MEETING SUMMARY

SHRP2 ADVANCED METHODS TO IDENTIFY PAVEMENT DELAMINATION (R06D) PEER EXCHANGE

TO	Kate Kurgan, Steve Cooper, Pam Hutton
COPY	Sam Rosenblum
PREPARED BY	Michael Heitzman and Jen Smoker
MEETING DATE	August 1-3, 2018
LOCATION	MnDOT Shoreview Training and Conference Center and MnROAD test track

Purpose

This Peer Exchange and Technology Demonstration was the final event planned regarding the nondestructive testing technologies (NDT) offered through *Advanced Methods to Identify Pavement Delamination* (R06D), which was developed through the second Strategic Highway Research Program (SHRP2). Participants saw first-hand demonstrations of ground penetrating radar (GPR) systems along with mechanical wave impact echo (IE) and spectral analysis of surface waves (SASW) systems and their corresponding software. The goal was for participants to see how these NDT operate, hear updates from the Implementation Assistance Program (IAP) states experiences using the technologies and collecting and analyzing data, and brainstorm future developments that would be beneficial to promote this technology among states. State representatives were given the opportunity to express needs the industry might address and support Federal Highway Administration (FHWA) and American Association of State Highway and Transportation Officials (AASHTO) might consider post SHRP2. The agenda was divided into four components: full-scale systems field demonstrations, presentations of agency experiences to date, presentations by participating vendors, and roundtable discussion on next steps or needs toward advancement of the technologies. See Appendix A for the Peer Exchange agenda.

Attendees

Nine states attended the event, as well as two NDT research practitioners assisting the IAP states. The peer exchange team in attendance were FHWA, AASHTO, and Jacobs Engineering Group Inc. (Jacobs). Mike Heitzman, Subject Matter Expert (SME) for R06D, coordinated the event and moderated the presentations. NDT technology equipment vendors 3D-Radar and Olson Engineering participated with the equipment demonstration and with presentations (see Appendix B for full list of attendees).

Executive Summary

Through the SHRP2 evaluation study *Advanced Methods to Identify Pavement Delamination (R06D)* completed in 2013, three technologies were identified that could make significant advances in detecting the extent and severity of pavement delamination in place of extensive forensic coring. The technologies are GPR, IE, and SASW. California, Florida, Kentucky, Minnesota, New Mexico, and Texas received Proof of Concept awards through the IAP, administered by the FHWA and AASHTO, to evaluate the technologies in their respective states.

The Peer Exchange achieved its overall intended purpose to have the agencies present their findings and special gratitude goes to the staff of the Minnesota Department of Transportation (MnDOT) who provided extensive effort to host the event. On Wednesday afternoon, participants took part in a full scale, hands-on demonstration of the NDT systems at the MnROAD Test Track. On Thursday, the five states participating in the IAP presented their pavement delamination challenges and their experience using R06D technologies. On Friday, the two vendors, 3D-Radar and Olson Engineering, gave presentations about their NDT systems and there was a roundtable discussion on future next steps.

Based on the participant evaluations, participants left the peer exchange with greater knowledge of the R06D technologies. The responses indicated the peer exchange content, specifically state and vendor presentations, were moderately to extremely effective. The comments were positive with many saying it was a successful event.

Thursday Agency Presentations

Welcoming Remarks: Glen Engstrom, MnDOT, Steve Cooper, FHWA, Kate Kurgan, AASHTO

MnDOT welcomed all participants. FHWA welcomed all participants and thanked them for taking time to invest in this conversation. AASHTO welcomed participants and reminded everyone that Round 7 of the SHRP2 Program has implemented 79 projects in 37 states. Overall, SHRP2 has implemented more than $130M of funding to 99 entities for 63 products and 430 projects are underway. Six states (CA, KY, NM, TX, MN, and FL) participated in R06D IAP. After this showcase, this report and the PowerPoint presentations will be posted on the AASHTO SHRP2 website.

Definition of Technologies

Spectra Analysis of Surface Waves (SASW)

Mechanical energy is introduced into a pavement layer. The mechanical energy wave traveling through the pavement is changed if there is delamination with in the pavement layer. The equipment is simple. The hardware includes a mechanical energy source tapping on the pavement surface and two sensors reading how that surface wave is carrying horizontally through the pavement.

