

ROADMAP 2006

RESULTS OF THE FHWA WORKSHOP
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1.0 INTRODUCTION

Community noise due to highway traffic is a growing problem in many regions of the U.S. In some cases, new development, increased population density and higher traffic volume have caused greater exposure to noise in communities. In other cases the public is growing less tolerant. Part of this change is caused by raised expectations as a result of reports of “quiet pavement”.

Similar community response is also occurring in most other developed countries. In some cases the communities have been more demanding than is typical in the U.S. Thus, in Europe and Japan major effort is devoted to developing “quieter” pavement alternatives. The technology developed in Europe and Japan is mostly transferable. Thus, a significant body of technology exists to be tapped.

Existing demonstrations of quieter pavement in the U.S. tend to be closely related to mature pavement technology. Much of the current quieter pavement technology has been discovered serendipitously (e.g., in Arizona, an asphalt pavement that was developed to increase durability was also found to be quieter as an additional benefit). In general the technology of quieter pavement is in early stage development. Many questions remain about how to design, build, and maintain quieter pavement.

The first U.S. Workshop for Quieter Pavement held in September 2004 was convened in order to bring all of the stakeholders in the development of reduced noise from tire/pavement interaction together to discuss the issues. A Roadmap was written as a result of the Workshop that largely addressed measurement standards, information exchange, and technology development. Much of the original roadmap has been accomplished. The second Workshop was convened to assess progress, to redefine priorities and to establish a course of action for quieter pavement for the next period of development.

The second Workshop took place in Indianapolis at the Hyatt Regency hotel on April 10-12, 2006. The Workshop was by invitation and was attended by 46 individuals representing state transportation agencies, the U.S. Department of Transportation (including the Federal Highway Administration and the Volpe National Transportation Systems Center), private industry (including construction companies, automotive and tire industry, pavement and materials associations, etc.), consultants, and universities. The list of attendees is included in Appendix A. The program of the Workshop included updates on the current state of technology and the steps

taken to address the first roadmap. The agenda for the Workshop is attached as Appendix B. The workshop participants identified and ranked gaps that need to be addressed and developed an action plan to address these gaps.

2.0 PROGRESS ON THE 2004 ROADMAP

The 2004 Workshop to develop a Roadmap to Quieter Highways was sponsored by FHWA and hosted by the Institute for Safe, Quiet and Durable Highways at Purdue University. It was held from September 14-16, 2004, on the campus of Purdue University. The workshop was attended by 46 participants.

The action plan developed at the first workshop included a near term component, the so-called “right turn out of the driveway” and a longer term component, the so-called “cross country voyage”.

The near term component consisted of four initiatives:

- ◆ **Clearinghouse:** Establish a web-based clearinghouse to clarify federal policy, to provide references to standards and provisional standards for tire/pavement noise measurement, and to collect and distribute data about tire/pavement noise measurements to all of the stakeholders.
- ◆ **Measurements:** Establish an Expert Task Group (ETG) on Tire/Pavement Noise Measurement to:
 - Develop Provisional Standards for consideration by AASHTO.
 - Coordinate international and U.S practitioners to advance measurement methods.
 - Coordinate international and U.S practitioners to establish the correlation between various types of measurements.
 - Contribute data to the FHWA clearinghouse.
 - Promote implementation of the Provisional Standards by practitioners.
 - Evaluate and refine the Provisional Standards to facilitate adoption as Standards.
- ◆ **Quieter Pavement Alternatives:** Mobilize state and federal resources, along with private sector contributions, to work to optimize several quieter pavement designs that are currently available:
 - diamond grinding for PCC pavements and
 - mix designs for porous asphaltic friction courses.

Monitor case studies for noise, friction, and pavement condition to detect changes over time.

- ◆ **Education:** Develop a training course or workshop with the objective of raising awareness of tire/pavement noise fundamentals to the pavement community and the noise/environmental community.

The longer term component of the plan consisted of the following initiatives.

- ◆ **Measurements:** Continue the work of the proposed Expert Task Group on Tire/Pavement Noise Measurement to ensure a final objective where all data collected on tire/pavement noise and traffic noise in the U.S. is directly comparable
 - Complete standardization of measurement methods for wayside and nearfield (source) measurement and for pavement acoustical properties
 - Correlate wayside and source measurements and develop methods to relate tire/pavement source measurements, pavement acoustical characteristics and wayside measurements
 - Develop calibration and certification pavements (perhaps at test tracks or test sections in each region) to serve as references for practitioners
- ◆ **Research Noise/Safety/Durability/Cost:** Examine the relationship of texture and pavement elasticity to noise, friction, and ride. This effort should be an integrated program of fundamental, laboratory-based work, and test-site-based work. Investigations should include but not be limited to the following:
 - Exposed aggregate concrete
 - Thin gap-graded asphalt overlays
 - Novel texturing methods such as dimpling
 - Porous concrete
 - Double layer porous asphalt

As the relationships between pavement characteristics and functional performance are better understood, it is expected that other novel pavement concepts will evolve.

- ◆ **Cost/Benefit:** Fund research work to examine the true costs and benefits of noise treatments, as well as safety, durability, and other performance aspects of pavement.

- ◆ **Guidelines:** Based on research results and field studies, FHWA/AASHTO should develop Guidelines for ride, friction, and noise. Individual states would use these Guidelines to develop project specific performance targets.
- ◆ **Monitoring:** Using measurement standards developed by the Expert Task Group on Tire/Pavement Noise Measurement, State DOT's should specify and monitor pavement noise (both as-constructed and in-service). For in-service monitoring, states should establish thresholds for (1) reactive maintenance (2) replacement-reconstruction.
- ◆ **Accelerated Testing:** A panel of pavement and noise experts should develop methods for accelerated testing for acoustical performance, based on existing methods for accelerated testing of pavements.
- ◆ **Education:** Material should be developed and distributed for inclusion in an academic course of study to teach students the concepts of designing quieter pavement. Variations of this curriculum should be offered in continuing education format (e.g., short courses, DVD learning materials) to practicing design engineers.

The stated ultimate goal developed at the first Workshop to develop a Roadmap for Quieter Pavement was a reliable design specification for pavements that are safe, durable, and cost competitive and that are substantially quieter than existing pavement over the entire design life. When this design goal is achieved, policy changes may permit the use of quiet pavement as an alternative for noise mitigation to protect the public. Policy changes may also include a methodology that utilizes pavement characteristics in noise predictions.

