

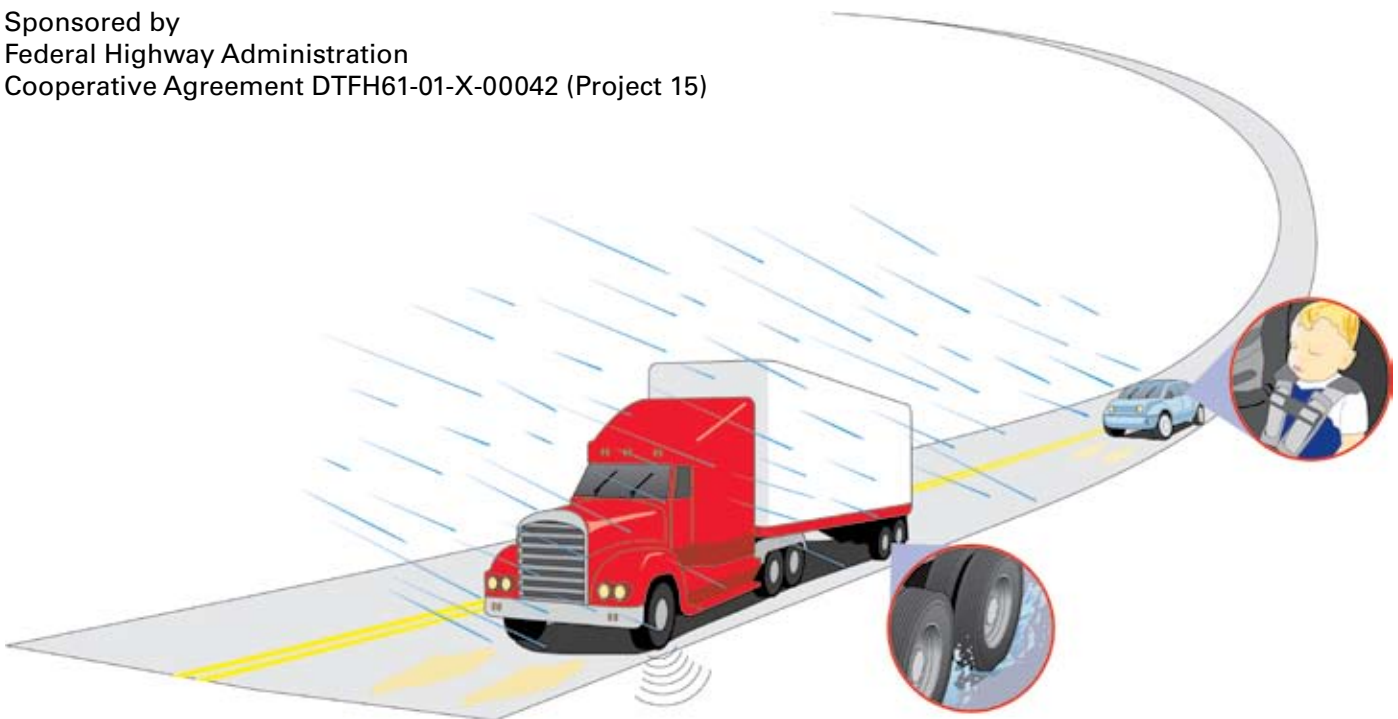


Strategic Plan for Improved Concrete Pavement Surface Characteristics

executive summary

Completed in cooperation with the Federal Highway Administration,
American Concrete Pavement Association, and other organizations

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INTRODUCTION

Surface characteristics represent a critical issue facing pavement owners and the concrete paving industry. The traveling public has come to expect smoother, quieter, and better drained pavements, all without compromising safety.

The overall surface characteristics issue is extremely complex since all pavement surface characteristics properties, including texture, noise, friction, splash/spray, rolling resistance, reflectivity/illuminance, and smoothness, are complexly related.

The following needs and gaps related to achieving desired pavement surface characteristics need to be addressed:

- Determine how changes in one surface characteristic affect, either beneficially or detrimentally, other characteristics of the pavement.

- Determine the long-term surface and acoustic durability of different textures.
- Develop, evaluate, and standardize new data collection and analysis tools.

It is clear that an overall strategic and coordinated research approach to the problem must be developed and pursued to address these needs and gaps.