Impact Echo (IE)

The same mechanical energy is introduced into the pavement. This portion of the energy wave travels down to the bottom of the pavement layer and rebounds to the surface. The energy source tap is the same and the receiving sensor is immediately next to it. Sensor is measuring the speed of the energy wave as it bounces down and up.

The hardware package and set-up for IE/SASW testing includes an impactor, receiver sensors, sensor spacing, measurement frequency, data logger, data processing equipment, DMI, and field display. For SASW, spacing of sensors is very important. The challenge for these contact point tests is to take measurements rapidly and cover the full lane width. Olson Engineering, a selected vendor for R06D, developed a hardware system that significantly improves the ability to take field measurements rapidly. The IE test has the potential to immediately display pavement layer thickness as the testing progresses in the field.

Ground Penetrating Radar (GPR)

A GPR antenna system sends radar energy into the pavement and measures the change in that energy as it reflects back to the GPR receiver antenna. If there is a change in the pavement material, the radar signal response reflects that change. Unfortunately, if there is simply two sequential layers with no bond, there is no change in the GPR signal so we cannot detect simple debonding. If the debonded zone includes water or air, then the GPR signal encounters a change in material properties and the receiving antenna measures a change in the signal.

Typical hardware systems for GPR have one or multi-antennas mounted on a vehicle. Most systems are single-frequency antenna, which influences the quality of the measured response. 3D-Radar, a selected vendor for R06D, has a hardware system that measures with a range (sweep) of radar frequencies across an antenna array that can cover up to the entire lane width.

The goal of the R06D project is to identify and develop NDT technology that can:

- Detect delamination in hot mix asphalt
- Operate at reasonable traveling speed
- Cover the full lane width

State Presentations: GPR and SASW (equipment evaluation, software evaluation, field correlation)

Please see slides located here: http://shrp2.transportation.org/Pages/R06D.aspx

All six agencies have some level of expertise with GPR technology. Their evaluations of the 3D-Radar system are provided as follows:

- Kentucky contracted with Kentucky Transportation Center to examine the GPR system. Kentucky uses GPR to collect good field data as part of forensic studies. Their analysis of GPR data starts with black and white images. They believe statistical processes could be applied to identify air and water. They also use GPR for other studies, such as locating voids beneath pavements and locating reinforcing steel.
- Florida contracted with Infrasense to assist them with their examination of the GPR system. Florida uses GPR to investigate 20 to 25 pavement forensic projects every year and the predominant use is to measure pavement thickness on approximately 1,500 miles each year. They use data to drive decisions and recognize the value of having a multi-frequency, lane-wide antenna array that can travel at highway speed. They must demonstrate a return on investment and note that the 3D-Radar system is a multi-use technology. Their initial mounting system was 24 inches from the vehicle and that was redesigned to 48 inches to reduce signal noise from the vehicle. They used ExploreGPR (by Infrasense) software to analyze and display the GPR data. They were successful in identifying gaps between layers as small as 1/4 inch.
- California is performing the GPR evaluation in-house. They use GPR for multiple types of projects including the use of air coupled GPR for tunnels, bridges, and pavements and ground coupled GPR for underground utilities. GPR is a part of their forensic study tools to help make decisions. They purchased a 3D-Radar system with their IAP funds and fabricated a custom-mounting system on a dedicated van. Particular attention was given to improving the accuracy of the measurement location using a separate global positioning system (GPS) tied to the GPR processing unit (Geoscope). They estimate 1 month of manual signal analysis for every 1 hour of field data collection. There is a need for quality check protocol for the GPR hardware system.
- New Mexico contracted with Texas Transportation Institute (TTI) to perform the GPR system analysis. New Mexico uses a single channel air coupled antenna for pavement studies. The primary issue they had with the 3D-Radar system was how to filter out cell tower interference. Effort was made to identify standard testing parameters for different types of studies, such as asphalt pavements and bridge decks. New Mexico also contracted with Dr. Hayat and University of New Mexico to develop mathematical tools to assist with GPR data analysis. This preliminary effort was focused on a single-channel output, but could be expanded to the 3D-Radar data array. It was noted that there is a significant learning curve to examining the GPR data.
- Texas contracted with TTI to perform the GPR system analysis. Texas contracts with TTI for numerous forensic studies each year. The GPR system analysis included side-by-side measurements with the TTI single channel GPR system. The 3D-Radar was mounted 48 inches away from the vehicle and 16 inches above the pavement surface. The two systems generated similar signal traces and the 3D-Radar multi-frequency system provided better images deeper in the pavement. Some variation in the signals between the 21 channels in the 3D-Radar were noted. TTI's system is tied to a video log and they believe it provides some value to a forensic study.