3.0 RECENT PROGRESS

Much of the near term component and part of the long term component of the original roadmap have been accomplished in the 18 months time period between the first and second workshops. Specifically

- ◆ **Quieter Pavement Alternatives:**
 - The FHWA Office of Pavement Technology has funded development of quiet pavement technology for both asphalt and Portland Cement Concrete (PCC). For asphalt, FHWA has funded the National Center for Asphalt Technology (NCAT)

to test certain variations of current mixes and several innovative surfaces at the NCAT track in order to establish the noise reduction benefit and the long term performance trends. Results of these efforts were reported at the Workshop by Smit. The FHWA has also funded the National Concrete Pavement Technology Center to do lab studies and field evaluations of variations of current technology and innovative PCC surfaces. Results of these efforts were reported at the Workshop by Rasmussen. In these early stage evaluations we are finding clear evidence of what not to do in order to avoid exceptional noisy pavements and are beginning to focus on concepts that consistently produce quieter pavements.

- A Quiet Pavement Pilot Program (QPPP) was initiated by the Arizona DOT in April 2003 for the Asphalt Rubber Friction Course (ARFC) pavement. The study has found that ARFC significantly reduces perceived noise relative to the preexisting pavement (usually a uniform transversely tined concrete). Measured reductions are typically about 5 dBA in adjacent neighborhoods. Additional monitoring will be done to establish the durability of the noise reduction effect. See the presentation by Dennis.
- Several states report progress on Quiet Pavement Research Programs (QPR) including California (see Rymer and <http://www.dot.ca.gov/hq/env/noise/publications>), Colorado (see Mero), Florida (see Berrios), Texas (see Shearer, Seiders, and Trevino), Virginia (see McGhee), and Washington (see Waters and Pierce).
- The NITE (Noise Intensity Testing in Europe) Project was funded by CALTRANS, AASHTO, and the FHWA and was conducted by Paul Donavan from Illingworth and Rodkin in fall 2004. Measurements were taken on more than 60 pavements in Germany, Netherlands, Belgium and France. In general, both the noise levels and distributions of current technology in Europe and in the U.S. are similar. The only European technologies that are not currently used in the U.S. that performed well in the NITE study were Double Layer Porous Asphalt (DLPA) and ground porous concrete. There is also a tendency in Europe to use smaller aggregate size for quieter pavement within a specific pavement type.

- NCHRP is funding project 1-44 Measuring Tire-Pavement Noise at the Source to develop a method to measure tire/pavement noise at the source.
 - NCHRP is funding project 8-56 Truck Noise-Source Mapping to do an acoustical imaging study of trucks to determine the rank priority of noise sources on trucks. In addition, CALTRANS has been funding Illingworth and Rodkin to look at tire-pavement noise of truck tires using the OBSI method. (See the presentation by Donovan).
- ◆ **Measurements:** An Expert Task Group (ETG) for Pavement Noise Measurement has been established. It consists of 10 members and 3 technical resources. The short-term objective of the ETG is to develop a draft provisional standard for consideration by the AASHTO Subcommittee on Materials for On-Board Sound Intensity and wayside sound measurement methods. The ETG has developed two draft provisional standards for measuring tire/pavement noise at the source. One of the provisional standards addresses the equipment specification, while the other addresses the measurement method. These provisional standards will be submitted to AASHTO for consideration as AASHTO Provisional Standards. AASHTO provisional standards are considered temporary and are used when the standard is expected to be subject to considerable and rapid change due to such aspects as the implementation of ongoing research and development efforts.
- ◆ **Education:** The first step in a technical education program has been successfully accomplished. The FHWA Office of Pavement Technology has funded the development and presentation of a one day workshop entitled Tire-Pavement Noise 101. The workshop is intended to bridge the gap between noise practitioners and pavement practitioners. Response has been very positive. Sixteen workshops will be complete by mid-July throughout the U.S. (in FL (2), KY, NJ, MN, IA, CA, WA, TX, VA, KS (2), HI, MD, MO) and a contract is anticipated for 15 more workshops.
- ◆ **Clearinghouse:** The FHWA offices of Pavement Technology and Noise have developed a web based Pavement-Related Traffic Noise Clearinghouse. The Clearinghouse at www.pavenoise.us includes web pages for Policy, News, Resources, and Contacts. The Clearinghouse was almost complete at the time of the Workshop and should be online as soon as approvals are complete.

Other notable accomplishments toward the objectives of the first Roadmap relate to longer term objectives and include:

- The Quiet Asphalt 2005 Symposium was held November 1-3, 2005 in Lafayette, IN. The Symposium was sponsored by the Asphalt Pavement Alliance. The Symposium consisted of presentations about current quieter asphalt technology in the U.S. and Europe, fundamental background material on noise and pavements, and discussion of future directions. For a summary of future directions see the presentation by Jones.
- The National Concrete Pavement Technology Center has led an effort to develop a strategic plan for Surface Characteristics (SC) that includes a section on tire/pavement noise reduction for concrete pavements. The plan includes field measurements of current technology and both laboratory and field investigation of innovative technology such as exposed aggregate and porous concrete. For a summary of the SC Roadmap, see the presentation by Wiegand.
- The FHWA Noise Office has issued a new FHWA Policy Memo “Guidance on Quiet Pavement Pilot Programs and Tire/Pavement Noise Research” and is currently revising the FHWA “Highway Traffic Noise Analysis and Abatement: Policy and Guidance”.
- Europe and Japan continue to advance the technology of quieter pavement (see the presentations by Sandberg and van Blokland). Significant investment is being made to develop innovative technology. Three efforts are of particular note, the effort to create a durable poro-elastic pavement in Japan, the Innovative Pavements Programs in the Netherlands, and the new EU integrated project called *Silence*.

4.0 THE REMAINING GAPS

During the presentations of the state-of-the-art, participants and speakers were asked to identify gaps and issues that either continued from the previous workshop or had emerged since the previous workshop. These gaps/issues were captured and displayed in real time to the participants. This listing was then sorted into categories similar to the categories used in the first Roadmap. The unedited, but sorted gaps/issues are attached in Appendix C. Each of the gap areas will be described in general terms.