OVERVIEW OF THE PLAN

This strategic plan is the result of numerous collaborative activities:

- The Federal Highway Administration (FHWA) and the National Concrete Pavement Technology Center (CP Tech Center) at Iowa State University (ISU) formed a partnership to address surface characteristics (June 2004)
- Stakeholder input to the CP Road Map Surface Characteristics Track (October 2004)
- National stakeholder outreach on surface characteristics (November 2004)
- American Concrete Pavement Association (ACPA) joined the ISU-FHWA partnership to address surface characteristics (April 2005)
- Final outreach event that validated the initial strategic plan (August 2005)
- Draft strategic plan published and widely distributed (September 2005)
- Final strategic plan updated based on ongoing input and new information (July 2006)

The strategic plan provides a 10-year guiding framework for the research, technology transfer, and implementation of the most cost-effective methods of designing, building, measuring, and maintaining optimal concrete pavement surface characteristics.

The plan identifies 40 problem statements representing an investment of between \$27 and \$56 million in research. The proposed research is organized into seven subtracks and presented in a recommended sequence:

- SC 1. Innovative and Improved Concrete Pavement Surfaces
- SC 2. Tire-Pavement Noise
- SC 3. Concrete Pavement Texture and Friction
- SC 4. Safety and Other Concrete Pavement Surface Characteristics
- SC 5. Concrete Pavement Profile Smoothness
- SC 6. Synthesis and Integration of Concrete Pavement Surface Characteristics
- SC 7. Technology Transfer and Implementation of Concrete Pavement Surface Characteristics Research

Each problem statement contained in the plan may correspond to one or more individual projects. The problem statements will need to be developed into research project statements with detailed descriptions of the research to be accomplished, specific budgets, and definite timelines.

Following the subtrack tables, Figure 1 illustrates the relationship of current and proposed work.

Subtrack SC 1. Innovative and Improved Concrete Pavement Surfaces

Problem Statement Schedule (10 years)										Products
Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	
Framework for Subtrack										A detailed, sequenced, and validated framework for the research to be conducted in this subtrack.
	Pervious Concrete Pavements to Provide Desired Surface Characteristics									Guidelines and specifications for the design and construction of pervious concrete surfaces for desired surface characteristics.
	Improvements to Concrete Pavement Texturing									Improved guidelines and specifications for designing and constructing conventionally textured concrete pavement surfaces.
	Improvements to Concrete Pavement Grinding and Grooving									Improved guidelines and specifications for grinding and grooving concrete pavement surfaces.
			Exposed Aggregate Surfaces in Two-Course Paving							Guidelines and specifications for designing and constructing exposed aggregate concrete pavement surfaces.
				Precast Concrete Pavements to Provide Desired Surface Characteristics						Guidelines and specifications for designing and constructing precast concrete pavements for desired surface characteristics.
				Advancing Innovative Concrete Pavement Solutions for Desired Surface Characteristics						Guidelines and specifications for the construction and design of promising new concrete pavement solutions to address one or more surface characteristics demands.

Subtrack SC 2. Tire-Pavement Noise

Problem Statement Schedule (10 years)										Products
Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	
Framework for Subtrack										A detailed, sequenced, and validated framework for the research to be conducted in this subtrack.
	Relationship of Tire-Pavement Noise to Texture and Other Factors									A sophisticated model for predicting tire-pavement noise as a function of concrete pavement texture, materials characteristics, and other physical properties.
		Standardized Tire-Pavement Noise Measurement Method								A standardized method or combination of methods for measuring tire-pavement noise; standards and specifications for use of the new tire-pavement measurement method.
			Tire-Pavement Noise Thresholds							Report defining tire-pavement noise thresholds; Guidelines for designing, constructing, and rehabilitating concrete pavements that do not exceed the thresholds.
				In-Vehicle Noise Measurement						A standardized method for measuring in-vehicle noise; Standards and specifications for using the recommended method.
					Behind-the-Paver Tire-Pavement Noise Sensing Equipment					Standards and specifications for using equipment to measure concrete pavement noise and related surface characteristics behind-the-paver.