- Minnesota contracted with Infrasense to assist them with their examination of the GPR system. Minnesota has extensive experience using GPR as a forensic tool. Significant effort was made to examine the hardware and signal output of the 3D-Radar with particular attention to air calibration, metal plate calibration and plastic slab calibration. There is a need to improve the quality of the data using the air calibration and adjusting the data from the 21 channels. Infrasense applied their ExploreGPR software to process field GPR data. The analysis process evaluates the amount of signal activity between horizontal slices. There was a 75-percent good correlation between the software analysis and verification cores. MnDOT is also developing software that scans for anomalies in the data applying acoustic emission theories.

None of the agencies have expertise with IE/SASW technology. Three agencies evaluated the Olson IE/SASW technology and their assessments are provided in the following list. The analysis is still performed by Olson staff because the software requires significant manual processing.

- Kentucky was the most recent agency to work with the Olson system and KTC lead the evaluation. Unlike high speed data collection with GPR, field data collection with IE/SASW requires a lane closure and the data is collected at a slow walking speed. Kentucky noted that there is a cost to providing a safe lane closure. One limitation of collecting data with the Olson system is location coordinates. The current system only uses DMI to record its location and would be more valuable if it was updated to a GPS system. Olson processed the field data and provided a report of the analysis. Kentucky did not have time before the peer exchange to complete a through correlation between the IE/SASW results and verification cores.
- New Mexico was the first agency to have the Olson system on field projects and TTI lead the evaluation. One focus of the field effort was to examine the impact of changing pavement material temperature on the quality of the measured signal. Both IE and SASW perform best on stiff materials. The SASW results were better than the IE results as the temperature increased. As the Olson system improves, the field measuring system could be equipped with a temperature sensor to record pavement surface temperature so that the data analysis can automatically adjust for change in material stiffness. The signal responses matched the verification cores in most cases.
- Texas applied the Olson system to a 1,000-foot section split between good and poor pavement condition. Both IE and SASW properly identified the thickness to the first material change (layer thickness). The Olson report included three methods to process and display the data. Each process highlights a different change in the measured signal and should be used together to interpret the results. The IE/SASW results had good correlation with verification cores.

Comments and Questions

<u>Questions and Discussion about 3D-Radar mounting</u>

- Regarding mounting of the 3D-Radar antenna on a vehicle, Alabama does not have dedicated vehicles so is there any other way to install sensors that wouldn't rely on a specific vehicle mount?
  - Vendors do not provide mounting hardware and it's up to the state to decide how they want to mount on a vehicle, on a trailer, or even a boat trailer and hitch.
  - Alabama could also use cameras to support safely hauling a trailer behind a vehicle.
  - With back hauling, consider potential splash and dirt picked up from the vehicle that may affect sensors.
- If you have a permanent van with the GPS antenna on top it can be shadowed by large trucks but if you put it on the trailer behind the vehicle the GPS signal could be shadowed by SUVs.
- A permanent mount is more technical. Maryland uses a ground coupled radar and has a trailer mount that can raise and lower it depending on when measuring or just traveling. They can also move the antenna to the left and right, so the vehicle can stay safely in the lane.
- Why do people purchase both ground-coupled and air-coupled systems?

- It depends on what your applications are. Maryland wants rebar algorithms so the resolution available in a ground coupled system was more important to them. If you want multi applications, it's a mix and match (like your golf clubs). (3D Radar – Kent Martin)

Recap of Day:

- There is a consensus that these technologies have multiple applications and will be used (and budgeted for) as forensic tools to look at pavements and other roadway features during project development. GPR can do a system-wide evaluation but the agency must consider how much data they want to collect and analyze. California went through the entire roadway network using GPR just to measure thickness and structure. GPR at traveling speeds can provide a system-wide analysis useful in many departments.
- There are differences between ground- and air-coupled GPR systems. Ground-coupled GPR is collected at slow speed but achieves good signal response for deeper (below 18 inches) features. Air-coupled GPR is collected at traveling speeds but has less detail for deeper features.
- Florida mentioned return on investment. What is the value of having this NDT equipment in the agency? It will not take long to pay for itself by eliminating costly mistakes in redesign or construction change orders for rehabilitation projects.
- Agencies recognize the need to automate the analysis. There are terabytes of data that agencies cannot dedicate staff to manually analyze.
- Agency staff will have a learning curve when applying these technologies. The agencies agreed there was a need for a contact network (directory) of people with experience. AASHTO will consider putting contact info on the R06D web page.
- Each agency will need to determine if one or both technologies meet the needs of the state.
- The SHRP2 IAP R06D GPR Analysis Group has started dealing with technical issues, such as mounting the antenna and automated analysis software.
- Examiner is a fairly user ready software package for GPR data, but it needs more analysis features to reduce manual staff time.
- Both technologies are NDT systems, which in some degree are a black box because they use invisible energy signals to give us information. We will have some false negatives and false positive interpretations of the data. It may never be 100% correct. Cutting one 4-inch core every 0.5 miles of a project does not achieve a 100% analysis either and provides far less information.
- The analysis software for IE/SASW is still being improved by Olson. It is not ready for use by agency (user) staff.
- Impact echo only goes to the first layer of material change. It cannot identify multiple layers of damage at the same point of test.
- TTI believes some amount of coring is needed to confirm the condition of the pavement shown by the NDT system. They did extensive evaluation in New Mexico to study if the cores correlated with the results. There was general agreement that some confirmation coring will still be needed.
- The system used to identify the position of the testing is important and agencies should always be open to methods to improve positioning.
  - Caltrans uses a high-level GPS system to record where things are during testing. An NDT system vendor needs data collection software that is ready to connect with this GPS data.
  - The work by Caltrans work with geo-referencing was a result of many bad experiences with GPS systems that did not work as well as needed. GPS systems that include position referencing from cell phone base stations work well.

- Vendors need to know what level of positioning accuracy the agency needs so they can identify GPS systems that are economical and flexible.
- Need accuracy for validation cores.

- States need to know who and how they will receive technical support from the Vendor after the purchase of the system.
  - When someone buys the equipment, the Vendor should have a detailed client support program
  - When the hardware breaks – how does the Vendor respond?
  - When there are software issues – who does the agency call for support?
    - 3D Radar, Kent – there is a full warranty on the system, the hardware is manufactured out of Charlotte, NC and there is a US presence. There is technical support, but not 24/7 for all problems. All of the resources of 3D-Radar are dedicated to commercial side and not military applications.
    - Olson, Pat – all of our hardware is manufactured in Denver, Colorado and technical service is also available out of Maryland. Call for troubleshooting or send the equipment back.

Friday Vendor Equipment Updates

Slides are available here: http://shrp2.transportation.org/Pages/R06D.aspx

3D Radar – Kent Martin

The step-frequency antenna array has been applied to Road Pavement, Airport Runway, Bridge Deck, Railroad Ballast, Utility Mapping, Archeology, and other applications. The system has been used for pre-bid data collection, post construction quality control, project condition prior to warranty expiration, roadway forensic studies, maintenance and preservation assessment and planning, and identifying core locations. The 3D-Radar system features ground-coupled and air-coupled antennas, multiple antenna sizes, automated software reporting, and dedicated support staff. Customer support includes venues for user exchange, such as an annual Examiner User Group Forum, Linkedin group, and quarterly Webex training sessions. 3D-Radar is developing "How-to" short videos on common analysis features, such as how to identify a pavement layer and exporting data. The staff in the United States is expanding to provide user support and repair capability. A new version of Examiner software will be made available in the near future.

Olson Engineering – Pat Miller

The Olson IE/SASW system is called the Sonic Surface Scanner (S^3). Based on the continued progress to apply the technology to asphalt pavements, the Rayleigh wave used for SASW testing has the best energy features to capture internal pavement distress. Impact echo testing is applied to concrete bridge decks, concrete pavement and other rigid concrete structures to assess the thickness, condition and presence of delamination. The next version of the analysis software will be ready in 2019.

Final Roundtable Discussion

How does the identification of delamination with these technologies advance after the SHRP2 Implementation Program ends? Notes taken throughout this session are sorted into four categories: (1) GPR equipment and software, (2) IE/SASW equipment and software, (3) agency user support, and (4) IAP Agencies evaluation summary.