Clearinghouse: The clearinghouse has significant potential value to the community. The workshop participants made a number of suggestions about materials that should be added to

the clearinghouse. For example, the participants suggested that the clearinghouse should become an archive for data to be shared in common format and as a repository for educational materials for the states and consultants.

ETG: The participants expressed the continuing need for measurement recommended practice and provisional standards. They urged the completion of the OBSI standard currently under development. They also urged more frequent meetings and a faster response from the ETG.

Quieter Current Pavement Technology: The participants acknowledged the significant and interesting ongoing worldwide effort to develop quieter pavement and encouraged an international synthesis of quieter pavement technology. They also identified two technologies, double layer porous asphalt and pervious concrete as technologies that should be investigated for their practicality for U.S. application.

Technology-based Education: Based on the success of Tire-Pavement Noise 101, it was suggested that more advanced short courses be developed to meet the needs of the pavement community as both general knowledge advances and as new technology evolves.

Measurements: The participants identified a number of gaps in the measurements area. The most crucial are the completion of the OBSI Provisional Standard, the development of a reference test tire for tire/pavement source testing, recommended practices for validation and storage of reference tires, development of additional measurement methodologies for the U.S., and a document to identify the applications for and advantages/disadvantages of the various measurement methods. There was also strong sentiment that we needed to develop an objective, reproducible, time-stable scale of noise generation potential based upon texture profile. This texture based noise index would weight the spectral components of texture based upon their contribution to overall tire-pavement noise generation in much the same way the International Roughness Index (IRI) weights different wavelengths of roughness based upon their contribution to vehicle response. Currently there is an understanding that texture and noise are related, however only simple empirical relationships have been developed to date. It is appropriate to pursue a more robust investigation of the texture – noise relationship with the availability of more advanced texture measurement tools such as the line laser technology.

Research Noise/Safety/Durability/Cost: The participants identified a number of areas of research that should be addressed. The primary concern about current quieter pavement

technology is the durability of the reduced noise effect. This remains a significant open issue. Even for a relatively low truck mix, trucks tend to dominate noise emissions from highways. Yet trucks have not been studied extensively. Thus a group of gaps/issues was developed that focused on truck noise sources, the behavior of truck tires, and the effect of trucks in a traffic mix.

Cost/Benefit: A recurring theme at the Workshops has been whether the benefits of quieter pavement could be monetized and compared against other noise mitigation alternatives to help decision making. Furthermore, the cost of investment in noise mitigation for traffic noise versus the benefits that accrue is a desirable aspect of environmental issues in general.

Policy and Guidelines: The participants raised a significant number of issues primarily around whether the benefit of quieter pavement could be used to reduce impact and noise mitigation. This might be implemented by allowing pavement type to be used in TNM or by allowing pavement specific REMEL data to be used. Another series of policy needs/issues revolved around the national sharing of data for the purpose of justifying either QPPP or pavement specific REMELs data.

Construction, Acceptance and Monitoring: The participants noted at various times that construction affects noise and that many pavements are observed to change noise characteristics over time. The construction, monitoring and maintenance of pavement are important to achieve expected results and to keep noise exposure levels in communities at expected levels.

Accelerated Testing: Current techniques to build and observe innovative pavement throughout their service life require a significant amount of time. In order to move the technology of quieter pavement ahead with the assurance that the reduced noise effect will be durable, it is necessary to find test methods whereby the life of the pavement is accelerated and the effect on noise emission can be monitored. One of the alternatives under consideration would be to couple noise testing with existing accelerated pavement testing for durability.

Public education and involvement: Many of the practitioners that deal with communities find it a challenge to explain traffic noise to lay groups. Much of this challenge is due to the complicated characteristics of human hearing and perceptions of annoyance and pleasantness. Educational tools to assist in these public education efforts would be helpful. These challenges are compounded by the expectations the public has of quieter pavement.

The benefits and limitations of the technology are not well described in news announcements. And lastly, many practitioners note that complaints are rising from communities far outside of the region defined as impacted by federal guidelines. A relatively long list of gaps/issues was developed identifying various elements of this problem. This issue had considerably more emphasis at the second workshop than at the first workshop.

The participants rank ordered the unedited list of gaps/issues. The number of votes received by each gap/issue is listed in parentheses behind the gap in Appendix C. This ranking was highly constrained and should be taken with some level of caution since the participants used a diverse set of voting strategies. The top ranked gaps/needs are:

1. *Establish construction guidelines and best practices (14)* – a large group of participants, regardless of area of practice, recognize from the data collected to date that construction plays a significant role in both the early life performance of quieter pavement and the longevity of the reduced noise effect. However, there is very little guidance for construction of quieter pavements. Currently, construction is specified in relatively general terms. Significant variations are found in nominally identical pavement. In fact in almost every pavement type using current methods, some sites are found that could be considered relatively quiet pavement. Careful correlation studies should be done to identify which pavement parameters cause this variation and what construction specifications control such parameters. A significant effort should be devoted to develop construction guidelines and QA/QC practices to reduce variation and make it possible for agencies to specify pavement that is consistently quieter than current technology.
2. *Standard tire for tire/pavement source noise testing (e.g., the SRTT) (11)* – tire design and fabrication changes with time and when vehicle models change or vehicle performance specifications change. In addition, a single model of tire (e.g., the Goodyear Aquatread) of a particular size has many variations depending on the customer/vehicle. Thus, tire manufacturers do not manufacture the same tire for the time period of interest for studies of tire/pavement noise from pavement test sites. To further compound this problem, tires age even when they are not used. Tire rubber compounds change when exposed to heat and light. To preserve the characteristic of a tire over a period longer than several years, it is necessary to store the tire in a special environment. In view of

these situations, we do not have a source of tires that we can trust to be the same. To address this problem it will be necessary to specify a standard tire that is easy to construct repeatably and to find a source that is willing to manufacture this same tire over a long period of time.