Subtrack SC 3. Concrete Pavement Texture and Friction

Problem Statement Schedule (10 years)										Products	
Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10		
Framework for Subtrack										A detailed, sequenced, and validated framework for the research to be conducted in this subtrack.	
	Behind-the-Paver Texture Sensing Equipment									Standards and specifications for using behind-the-paver texture sensing equipment.	
	Model to Relate and Integrate Texture and Friction									A model that relates and integrates texture and friction characterization.	
	High-Speed 3D Macrotexture Measurement										Standards and specifications for the use of effective, high-speed 3D macrotexture assessment equipment.
		Multidimensional Friction Measurement Model									Effective method for multidimensional friction measurement; Standards and specifications for use of the method.
			Automated, In Situ 3D Microtexture Measurement								Guidelines, standards, and specifications for the use of in situ 3D microtexture assessment equipment.
					High-Speed 3D Microtexture Measurement						Standards and specifications for the use of effective, high-speed 3D microtexture measurement equipment.

Subtrack SC 4. Safety and Other Concrete Pavement Surface Characteristics

Problem Statement Schedule (10 years)										Products	
Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10		
Framework for Subtrack										A detailed, sequenced, and validated framework for the research to be conducted in this subtrack.	
	Splash and Spray									Guidelines and specifications for using splash and spray assessment equipment; Guidance for designing pavement surfaces to minimize splash and spray.	
		Rolling Resistance Assessment								Guidelines and specifications for using rolling resistance assessment equipment.	
		Reflectivity and Illuminance Assessment								Guidelines and specifications for using reflectivity and illuminance assessment equipment.	
		Relationship of Pavement Surface Characteristics to Vehicle Crashes									Evaluation of vehicle crash risks as a function of surface characteristics; Guidance on designing and constructing pavements with reduced crash rates.
				Relationship of Pavement Texture to Tire and Vehicle Wear							Guidelines and specifications for using tire and vehicle wear assessment equipment.

Subtrack SC 5. Concrete Pavement Profile Smoothness

Problem Statement Schedule (10 years)										Products	
Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10		
Framework for Subtrack											A detailed, sequenced, and validated framework for the research to be conducted in this subtrack.
	Design and Construction Guidelines to Improve Pavement Smoothness										Comprehensive and accurate design and construction guidelines to assist stakeholders in improving concrete pavement smoothness.
	High-Speed, High-Resolution 3D Pavement Profiling										An effective method for high-speed, high-resolution 3D pavement profiling; Standards and specifications for use of the method.
		Behind-the-Paver Smoothness Sensing Equipment									Advanced, effective behind-the-paver smoothness sensing equipment with standards and specifications for its use.
				Next Generation Concrete Pavement Smoothness Standards							Recommended refinements to AASHTO provisional standards for pavement profiling and ride quality.

Subtrack SC 6. Synthesis & Integration of Concrete Pavement Surface Characteristics Research

Problem Statement Schedule (10 years)										Products	
Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10		
Framework for Subtrack											A detailed, sequenced, and validated framework for the research to be conducted in this subtrack.
	Comprehensive Surface Characteristics Field Evaluation										A rich concrete pavement surface characteristics database available for additional future data analysis; Guidance report with case studies that defines optimum concrete pavement surface characteristics and the methods for achieving them.
		Durability of Concrete Pavement Surface Characteristics									Reports that document the longevity and durability of various surface characteristics; Guidance on effective surfacing methods that provide durable surface characteristics.
				Unified Model of Concrete Pavement Texture, Noise, Friction, and Smoothness							A comprehensive model that unifies texture, noise, friction, smoothness, and other related variables.
							Mix Design System for Desired Surface Characteristics				A mix design system that accounts for the functional demands of the pavement surface layer.

Subtrack SC 7. Technology Transfer & Implementation of Concrete Pavement Surface Characteristics Research

Problem Statement Schedule (10 years)										Products	
Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10		
Framework for Subtrack											A detailed, sequenced, and validated framework for the research to be conducted in this subtrack.
	Workshops and Publications on Concrete Pavement Surface Characteristics Measurement Equipment and Techniques										Workshops and publications on new methods and equipment for measuring concrete pavement surface characteristics.
		Online Training to Implement New Products and Methods for Improved Concrete Pavement Surface Characteristics									A website with web-based modules that train contractors, designers, and owner-agencies in new models, software, and methods for improved surface characteristics.
			Workshops and Publications on Designing and Constructing Concrete Pavements with New and Improved Surface Characteristics								Workshops and publications on designing and constructing concrete pavements with improved concrete pavement surface characteristics.