(1) GPR equipment and software

The 3D-Radar antenna used for this IAP was 1.8 meters wide and two passes with this antenna are not sufficient to get full lane-width coverage. There is a 2.1-meter antenna that agencies could consider. Each agency will need to answer the following questions. Is it necessary to get full width? What about encroachment into other lanes or across the centerline? Is it acceptable to only make two passes and miss a small width in the middle of the lane? The answer will depend on the level of detail needed for a specific investigation. Asphalt stripping often begins along the edge of the pavement where moisture is present and deterioration in longitudinal joints is critical in many States.

Better pavement layer thickness accuracy using the 3D-Radar system will require more uniform antenna performance. A standard software feature to measure, adjust, and report the difference between each antenna pair would be beneficial. Minnesota and Texas each presented their in-house antenna signal analysis effort. Better antenna performance should include both air and metal plate calibration need to become a part of a standard routine operating practice.

A guide with suggested testing protocols would be valuable to new users. Testing parameters for bridge decks are different from parameters for a 10-mile pavement rehabilitation project. Example, for a bridge deck what are the best filter settings?

Many agencies have a general knowledge of GPR, but the details of Examiner software will require training. On-line short video tutorials would be valuable. The basic concept of analyzing the GPR signal is similar for all systems but understanding how to process the high density of data collected by 3D-Radar's antenna array is needed. An analysis process guide is needed. In short, Jacopo cannot process all the data.

Automated analysis software to identify the locations of pavement distress is vital to reducing the staff time required to process the data. Automated analysis software must be supported with experienced manual analysis.

Forensic studies can begin with an initial GPR scan and video, then return to the site for more detailed information (coring, other devices) based on the information of the initial GPR scan. GPR is a great scanning tool for a broad assessment of large projects. The GPR data does not give a definitive description of delamination. Other pavement analysis tools, such as coring, thermal image and LIDAR, may confirm the presence of stripping and delamination.

To the extent possible, make Examiner software output compatible with common agency plan development software. The challenge is all Departments of Transportation (DOTs) do not use the same design package (MicroStation, AutoCad, KML, TGM, Google Earth/KML). Could this be compatible to contractor laptops in the field?

Currently, 3D-Radar only sells the antenna hardware and software system. With the assistance of the R06D IAP GPR Analysis Group, a guide document is needed to direct users on proper vehicle mounting to achieve quality measurements.

(2) IE/SASW equipment and software

The Olson scanner only uses the test wheel as a DMI for recording test location. The system should include GPS to make the analysis easier to tie to pavement location. DMI may be better for small on-site evaluation of a pavement.

Hardware for measuring IE/SASW response is rugged, self-contained, and user ready. The software to analysis the data is not user ready yet. The system is not ready for widespread dissemination without user software. To date, Olson has provided all the data analysis for this IAP evaluation.

(3) Agency user support

The best way to get information on this technology to other agencies is a webinar. Two SHRP2 webinars (one for each technology) are already posted on the SHRP2 website, along with a brochure.

How do you keep your agency departments apprised of the tools? TTI will provide one-page summaries with photos to inform TXDOT on each testing tool and what can be done with each. Need to train regional staff in operating and analyzing. CA word of mouth works best initially, followed by incorporating it into the design academy courses within the agency. KY will start with SPR research to showcase the technologies for the KYTC staff, which will generate 'come help' phone calls. In MN, the research units provide updates to District Engineers twice a year, then the Districts will call asking for investigating issues.

Is there value in having a National GPR User Group to continue addressing limitations and improving these NDT technologies? There are numerous roadway evaluation needs and the technologies will continue to improve. A peer exchange format is valuable. Should the various uses of GPR be combined into a single user group? Or should more focused task specific groups be formed? There is value in learning how other users apply the NDT technology. Pavement condition, utility mapping, and compacted density use the same technology but are very different users. If there are further technology developments for one application, then a focus group may need to be more specific. The highway agencies in MN, TX, CA, and MD (not a member of the R06D group) are leaders in the use of GPR and would be good champions for a User Group.

Technical training sessions lasting 4 hours are cumbersome. One hour sessions periodically are more helpful. The proposed "How to" short, topic specific videos should be helpful.

(4) IAP Agencies evaluation summary

What are the most important things to move forward with?

An NDT system should have these features to become a good agency tool. Every agency will develop their own strategy for these features based on their level of expertise and experience.