3. *Synthesis of global practice (11)* – significant effort is funded in Japan and Europe to identify quieter pavement alternatives and explore how to make such innovations practical for typical traffic mix and loads. The European Scanning Tour for Quiet Pavement and the recent comprehensive book by Ulf Sandberg and Jerzy Ejsmont provide a summary of those results a couple of years ago. There is also significant effort to develop measurement standards through ISO TC43/SC1/WG 33. Many, but not all, of these advances in technology and standards are applicable in the U.S. Rather than repeat these efforts, the U.S. should have a dedicated effort to monitor these activities, establish a liaison with international leadership in the area of quieter pavements, and attempt to synthesize the appropriate technology into application. A continuing synthesis of global practice would be of significant value to the U.S. efforts to develop quieter highways.
4. *Understanding the durability of the noise reduction effect (9)* – there is evidence that some noise reducing pavements lose their acoustical benefit over time as the pavement ages. There are two studies, one on I80 near Sacramento, and one on Highway 138 in California where the noise reduction benefit has been monitored for part of the service life. There have been other studies where pavement, particularly the Arizona ARFC, was placed at many sites before it was recognized as a noise reducing pavement. Thus, an attempt has been made to make noise measurements of pavements that are believed to be of similar construction with different age to determine whether there is a systematic change in the noise properties. Additional systematic studies are required to monitor the effect of pavement age and condition on the noise reduction effect. Such studies should be done for all of the various alternatives that will be considered for noise reduction benefit with significant enough samples that the typical variations that are known to occur in pavement noise emissions are accounted for.
5. *Relative advantages/disadvantages of various measurement methods for different applications, specifically wayside and OBSI. (8)* – the various wayside and source measurement methods have different intent. This is confusing to engineers new to the

quieter pavement field. In addition, an incorrect technique is sometimes used for a certain measurement. A document that would describe the methods and their application would be useful to standardize practice in the U.S. and ensure that the correct measurements are taken as the quieter pavement community attempts to advance this technology.

6. *Durable pavements with acoustic longevity (8)* – some quieter pavements, particularly the poro-elastic concepts attempted in Sweden and Japan, have very short service life. Porous asphalt pavements have also been found in some cases to have a short service life. Other porous pavements with reasonable service life sometimes lose their acoustical benefit. Thus, we still seek more pavement options that have comparable service life to current technology and maintain an acoustical benefit over that service life.
7. *Consistent terminology (7)* – in both the pavement industry and on the acoustical side, terminology required for communication of the pavement type and the acoustical benefit have evolved using local standards. An agreed list of terminology would be helpful to allow practitioners to communicate and to advance the technology.
8. *Develop double layer porous asphalt (DLPA) (6)* – the DLPA pavement is a technology that showed good performance in Europe but is not currently being explored in the U.S. To implement DLPA in the U.S. a number of questions must be answered about mix design using local materials, construction practices, and long term performance. While some Europeans claim relatively long service life (up to 10 years) and minor deterioration of the noise reduction benefit, none of their installations have been in place long enough to verify these claims. A significant number of questions must be resolved in order to bring a DLPA solution to practical application. However, from the data gathered in Europe, the benefit could be substantial.
9. *Develop an International Noise Index (INI) (6)* – for passby noise, the ISO has established a statistical passby index (SPBI) which accounts for a statistical variation of vehicles at a typical variation of speed. Other technological areas, such as pavement smoothness, have found it useful to develop a single number index metric to characterize the properties of pavement in order to compare various options. An INI would be useful for helping us to determine the relative performance of pavement. An INI might also be useful for construction acceptance.

10. *Measurement Methods (6)* – measurements of pavement and tire/pavement noise will be used for many purposes, including research to understand tire/pavement noise, construction acceptance, network monitoring, quantifying tire/pavement source levels, understanding noise propagation characteristics, quantifying traffic noise propagation to the wayside, and community noise due to traffic. Only a few measurement methods have been standardized to accomplish these objectives. A relatively long list of standard measurement methods should be developed including, time-averaged wayside measurements, community noise measurements, sound propagation measurements, pavement acoustical properties measurement, and controlled passby or coastby.
11. *Pavement type (surface texture) in TNM (6)* – TNM currently has a database that distinguishes between concrete pavement, asphalt pavement, and open graded asphalt pavement. However, FHWA policy requires the use of average pavement, which is the average of concrete and asphalt pavement, for noise prediction regardless of the pavement used in the application. In addition, current FHWA policy does not permit the use of the noise reduction benefit of quieter pavement. These policies have been formulated based on the documented uncertainty about tire/pavement noise emissions due to variations and possible loss of noise benefit with pavement age. The issue was raised whether sufficient data have been collected to change this policy and what type of data would be required in order to allow the noise reduction benefit of quieter pavement to be used in TNM prediction.
12. *Traffic Mix Effects (5)* – while less data is available about tire/pavement noise emissions from truck tires, the data that have been collected indicate that the noise reduction benefits of quieter pavements are different for truck tires than for car tires. In most cases measured thus far, the benefit is less for truck tires. In addition, the noise sources on trucks are different than the noise sources in automobiles. For example, the stack noise is radiated from high above the pavement. In addition, trucks are relatively long and the noise history at passby sites at 25' and 50' is somewhat different from automobiles. The relationship between tire/pavement noise measured at the source and traffic noise from a traffic stream consisting of a significant percentage of trucks may not behave in the same fashion as the studies done thus far which have focused primarily on traffic streams that consist primarily of light vehicles.

13. *Construction and construction acceptance (5)* - in the future there is some expectation that pavement acceptance may be based on tire/pavement noise characteristics. Acceptance testing using noise characteristics may not only be for noise considerations but as a check on other performance properties as well. The challenge of these approaches includes the break-in period for new pavement. Noise characteristics have been observed to change from early traffic and due to winter maintenance. The benefit of this approach is the simplicity of making a source
14. *Cost/Benefits of Quieter Pavement (5)* – the potential benefits of quieter pavement include the potential to avoid impact and the reduction of the degree of noise mitigation required. In addition, for the region outside the area of potential impact, quieter highways may reduce community annoyance, and subsequent resistance to highway projects. Quieter highways also potentially increase the quality of life of residents near enough to the highway to hear traffic noise. All of these benefits must be weighed against possible increased costs to construct new pavements and possible increased costs to maintain or replace quieter pavements. In order to evaluate quieter pavement alternatives, it would be valuable to monetize, or otherwise quantify, both the benefits and costs of quieter pavement. Cost/benefit analysis would be helpful not only for engineering decision-making but an understandable metrics for us to establish policy and to communicate with the public
15. *“We need to be able to answer the public’s questions about quiet pavement and annoyance” (5)* – with increasing publicity about quieter highways in various parts of the U.S., citizens and community groups are increasingly requesting the placement of quieter pavement in their neighborhood. The terminology of noise and the indirect relationship between our typical metrics and the public’s perceptions create additional confusion. The state and local transportation agencies that interface directly with the public and community groups would find it very helpful to have materials that would help to explain traffic noise and to describe the benefits and limitations of current quieter pavement technology.