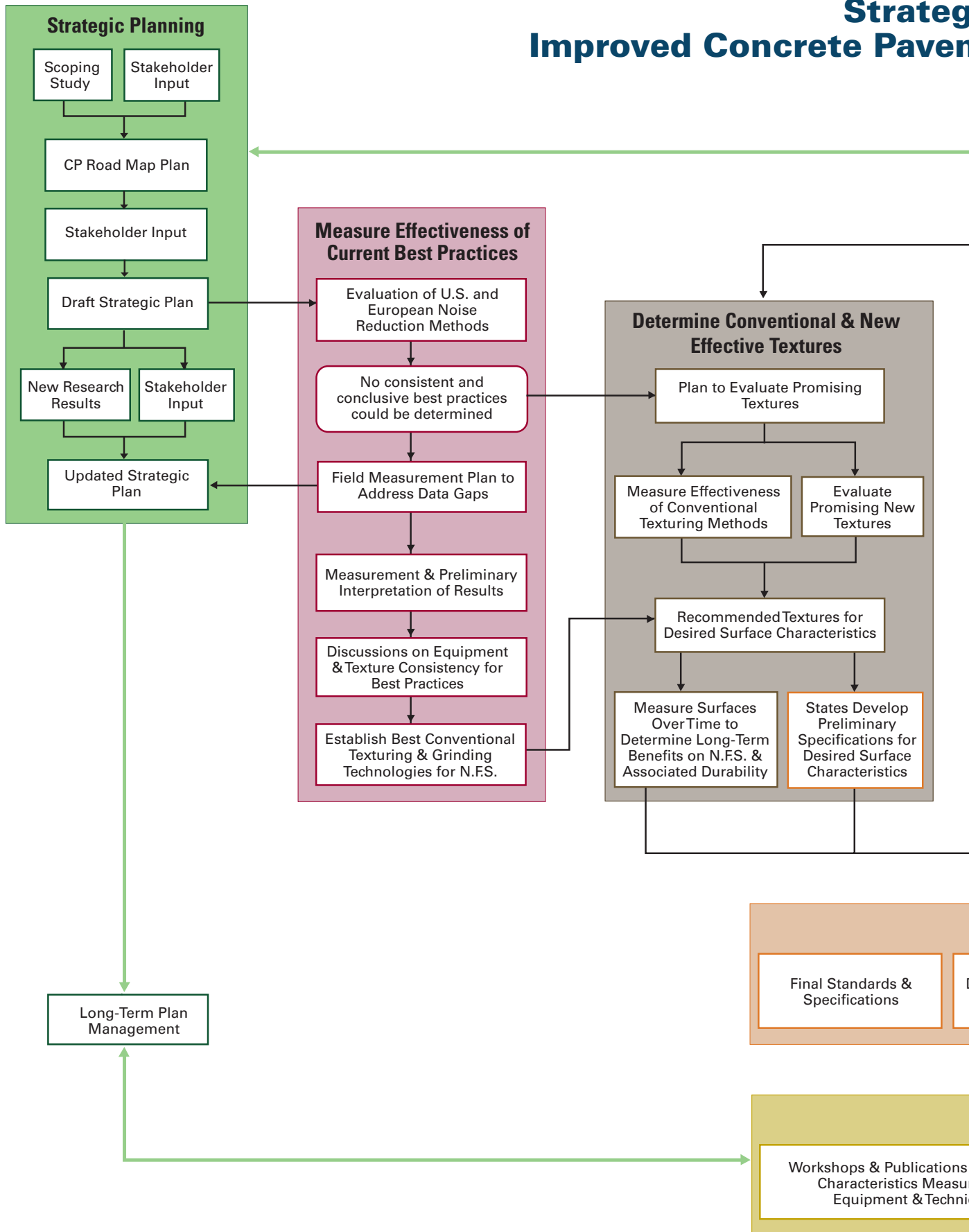
