research activities themselves fit with the R&T strategic plan objectives?
- How do research projects contribute to intelligent construction?
- How are new research projects determined?
- How are research outputs reviewed, used, and shared?
- What are the criteria for determining which projects should go to the next stage of development (field trials), and, if they do proceed, how is their suitability to be determined?

In the absence of answers to these questions, evaluation of the effectiveness of the research for the ICST program is difficult. A framework for developing new projects and documenting the standards to which new projects are held would provide greater transparency and therefore make those decisions more influential. Therefore, such a framework is recommended. Part of that framework should explicitly relate to the ICST team's coordination with other agencies involved in similar research. After a project is identified, a "dashboard" of project progress should be developed to show the manner in which projects go through stages (illustrated in the technology development cycle on page 10 of the roadmap document).

GRS in ABC

The use of GRS to create bridge abutments provides a relatively new but proven method to cut cost and construction time for new bridges with simple spans of up to 140 feet. Engineered fills with closely spaced alternating layers of compacted granular fill and geosynthetic reinforcement are used to construct the abutments and integrated approach. The method removes the time and expense of driving piles to support the bridge and eliminates the need for conventional approach and sleeper slabs. It also removes the proverbial "bump at the end of the bridge" because the bridge elements and abutments settle as one unit.

The GRS method is not "intelligent" construction, and FHWA has not clarified under what broad definition of "intelligent" construction it has been included in the ICST program. It is, however, an innovative technology that could save substantial money and construction time and improve bridge performance in locations that can accommodate GRS applications. FHWA has proved the technical performance of the method and has developed implementation design and construction guides along with implementation aids. As of 2012, more than 80 bridges of this type have been successfully designed or constructed in 31 states and on federal lands. Challenges identified by FHWA to wider adoption include the following: reluctance of owners to the use of geosynthetics and shallow foundations, concerns about the potential effects of scour, concerns with the durability and aesthetics of the block facing elements, and owners' lack of familiarity with the method and its benefits. FHWA has developed a training program to help overcome these and other obstacles. Through research, the durability issues for the most part have been resolved, and scour countermeasures can be designed by using FHWA guidance.

GRS represents one of the success stories of FHWA's R&D and implementation activities. Its development of implementation tools and outreach program could serve as a guide for other technologies being advanced through the ICST program. The committee questions whether this initiative fits under the banner of intelligent construction. Nonetheless, it encourages continued strong support for FHWA's implementation efforts for this technology through complementary programs such as EDC.

Technical Briefs and Web-Based Training for ICST

FHWA has contracted with a consultant to develop 10 technical briefs. The briefs cover four topic areas: 3D, 4D, and 5D design and modeling; IC; automated machine guidance; and bridge sliding and jacking. An executive summary and a more detailed project-level brief are in preparation for each topic area. The committee concurs with FHWA's approach of developing two levels of technical briefs. However, the committee asks whether the costs to produce these technical briefs are typical and similar to the costs of producing such briefs in the past and whether there might be a more cost-efficient way to produce the briefs, especially since a technical working group appears to be assisting the consultant in developing the content and gathering information. The committee recommends that the technical working group include local public agencies (such as county representatives) in addition to state DOT, university, and FHWA representatives. The committee also recommends development of a plan for updating the technical briefs as the various technologies advance.

FHWA has issued a contract to complete two web-based training courses that will be hosted online for 2 years. The meeting presentation provided limited details on the existing contracts and the courses to be developed, so evaluation of the plan is incomplete. However, the committee concurs with FHWA working toward developing training on ICST topics. For topics with no existing contract, the committee recommends that FHWA partner with the National Highway Institute, AASHTO, and the Transportation Curriculum Coordination Council in preparation of future courses. While it is important that the training consider the needs of different audiences (designers, field inspectors, contractors, etc.) and should be provided at different levels of detail and duration in terms of deployment of new ICST technologies, the timeline for the courses should match the rate at which DOTs are willing to attempt change. It might be better at this time for the FHWA to tailor training resources specifically for DOTs that are change leaders. The success of leader DOTs will serve as the model for other DOTs and the courses developed later would be built on the lessons learned from the earlier deployments. As in the case of the technical briefs, the committee recommends that FHWA develop a plan on how to update the training courses as the various technologies advance.

In conclusion, the committee found its first meeting to be informative and productive. It provided an excellent opportunity to learn firsthand and exchange views with those who are leading this national effort at FHWA. The receipt of reading material a week or 10 days before future meetings would help the committee members in their preparation. In addition, slides and handouts with white backgrounds would be helpful in interpreting presentation slides.

The committee commends FHWA staff for their work in developing this program and for striving to improve its goals and strategies. It particularly appreciates FHWA's efforts to reach out to stakeholders from all relevant groups to seek their input into the program. The committee shares FHWA's view that only the active participation of all stakeholder groups in all phases, from research to deployment and training, will ensure that the program achieves its ultimate goal of building roads and bridges that last longer, cost less money and take less time to build and maintain, and are safer to travel. The committee looks forward to a continuing dialogue with its FHWA partners on this important national endeavor at its next meeting, which is scheduled for early fall.

Sincerely,

Mary Lou Ralls

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Program Review

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