5.0 ACTION PLAN

The action plan consists of two parts; a plan to build the infrastructure needed to address the highest priority gaps/issues and a plan to address the highest priority gaps/issues. The working

document used to record the discussion of the action plan is attached as Appendix D. In addition to the action plan itself, the participants estimated whether the action should be done in the short or long term, where the action should be assigned, and where the resources required would be secured.

5.1 Quieter Pavement Pooled Fund Study

The Washington State Department of Transportation (WSDOT) volunteered to organize a pooled fund study in order that states could cooperate in addressing the gaps/issues raised at the workshop. It is proposed that the scope of the pooled fund include all of the issues raised at the workshop. The effort would be divided into four subareas:

- A. Construction and materials
- B. Testing and research
- C. Education and Public involvement
- D. Policy

Each of the gaps/issues in the table in Appendix C was identified with one of these subareas. The pooled fund solicitation, **Solicitation Number 1104: Tire/Pavement Noise Research Consortium** was posted on May 15, 2006 (see www.pooledfund.org). The participants of the Workshop will assist in building the case and seeking funding for the pooled fund study.

If the WSDOT pooled fund study effort is only partially successful, an alternative method or methods will be found to assemble funding from federal, state, and private sources to implement the action plan. The effort should be a nationally coordinated effort utilizing the complementary skills of researchers and practitioners from a national pool on an aggressive timetable that will allow us to address these problems as new pavements are built.

5.2 Action Plan

The following action plan is synthesized by extracting items from the table in Appendix D and augmenting the list with items from the table in Appendix C, listing high priority items with identifiable tasks under each topic.

5.2.1 Improved measurements

Standard Tire(s)

Assigned: Measurement ETG, FHWA, AASHTO, Tire Industry

As discussed in Section 4, the lack of a standard tire is a potentially troublesome issue. Other technical communities, including the pavement friction testing community, have negotiated with tire manufacturers to design and construct a standard tire. The tire/pavement noise community and the FHWA should negotiate with a tire company to develop and build reference tire(s) for noise testing. This effort should be done in conjunction with ISO TC 43/SC 1/WG 33 if possible.

OBSI Standard

Assigned: Measurement ETG

It is imperative that the OBSI standard be completed. A significant amount of data is being collected on the current pavement network and for various QPR projects. In order that the data be comparable and of maximum value, it should be collected according to standard, controlled methods. The tire/pavement noise measurement ETG should complete this effort and distribute the final result.

Time-Averaged Wayside Measurement Standard and Similar Standards

Assigned: Measurement ETG

A standard should be developed for time-averaged wayside measurements, a method that is currently used for a number of projects in the U.S. and Europe to determine the community benefits of quieter pavements under normal, heavy traffic. The ETG should initiate this effort and work with the European community to develop the standard. In addition to time-averaged wayside measurements, other community noise measurement standards should also be developed or adapted for use in the U.S.

Measurement Method Applications

Assigned: Measurement ETG or Pooled Fund

In addition to developing measurement methodologies, guidelines should be developed that describe the application of each type of noise measurement and when each type of measurement has particular advantages and disadvantages.

Measurement correlations

Assigned: Measurement ETG, State QPR

Measurements at the source using OBSI, at the pavement wayside, and in the community all serve different purposes. In some cases these measurements have been found to be quite comparable. In other cases, the results have unexplained differences. The differences may be due to pavement absorption properties, meteorological conditions, propagation phenomena or to other unidentified aspects. A systematic investigation should be done to correlate OBSI,

wayside, and community measurements and to explain the causes when correlation does not occur.

5.2.2 Policy Forum

Policy Forum

Assigned: FHWA Noise Office

In most discussions of traffic noise and quieter pavement policy, there is a natural dialogue about protecting the community near the pavement, the cost of noise mitigation, and providing incentives that will encourage innovation in pavement technology. The various policy alternatives include turning on pavement type in TNM, developing and allowing pavement specific REMELs data, and modifications to QPPP and QPR policy. At the workshop it was suggested that a series of forums be organized in order that various alternatives can be explored to simultaneously protect the public while accelerating innovation and encouraging the implementation of quieter pavements.

5.2.3 Public response and public education

Public education

Assigned: Pooled Fund or ADC40 initiative

This effort would involve the development of listening experiences, brochures, and other useful materials to inform the public about traffic noise in general and about the benefits and limitations of quieter pavement. When possible, materials would be available on the Clearinghouse. Materials would also be available for distribution through organizations such as ADC40.

Community response to quieter pavement ***Assigned: Pooled fund or State QPR***

To address the question of the correlation of community response and the standard metrics used for quantifying traffic noise, a study should be done of public response to different pavements. The study should include measurement of loudness and annoyance metrics as well to determine if these metrics correlate better with community response.

5.2.4 Synthesis of global practice

Global synthesis

Assigned: NCHRP or Pooled Fund

Major effort continues in Europe and Japan to develop quieter pavement and to study the durability of the noise reduction effect and understand the mechanisms that cause tire/pavement noise. A continuing effort is needed to monitor progress made globally and report this to the U.S. traffic noise and pavement community. This effort would include participation in the ISO

TC 43/SC 1/WG 33, attendance at international conferences and workshops, and synthesis of published papers.

5.2.5 Innovative pavement technology

Double layer porous asphalt

***Assigned: NCAT or North Central
Superpave Center***

The double layer porous asphalt (DLPA) concept has been measured to be significantly quieter than other pavement concepts in Europe. The Europeans also believe this solution is able to sustain the reduced noise effect with age due to self-cleaning properties. However, the practicality of this concept has been questioned for U.S. applications. Research should be done to examine the open questions about construction, pavement life, durability of the noise reduction effect, cleaning maintenance, black ice formation, and winter maintenance. In addition, optimization of the mix properties could be a part of the investigation.