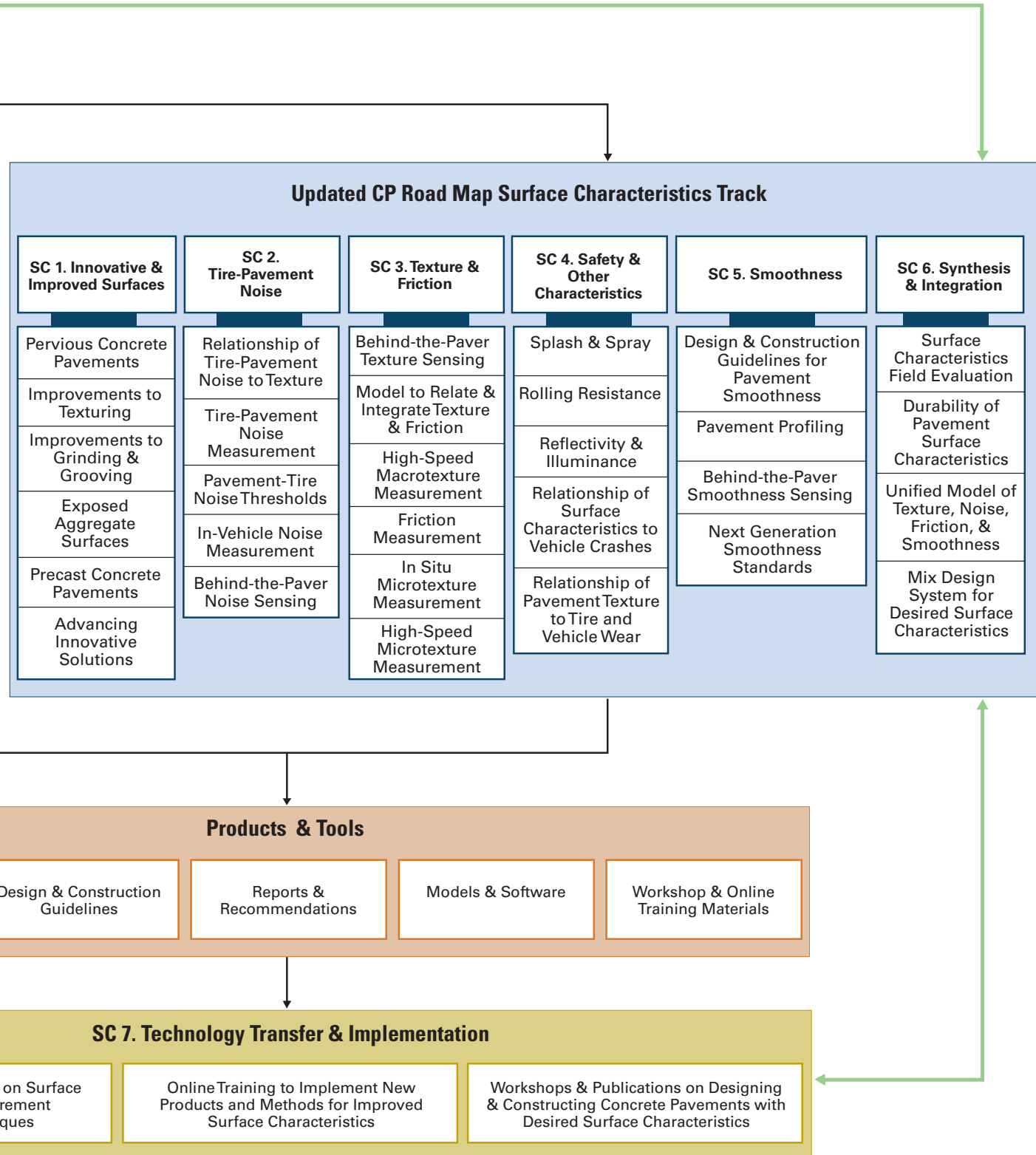