- Equipment calibration assures precision and accuracy of the measurements. The hardware system should be delivered from the vendor with a calibration certification. In addition, the NDT system should include a standard set of calibration features that an agency can apply. This does not eliminate the need for regular system checks by the vendor. Agency calibration provides for more frequent system checks to keep the system operating correctly. Both air calibration and metal plate calibration are important calibration practices.
- Equipment verification assures proper operation before field testing. The NDT system should include an internal components diagnostic check that the agency can run frequently before field testing so there is assurance that the collected data is good. GPR can be operated as a high-speed NDT system to make field data collection cost-effective and time efficient, but agencies will tolerate wasted field effort if the system is not operating correctly. It was reported that MD SHA has a verification protocol.
- Testing protocols guide measurement quality for different roadway features. Experienced users need to document the testing protocols that provide the best results for specific types of investigations. The frequency and quality of data collected needs to match the roadway feature in question. For example, a general 10-mile pavement evaluation can be effectively achieved with a lower frequency of testing compared to assessing the level of distress below transverse cracks.
- Recording test location is key to identifying the location of distress. In most cases a quality GPS system will be valuable for large projects, but a DMI feature will be sufficient for testing specific small locations.
- Software to automate data analysis improves efficiency of analysis time. These NDT systems generate a lot of data. Manual data analysis (as currently practiced) is not acceptable for regular application of the NDT system for roadway agencies.

Validate the NDT results with another technology. These systems measure energy response to in-place materials. Some level of validation with another technology improves the confidence in the data. Validation could include physical coring or another NDT system. For pavement delamination, GPR results can be validated with SASW testing under most situations.

Continue the R06D GPR Analysis Group and move towards a boarder User Group for all GPR users. Key leader (champions) are needed and their effort should be supported with assistance from FHWA. There is a need for sharing standard practices and identifying key resources. A User Group can maintain communication with the vendors to provide specific direction for system improvements and user needs. A User Group can provide guidance to new users and document the return-on-investment provided by the technology for agency managers.

This could lead to an international workshop. This will require a stable communication venue to exchange information.

Specific to the GPR system manufactured by 3D-Radar, is it ready for use by all DOTs? The consensus of the R06D IAP agencies is yes, while there are numerous advances identified that will improve the system and the learning curve for data analysis is steep, the current product achieves the objective of identifying pavement distress and has the added benefit that it can be used for other roadway features.

Specific to the IE/SASW system manufactured by Olson, is it ready for use by all DOTs? The R06D IAP agencies noted that the SASW technique may compliment or supplement coring. It can be used to compliment project-wide GPR results to reduce the amount of cores taken as confirmation data to set boundaries for damaged area. Pavement temperature effects are a concern. Data analysis at this point is still complicated and the software is still evolving. The field testing requires a lane closure, but the area covered is a value compared to isolated cores.

Appendix A. Agenda

Photos courtesy: MDOT, VDOT, KYTC, Olson Engineering

Preliminary Agenda
SHRP2 Peer Exchange
Advanced Methods to Identify Pavement Delamination (R06D)
August 1-3, 2018

Wednesday, August 1, 2018
MnROAD Facility
9011 77th Street NE
Monticello, MN 55362

Time	**Topic**	***Speakers***
1:00 PM – 4:00 PM	**Demonstration of Equipment and Software at MnROAD Facility**	***All Participants***
	4 Stations • GPR equipment • GPR data processing software • IE/SASW equipment • IE/SASW data processing software	*Kent Martin, 3D Radar* *Larry Olson, Olson Engineering*
6:00 PM	**Optional Group Dinner TBD**	

Preliminary Agenda
SHRP2 Peer Exchange
Advanced Methods to Identify Pavement Delamination (R06D)
August 1-3, 2018

SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

Photos courtesy: MDOT, VDOT, KYTC, Olson Engineering

Thursday, August 2, 2018 MnDOT Shoreview Training and Conference Center 1900 County Road I West, Shoreview, MN 55126		
Time	**Topic**	***Speakers***
8:00 AM – 8:15 AM	**Welcome**	*Glenn Engstrom, MN DOT Steve Cooper, FHWA Kate Kurgan, AASHTO*
8:15 AM – 9:00 AM 9:00 AM – 9:45 AM	**GPR IAP (equipment eval, software eval, field correlation)** • KY (field correlation) • FL (mounting frame, field correlation)	*Mike Heitzman, NCAT, moderator Brad Rister, KY Charles Holzschuher, FL Ken Maser, consultant*
9:45 AM- 10:00 AM	**BREAK**	
10:00 AM - 10:40PM 10:40 AM - 11:20PM 11:20 AM - 12:00PM	**GPR IAP (equipment eval, software eval, field correlation)** • CA (mounting frame, GPS, data management) • NM (software automation, field correlation) • TX (mounting frame, field correlation)	*Mike Heitzman, NCAT, moderator Bill Owen, CA Darlene Goehl, TTI Darlene Goehl, TX*
12:00 PM – 12:45PM	**LUNCH (Purchased in advance for delivery)**	
12:45 PM- 1:45 PM	**GPR IAP (equipment eval, software eval, field correlation)** • MN (mounting frame, GPS, data management, software automation)	*Mike Heitzman, NCAT, moderator Kyle Hoegh, MN Ken Maser, consultant Shongtao Dai, MN*
1:45 PM – 2:15 PM 2:15 PM – 3:00 PM	**SASW IAP (equipment eval, software eval, field correlation)** • KY (field correlation) • NM (field correlation, temp study)	*Mike Heitzman, NCAT, moderator Brad Rister, KY Shawn Romero, NM*
3:00 PM – 3:15 PM	**BREAK**	
3:15 PM – 4:00 PM	**SASW IAP (equipment eval, software eval, field correlation)** • TX (field correlation)	*Mike Heitzman, NCAT, moderator Darlene Goehl, TX*
4:45PM – 5:00 PM	**Recap and Adjourn**	*Mike Heitzman, NCAT*
6:00 PM	**Optional Group Dinner TBD**	

Preliminary Agenda
SHRP2 Peer Exchange
Advanced Methods to Identify Pavement Delamination (R06D)
August 1-3, 2018

Friday, August 3, 2018
MnDOT Shoreview Training and Conference Center
1900 County Road I West
Shoreview, MN 55126

Time	**Topic**	***Speakers***
8:00 AM – 8:10 AM	**Welcome and Recap of Thursday**	*Mike Heitzman, NCAT*
8:10 – 8:40 AM 8:40 – 9:10 AM	**Vendor Equipment Updates** • 3D-Radar (improvements since Oct-2017 Showcase) • Olson Engr (improvements since Oct-2017 Showcase)	*Mike Heitzman, NCAT, moderator* *Kent Martin, 3D Radar* *Larry Olson, Olson Engineering*
9:10 AM -10:45 AM	**Post SHRP2 Future Needs for Advancement Roundtable** • How to encourage data analysis improvements • Value of a user group with regular meetings • Potential agency use of NDT for project development • Potential agency use of NDT for network level pavement condition • Needed advances with GPR • Needed advances with SASW/IE • Needed training on equipment and software • Draft future work plan for discussion	*Mike Heitzman, NCAT* *Brad Rister, KY* *Shawn Romero, NM* *Charles Holzschuher, FL* *Darlene Goehl, TX* *Bill Owen, CA* *Shongtao Dai, MN* *Kent Martin, 3D Radar* *Larry Olson, Olson Engineering*
10:45 AM – 11:00 AM	**Wrap up and Adjourn**	

Appendix B. Attendee List

First Name	Last Name	Agency or Company
Peter	Annan	Sensors and Software
Janice	Arellano	Pennsylvania DOT
Jeff	Brunner	MnDOT
Kevin	Chesnik	ARA
Steve	Cooper	FHWA
Jamie	Creech	University of Kentucky
Shongtao	Dai	MnDOT
Glenn	Enstrom	MnDOT
Brad	Frazier	Kentucky Transportation Cabinet
Darlene	Goehl	Texas A&M Transportation Institute
Juan	Gonzalez	Texas DOT
Michael	Heitzman	National Center for Asphalt Technology
Kyle	Hoegh	MnDOT
Charles	Holzschuher	Florida DOT
Monica	Jurado	FHWA
Kevin	Kliethermes	FHWA
Kate	Kurgan	AASHTO
Kent	Martin	3D-Radar
Ken	Maser	Infrasense
Pat	Miller	Olson Engineering
William	Owen	Caltrans
Brad	Rister	University of Kentucky
Sergio	Rodriguez	Alabama DOT
Shawn	Romero	New Mexico DOT
Jacapo	Sala	3D-Radar
Jennifer	Smoker	Jacobs
Ogechi	Thomas	New Jersey DOT
Curt	Turgeon	MnDOT
Guangming	Wang	Florida DOT
Tom	Yu	FHWA
Eyoab	Zegeye Teshale	MnDOT