Porous concrete

Assigned: PCC Technology Center

The Germans, Belgians and others have started an investigation of the suitability of porous or pervious concrete as a practical quieter pavement alternative. Issues for U.S. application include pavement life, response to freeze/thaw loads, cleaning, and winter maintenance. In addition, there is much to be learned about optimization of the pavement mix design.

5.2.6 Additional materials for the Clearinghouse

Acronyms and definitions

Assigned: Pooled Fund, FHWA, and TRB

At this early stage of technology development in the area of quieter pavements, we are gathering together practitioners from many fields and are working on a multi-state basis. In many cases practitioners must communicate in areas outside their field of expertise. In addition, states often use different terminology. A list of acronyms and definitions is needed to unify terminology in the area and promote better communication. This list can be collected from existing sources. Some vetting of the list could be done through the Pooled Fund committee or through TRB committees. The list should eventually be posted on the Clearinghouse and distributed through TRB committees and state DOTs.

Template for sharing data:

Assigned: Pooled Fund

A template should be developed such that tire/pavement source data can be posted on the clearinghouse and shared with the community.

5.2.7 Synthesis of cost/benefit analysis

Cost/benefit analysis

Assigned: Pooled Fund support for transportation economists

Currently quieter pavement is considered simply an extra expense if the pavement costs more than traditional pavement. The benefits of quieter pavement include the potential to avoid impact as well as to reduce the cost of traditional noise mitigation, such as barriers or the change of vertical or horizontal right-of-way alignment. In addition, reduced annoyance may be a benefit to the community far from the region where impact is defined. It would be helpful for decision making to have a cost/benefit methodology for quieter pavement. The study should be done in a flexible manner, such as in a spreadsheet format, so that different states could apply different monetization guidelines.

6.0 CONCLUSIONS

Much has been accomplished since the first Workshop to develop a Roadmap for Quieter Highways in 2004. Many states have begun QPR programs and the database of measurements is growing. Many of the technological issues are better understood. We understand the potential solutions better and the limitations of existing pavements. Thus the dialog at the second workshop was significantly different than the first workshop. At this workshop, a substantial amount of tire/pavement noise data was discussed, there was greater emphasis on public education and engagement, there was continued discussion of policy alternatives, there was greater appreciation of the applicability of international technology to U.S. problems, and there was a clear desire to organize a national effort to share data in a manner that allows the community to progress in the development of quieter highways. The effort has gained significant momentum due to the accomplishments achieved toward the goals of the first Roadmap. This second Roadmap identifies another layer of issues that should be addressed. It also recommends that we capitalize on the higher level of activity to suggest a major, coordinated activity toward the goal of developing and implementing quieter pavement. Clearly, the agenda set in this Roadmap capitalizes on the momentum achieved thus far and takes us on another step toward making quieter highways a practical reality.

APPENDIX A
LIST OF ATTENDEES

APPENDIX A: LIST OF ATTENDEES

1. Iyad Alattar FHWA – Nevada
2. Adam Alexander Ohio DOT
3. Bob Bernhard SQDH, Purdue University
4. Mariano Berrios Florida DOT
5. Jay Bledsoe Missouri DOT
6. Michael Blumenthal Rubber Manufacturers Association
7. Steven Butcher Rubber Manufacturers Association
8. Doug Carlson Rubber Pavements Association
9. Ken Davies FHWA – Nevada
10. Mike Dennis Arizona DOT
11. Paul Donavan Illingworth & Rodkin, Inc.
12. Mark Ferroni FHWA Washington DC
13. Les Grundman International Truck & Engine Corp
14. Tie He Nevada DOT
15. Lloyd Herman Ohio University
16. Bernard Izevbekhai Minnesota DOT
17. Don Johnson SQDH
18. Wayne Jones Asphalt Institute, Inc.
19. Jeff Lewis FHWA California
20. William Lohr FHWA Minnesota
21. William McColl New York DOT
22. Kevin McGhee Virginia Transportation Research Council
23. Chris Menge Harris, Miller, Miller & Hanson, Inc.
24. Bob Mero Colorado DOT
25. Doug Moore General Motors
26. Jim Musselman Florida DOT
27. Duff Parker Safety Grooving & Grinding
28. Linda Pierce Washington DOT
29. Rob Rasmussen The Transtec Group, Inc.
30. Judy Rochat Volpe National Transportation Systems Center
31. Ulf Sandberg Swedish Road & Transport Research Institute
32. Larry Scofield American Concrete Pavement Association
33. J. Jeffrey Seiders Texas DOT
34. Gary Sharpe Palmer Engineering
35. Mike Shearer Texas DOT
36. Andre Smit National Center for Asphalt Technology
37. Mark Swanlund FHWA Washington DC
38. Will Thornton SQDH
39. Manual Trevino Center for Transportation Research – University of Texas at Austin
40. Gijsjan van Blokland M+P Engineers
41. Jay Waldschmidt Wisconsin DOT
42. Mia Waters Washington DOT
43. Roger Wayson University of Central Florida
44. Paul Wiegand Center for Transportation Research and Education
45. Becky McDaniel North Center Superpave Center
46. Lee Gallivan FHWA Indiana

APPENDIX B

AGENDA

APPENDIX B: AGENDA

FHWA TIRE/PAVEMENT NOISE STRATEGIC PLANNING WORKSHOP

April 10-12, 2006
Hyatt Regency Hotel, Indianapolis, Indiana

First Day – April 10, 2006

12:15 p.m. to 1:00 p.m. **Workshop Check in** - Outside Hyatt Meeting Room

1:00 p.m. to 1:30 p.m. **Call to Order/Housekeeping Items**
Don Johnson, Program Manager, SQDH

Welcome to Workshop

*Robert J. Bernhard, Director,
Institute for Safe, Quiet and Durable Highways*

Workshop Purpose, Goals and Direction

*Keth Sapp – Facilitator, Researcher, Purdue University,
Center for the Advancement of Transportation Safety*

1:30 p.m. to 2:00 p.m. **Original Roadmap and Highlights from the September, 2004 Workshop.**
Robert J. Bernhard

2:00 p.m. to 3:15 p.m. **Roadmap Updates – short-term deliverables**

**Noise 101 Activity and Future Plans, and
ETG Report on Activities and Future Plans for ETG(s)**
Mark Swanlund, Federal Highway Administration