Figure 1. Flow chart of current and proposed surface characteristics research

Strategic Plan for Improved Concrete Pavement Surface Characteristics

N.F.S. = noise, friction, and smoothness



WHAT'S NEW IN SURFACE CHARACTERISTICS RESEARCH

Recently completed, ongoing, and newly proposed research related to concrete pavement surface characteristics is summarized in Tables 1–6. These tables provide a snapshot as of July 2006 and are not intended to be exhaustive.

The projects are grouped by the plan's subtrack topic areas, but it should be noted that as all surface characteristics are

interrelated, many research efforts such as Parts 2 of the CP Tech Center's Concrete Pavement Surface Characteristics Project cross subtrack lines. Much of this work is being cross-coordinated and will collectively advance the CP Road Map Surface Characteristics Track.

Table 1. New innovative surfaces research (Subtrack SC 1)

Project	Sponsors	Summary
Concrete Pavement Surface Characteristics Project (Part 3): Field Evaluation of Conventional Practices and Innovative Solutions for Desired Concrete Pavement Surface Characteristics	FHWA, ACPA, states, CP Tech Center at Iowa State University	This part of the project includes identifying and evaluating innovative texturing techniques that have the potential to reduce noise by an order of magnitude or more, while also not degrading the other surface characteristics of the pavement.
Innovative Methods for Creating Texture on Pavements	FHWA	The objective of this task-ordered project is to develop, test, and evaluate methods/equipment for creating texture consistent with a specified "target texture." Innovative equipment and methods may include stamping, imprinting, brushing techniques, removable inclusions, and aggregates with variable wear rates.

Table 2. New tire-pavement noise research (Subtrack SC 2)

Project	Sponsors	Summary
Caltrans Quiet Pavements Research Program	Caltrans	This work includes developing a database for life-time performance trends and verifying the operational capability to measure noise/texture values.
Evaluation of Tire/Pavement and Environmental Traffic Noise	Colorado DOT	The goal of this project is to develop and execute a comprehensive, long-term study to determine if a particular pavement surface type and/or texture can be successfully used in Colorado to help satisfy the FHWA noise mitigation requirements.
Evaluation using Tire/Pavement Test Apparatus	ACPA	The objective of this research is to examine noise radiation from textured concrete samples using the Purdue University Tire/Pavement Test Apparatus (TPTA). Phase 1 is directed at grinding experiments, and Phase 2 is directed at imprinting or surface texture casting procedures. This investigation is a first step in the long-range objective to identify surface texture options that are substantially quieter than current technology.
Measuring Tire-Pavement Noise at the Source (Project 01-44)	NCHRP	The objectives of this research are to develop rational procedures for measuring tire-pavement noise and to demonstrate applicability of the procedures through testing of in-service pavements.
Noise Level Adjustments for Highway Pavements	Texas DOT	This project focuses on reducing the chief source of highway noise, the tire-pavement interaction.
Pavement Noise Intensity Testing in Europe for Comparison to the United States (Project 20-07, Task 204)	NCHRP	This study will develop a comprehensive plan for using quiet pavements in the United States. The study will be guided by the panel for NCHRP Project 01-44, Quiet Pavement Pilot Project Study.
Study of Implementation of Pavement Effects into Traffic Noise Model (TNM)	FHWA	The objective of this project, conducted by the Volpe National Transportation Systems Center, is to evaluate the impact of different pavement types on the FHWA Traffic Noise Model (TNM) for predicting highway noise impacts.
Tire-Pavement Noise 101 Workshops	FHWA	This effort includes workshops on tire/pavement noise fundamentals to raise the level of awareness of tire/pavement noise for the pavement engineering community and the environmental/noise community.
Traffic Noise Model (TNM) Technical Support and Distribution	FHWA	The Volpe National Transportation Systems Center provides technical support for the FHWA TNM, which is a new, state-of-the-art computer program used for predicting noise impacts in the vicinity of highways.
Truck Noise-Source Mapping (Project 08-56)	NCHRP	The objective of this study is to use acoustic measurement and noise-source mapping techniques to accurately identify, locate, and quantify the noise sources on typical commercial truck and tractor-semi-trailer combinations operating in the U.S. roadway environment.
Tire/Pavement Noise Research Consortium (TPF-05(135))	Washington DOT	This effort is to provide a forum for states to discuss tire/pavement noise issues and develop a plan for research and data sharing.

Table 3. New texture and friction research (Subtrack SC 3)

Project	Sponsors	Summary
Circular Texture Meter and Dynamic Friction Tester Equipment Loan Program	FHWA	The objective of this project is to provide an opportunity for agencies to evaluate circular texture meter (CTM) and dynamic friction tester (DFT) equipment prior to recommending purchase. Technical assistance will also be provided.
Guide for Pavement Friction (Project 01-43)	NCHRP	The objective of this research is to develop a guide for pavement friction, for consideration and adoption by AASHTO.
Texturing of Concrete Pavements (Project 10-67)	NCHRP	The objective of this research is to recommend appropriate methods for texturing concrete pavements for specific applications and ranges of climatic, site, and traffic conditions.