Clearinghouse Activities, and Policy – QPPP and QPR
Mark Ferroni, Federal Highway Administration

Open discussion

3:15 p.m. to 3:30 p.m. **Break**

3:30 p.m. to 5:30 p.m. **Pavement Research/Updates**

Asphalt 2005 Results
H. Wayne Jones, The Asphalt Institute

Surface Characteristics Road Map
*Paul Wiegand, National Center for PCCP
Technology, Iowa State University*

ISU Test Sites
Rob Rasmussen, The Transtec Group, INC

NCAT Test Sites

*Andre Smit, National Center for Asphalt Technology
Auburn University*

Open discussion

Second Day - Tuesday – April 11, 2006

7:00 a.m. to 8:00 a.m. **Continental Breakfast**

8:00 a.m. to Noon **State Experiences (since September 2004 Workshop)**
(Break around 10 am)

15 State presentations (10 Minutes Each)

- **Brief Overview Quiet Pavement Program**
- **Importance of Noise Program to the State**
- **Review Their Findings**
- **Identify Roadblocks or Problems**
- **State's Needs**

Open discussion and questions following the presentations.

Noon to 1:00 p.m. **Lunch**

1:00 p.m. to 5:00 p.m. **Noise Research/Updates**
(Break around 3pm)

EU Update / Recent Work

*Ulf Sandberg, Swedish National Road and Transportation
Research Institute*

**Sylvia Update / EU Implementation of Pavement Effects into Noise
Prediction Models**

Gijsjan van Blokland, M + P Raadgevende ingenieurs bv

Illingworth & Rodkin Updates

Paul Donovan, Illingworth & Rodkin, INC.

Volpe Center Updates

Judy Rochat, US DOT/Volpe Center

Purdue Updates

Bob Bernhard

Open discussion

Third Day -Wednesday – April 12, 2006

7:00 a.m. to 8:00 a.m. **Continental Breakfast**

8:00 a.m. to 8:15 a.m. **2006 Roadmap – Discussion topics**
Robert J. Bernhard

8:15a.m. to 10:00am **Group Discussions on the Issues and Research Needs for the 2006 Roadmap.**

10:00a.m. to 10:15a.m. **Break**

10:15 a.m. to 11:30a.m. **Group Discussions Continued and Finalized**
Includes goals/Roadmap for U.S., goals of ETG (possibly some scheduling), environmental funding issues and pooled funds studies (identify potential contributors and potential topics)

11:30 a.m. to Noon **2006 Roadmap – Conclusions**
Robert J. Bernhard

Noon **Closing Comments/Adjourn**
Robert J. Bernhard

APPENDIX C
LIST OF GAPS/ISSUES

APPENDIX C: LIST OF GAPS/ISSUES

The following is the table of current gaps and issues raised at the Workshop that should be addressed in the Roadmap. The numbers in parentheses correspond to the priority rating established by the Workshop participants. The letter code in the right hand column corresponds to the assigned area for future consideration of the pooled fund study. The areas are; A – Construction. B – Testing/Research, C – Education/Public education, D – Policy.

Gap	Assigned to
Clearinghouse	
A template for the data on the clearinghouse web site(3)	B
Shared wavfiles (1)	C
Sharing data (2)	B
List of acronyms and definitions	All
Industry participation and contribution (1)	
Establish ETG (measurement)	
Meet more often and communicate more often, maybe subgroups (1)	B
Quieter Current Pavement Technology	
Consistent inter-agency reporting (1)	all
Develop double layer porous asphalt (6)	A, B
Synthesis of global practice (11)	NCHRP
Pervious concrete/porous concrete overlay (1)	A, B
Education/Noise 101	
Establish Noise 201 (1)	C
Measurements	
Measurement Methods (6)	B
Improved noise metrics (0)	B, D
We need a standard tire for noise testing (e.g., the SRTT) (11)	B
What are acceptable variations of measurement methods? (0)	B
Would it be useful to have a common, shared vehicle for noise testing? (1)	B
Need more precise acoustic data to optimize noise mitigation strategies (0)	B
Get public response to different pavements. (2)	B, C
Can we describe the relative advantages/disadvantages of various measurement methods for different applications, specifically wayside and OBSI? (8)	B
Identify storage for test tires (1)	B
Create a recommended equipment list for measurement practitioners (e.g., hardness tester) (0)	B

Identify age and wear parameters when test tire replacement is required (0)	B
Validation of reference tire versus population (0)	B
Develop an International Noise Index (INI) as an objective, reproducible, time-stable scale of noise generation potential based upon texture profile (6)	B
Research Noise/Safety/Durability/Cost	
Understanding the Durability of the Noise Reduction Effect (9)	B, D
Understanding Pavement Characteristics and Noise (3)	A, B
Can quieter pavements be built for studded tire applications? (1)	A, B
We should look at what is happening inside the car. (0)	B
Better understanding of meteorological effects (0)	B
Improve noise modeling capabilities (2)	B, D
Durable pavements with acoustic longevity (8)	A, B
The effect of pavement absorption on the propagation of tire/pavement noise to the wayside (1)	B
Traffic Mix Effects (5)	B
Is the texture/noise relationship the same for trucks and passenger cars (4)	A, B
What are the effects of “wide-based tires”? (0)	B, D
Will truck volumes and weights continue to increase? (0)	
Can we make pavements safe and quieter? (0)	A, B
Better understanding of trucks (source contributions) (1)	B, NCHRP 8-56
Research Cost/Benefit	
Cost/Benefits of Quieter Pavement (5)	All
Can we monetize the benefits of quieter pavement? (1)	All
Policy & Guidelines	
Can we discuss modifications to the QPPP policy? (0)	D
More tools in the noise mitigation toolbox (1)	D
We should emphasize impact avoidance (2)	D
Is it possible to do a user defined pavement type in TNM (4)	D
Consistent and qualified reporting of data (1)	D
Can we have pavement type (surface texture) turned on in TNM? (6)	D
Can we do pavement type (surface texture) from other similar states? ((4)	D
Establish a policy ETG (1)	D
Establish pool fund for travel and research prioritization (4)	D
A national QPPP or QPR (2)	D
A reference pavement (ability to develop delta) (3)	D
Construction, Acceptance & Monitoring	
Maintaining Quieter Pavements (3)	A
Construction and construction acceptance (5)	A, B

Construction issues are pretty universal recognized as causing variability (2)	A
What is needed for communicating texture and material specs (i.e., ride model)? (0)	A
Establish construction guidelines and best practices (14)	A
Accelerated Testing	
Couple accelerated pavement testing to include acoustical testing (2)	B
Education (General public education and involvement)	
“We need to be able to answer the public’s questions about quiet pavement and annoyance” (5)	C
A lot of complaints we are asked to address are coming from far from the pavement (<<67 dB). Perception of traffic noise at distance, particularly related to low frequency and perception (1)	C
Learning gap: communicating spectra and understanding perception? Communicating connection between quantity and quality of sound (3)	C
Educational tools for the public (a toolbox) (3)	C
Can we educate the public about the difference between the interior and exterior sound? (1)	C
Consistent terminology (7)	C
Collecting psycho-acoustics literature related to highway noise (1)	C
How perception metrics would be used (1)	C
Miscellaneous	
What is the real traffic noise problem? (2)	All

APPENDIX D
ACTION PLAN

APPENDIX D: ACTION PLAN

Action	Long or short term	Assigned to	Source of needed resources
Establish a pooled fund through Washington state with 4 subgroups <ul style="list-style-type: none"> - Construction/materials (A) - Testing and research (B) - Education and public involvement (C) - Policy (D) 	short	Washington State DOT	Pooled fund
List of acronyms (environmental and materials) <ul style="list-style-type: none"> - list of words - definitions 	short	Consultant to pooled fund study	Pooled fund study or
Ordering/use/storage of SRTT tire	short	Manufacturer	manufacturer
Define acoustic durability	short		
Finish the OBSI standard	short	ETG	FHWA
Document for OBSI & wayside	Short	ETG	FHWA
DLPA	Short	INDOT/NCAT	?
Synthesis on Cost/Benefit & recommendation	Short	Pooled fund or NCHRP	
Synthesis of global practice	Short	Pooled Fund A. & WSDOT	
Clearinghouse items on other list	Short	ETG	Volunteer plus some funded
Mechanistic/experimental hybrids models and connection to testing	long	Federal agencies with international cooperation	Federal plus state DOT (possible piggyback on European efforts)
Discuss turning on “pavement type” in TNM	Short	US DOT	
Policy issues on other list	Short	US DOT	
General public education issues	Short	ETG	Pooled fund study
Distribution of short term findings on public education	Long	State DOT’s	State DOT’s
Get public response to different pavements	Long	State DOT’s	State DOT’s

APPENDIX E
POOLED FUND SOLICITATION

APPENDIX E: POOLED FUND SOLICITATION

Solicitation Number: 1104

Status: Solicitation posted

Title: Tire/Pavement Noise Research Consortium

Sponsoring Agency: Washington State Department of Transportation

Sponsor Solicitation Contact: Kim Willoughby (willouk@wsdot.wa.gov)

Phone: 360-705-7978, Fax: 360-705-6911

Technical Contact: Linda Pierce (PierceL@wsdot.wa.gov), Phone: 360-709-5470,

Fax: 360-709-5588

Lead Agency Contact: Linda Pierce (PierceL@wsdot.wa.gov), Phone: 360-709-5470.

Fax: 360-709-5588

Lead Agency: Washington State Department of Transportation

Partners: MT, TX, WA

Date Posted: 5/15/2006 12:06:23 PM

Solicitation Expires: 6/30/2006

Commitment Start Year: 2007

Commitment End Year: 2012

Duration: 60 months

100% SP&R Approval: Pending Approval

Commitments Required: \$100,000

Commitments Received: \$30,000

Background: Minimizing the impact of traffic noise on the public is a priority for state highway agencies and the FHWA. As tire-pavement noise is the single largest contributor to traffic noise on many highways, increased utilization of low-noise pavement surfaces may reduce overall traffic noise or reduce the need for expensive traditional noise mitigation measures. Developing low-noise pavement surfaces that are both durable and safe is of high interest to both state highway agencies and FHWA. Utilization of low-noise surfaces may also provide a noise reduction alternative where traditional noise mitigation measures such as walls and berms are not a viable solution. Examples of problematic areas include many bridges/structures, areas with unstable slopes, locations near water bodies/wetlands, dike/levee/floodplain sectors, where utilities near roadways cannot be moved, and in heavily urbanized areas within a built environment.

Research into these low-noise pavement treatments and materials is beginning in earnest in a variety of states. Coordinated sharing of research development, evaluation techniques, and study results is critical to reduce overall costs for key research pieces, reduce redundancy of effort, focus funding in the most needed areas, and find viable solutions that can be implemented expeditiously for the highest number of states. In short, a collaborative effort can create greater benefits than the independent efforts of individual states.

Objectives: The objectives of this research are as follows:

- Provide a forum for states to discuss tire/pavement noise issues and develop a proposed research plan.
- Pool resources and efforts of multiple state agencies and industry to perform tire/pavement noise research in a similar manner (avoiding duplication) and sharing of data.

Scope of Work: The anticipated scope of the study would consist of the following tasks:

- Provide a forum for states to discuss noise issues, utilize the same techniques to build a larger database, and share data. The ultimate goal is to incorporate pavement type into the FHWA Traffic Noise Model.
- Perform a synthesis of global practice in regards to utilizing pavement technology for decreasing tire/pavement noise;
- Perform a synthesis on the cost/benefits of using low-noise pavements;
- Produce a document for general public information regarding noise reduction;
- Provide a baseline for quieter pavement discussion (e.g. definitions, list of acronyms, etc.);
- Provide a guideline for best practices in measuring and evaluating noise benefits and decreases over the wearing life of the roadway surface.

A technical advisory group consisting of a pavement expert and a noise expert from each contributing agency and invited participants will refine/expand this scope of work and provide technical input/guidance throughout the duration of the research.

Comments: This study is open to all states; however, a minimum contribution of \$10,000 will be required to be a member of the Technical Advisory Committee (TAC). The TAC will provide guidance for the study and review and comment on all documents produced by the research team. This contribution will pay for the research conducted and travel to the annual meeting for a pavement expert and noise expert.