Table 4. New safety research (Subtrack SC 4)

Project	Sponsors	Summary
Wet Pavements Crash Study of Longitudinal and Transverse Tined PCC Pavements	Wisconsin DOT	The objective of this study is to clarify the relative safety characteristics of longitudinal- and transverse-tined pavements through an analysis of crash data.

Table 5. New smoothness research (Subtrack SC 5)

Project	Sponsors	Summary
Development of a Golden Tire Footprint for Improvement of Profiler Relevance	FHWA	The objective of this project, conducted by the University of Michigan Transportation Research Institute, includes development of sampling strategies or filtering procedures for inertial profiler height sensor data that better represent how a tire envelopes pavement texture. These procedures will allow more repeatable and reproducible pavement profile data.
Improving the Quality of Pavement Profiler Measurement (TPF-5(063))	FHWA, states	This project includes development of a sample procurement specification, maintenance guidelines, and profile analysis software program; establishment of verification centers; and technical review of software.
Pavement Smoothness Workshops	FHWA	The objective of these workshops is to help address the specific needs of targeted states with respect to pavement smoothness numbers.
ProVAL Software Enhancement and Deployment	FHWA	This project includes the continued development of the ProVAL software to allow for more advanced analysis, improved quality control tools, and harmonization with AASHTO Interim Specifications. An implementation workshop is available through this work.

Table 6. New synthesis and integration research (Subtrack SC 6)

Project	Sponsors	Summary
Concrete Pavement Surface Characteristics Project (Part 1): Concrete Pavement Surface Characteristics Strategic Plan	FHWA, CP Tech Center at Iowa State University	In addition to the strategic plan described herein, this project included the identification and evaluation of tire-noise reduction methods and results, with a specific focus on European and U.S. practices.
Concrete Pavement Surface Characteristics Project (Part 2): Field Evaluation of the Relationship of Concrete Pavement Surface Textures to Surface Characteristics Properties	FWHA, ACPA, CP Tech Center at Iowa State University	The objective of this initial field evaluation is to measure and analyze conventional texturing variations and grinding techniques and their respective surface characteristics, particularly with respect to tire-pavement noise.
Concrete Pavement Surface Characteristics Project (Part3): Field Evaluation of Conventional Practices and Innovative Solutions for Desired Concrete Pavement Surface Characteristics (TPF-05(139))	FHWA, ACPA, states, CP Tech Center at Iowa State University	This work includes a comprehensive analysis of Part 2 data that will in turn lead to building more successful texturing techniques using conventional methods.
Pavement Surface Properties Consortium (TPF-05(141))	Virginia DOT	The objective of this pool fund is to establish a research program focused on enhancing the level of service provided by the roadway transportation system through optimized pavement surface texture characteristics. The initial focus of the program will be the application of inertial and laser-based equipment for measuring these properties.
PCC Surface Characteristics - Rehabilitation (TPF-05(134))	Minnesota DOT	The objective of this study is to field construct and evaluate grinding strategies and their impact on smoothness, friction/texture, and tire-pavement noise using the MnROAD facility.

COORDINATION AND ACCOMPLISHMENT OF THE PLAN

It is recommended that this plan be coordinated and accomplished as a CP Road Map track according to the protocols established by the FHWA and CP Road Map Executive Advisory Committee.

The CP Road Map includes a research management plan that outlines a progressive, cooperative approach to managing and conducting the research. Under this plan, organizations identify common interests, partner with one another in executing specific contracts, and, in the end, produce and share a product that is greater than the sum of the parts.

The relationships and roles of the CP Road Map Executive Advisory Committee, Track Teams, Administrative Support Group, Sustaining Organizations, and Researchers are illustrated in Figure 2.

Federal and state agencies, private industry, and academia have provided input that guided development of the plan. Continued stakeholder support and participation in the plan is critical to its success.

The Surface Characteristics Track Team should be identified and meet to discuss partnerships, priorities, and partners for developing the framework for each subtrack.

The following products and benefits are anticipated to result from the work outlined in the surface characteristics strategic plan:

- Clearer understanding of the relationship between pavement texture and surface characteristic performance levels
- Fully field-tested and validated concrete pavement designs and construction methods that produce consistent surface characteristics that meet or exceed highway user requirements for tire-pavement noise, friction/safety, smoothness, splash and spray, light reflection, rolling resistance, and durability
- High-speed, continuous measurement equipment and procedures for measuring texture, noise, friction, smoothness, splash and spray, rolling resistance, and other key surface characteristics

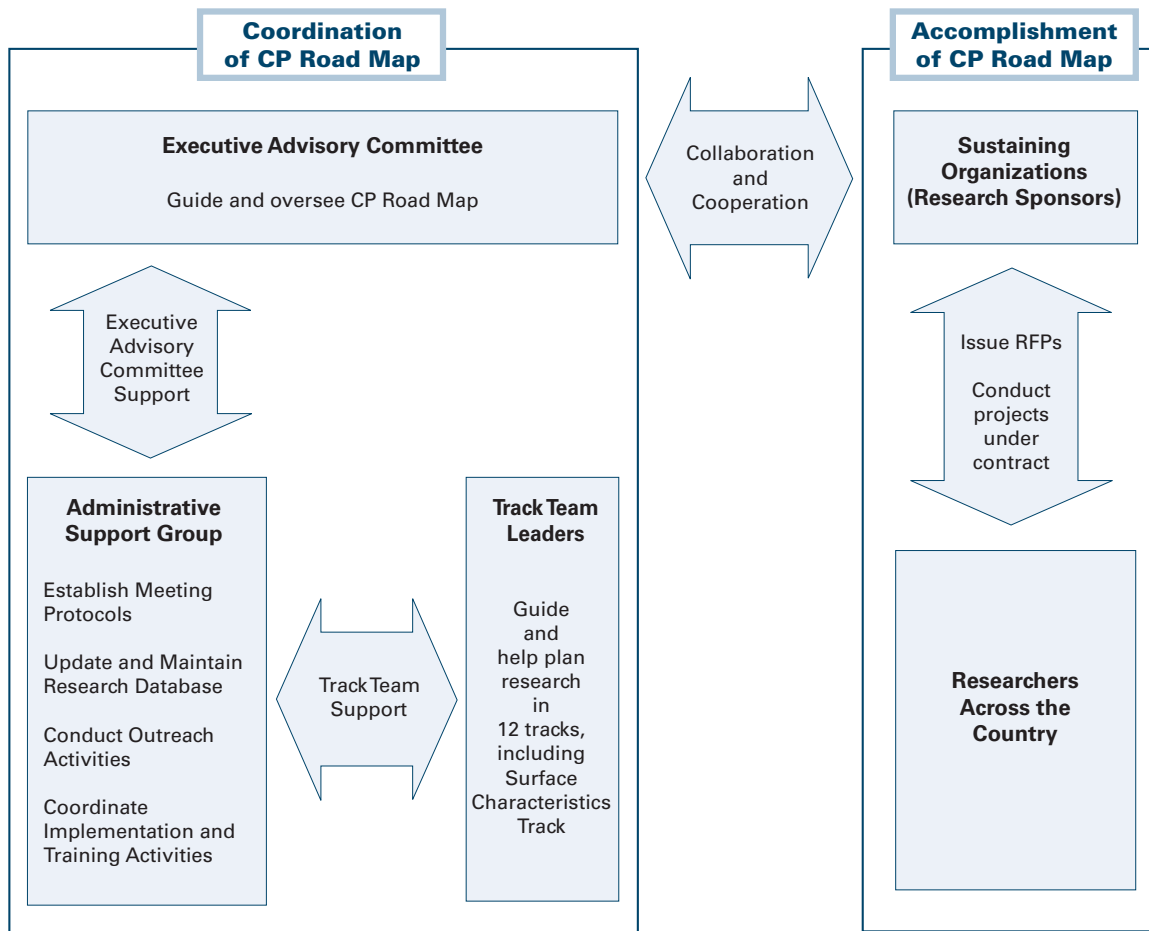


Figure 2. CP Road Map coordination and accomplishment

The mission of the National Concrete Pavement Technology Center (CPTech Center) is to unite key transportation stakeholders around the central goal of advancing concrete pavement technology through research, tech transfer, and technology implementation.

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