Performance Specifications

Strategic Road Map

Spring 2004

Table of Contents

Foreword..2

Executive Summary.......................................3

Chapter 1. Examining the Issues......................5

Chapter 2. Performance Specifications..............9

Chapter 3. Defining the Future.......................16

Chapter 4. Organization and Management.........20

Chapter 5. A Viable Contract Option.................24

Appendix 1. Postscript..................................26

Foreword

In May 2000, the Florida Department of Transportation (DOT), in cooperation with the Federal Highway Administration (FHWA) and the National Partnership for Highway Quality, conducted a workshop on the future of performance-related specifications (PRS) in the highway industry. More than 50 Federal, State, and private sector engineers met to discuss the background, history, and future of this topic. The attendees agreed that the subject was important, extremely complex, and had to be addressed. They recommended a national strategy to identify and coordinate efforts, and FHWA agreed to initiate the process.

In December 2001, FHWA, in cooperation with the American Association of State Highway and Transportation Officials (AASHTO) and various industry associations, sponsored the first national PRS Technical Working Group (TWG) meeting. The purpose of the meeting was to establish the foundation for a PRS movement to foster the development and application of performance-related specifications. The PRS TWG identified a series of activities that lead to continued development and implementation of PRS. At that meeting, the mission was expanded to include the formation of expert task groups in various technical disciplines and to include warranties, which are clear and growing alternatives to PRS.

In November 2002, the PRS TWG met again to review work accomplished by the expert task groups and to discuss several additional aspects of PRS. The attendees reemphasized their support for the effort and suggested that method specifications be addressed in some format in the PRS mission. Noting that the mission had been expanded to include method specifications and warranties along with performance-related and performance-based specifications, the attendees also recommended that the name of the effort be changed to the Performance Specification Program.

This Performance Specifications Strategic Road Map is intended to be used as a tool to guide the highway community in developing, implementing, and accepting performance specifications as viable alternatives for highway construction. It is a working document that will be maintained by the FHWA on its website and periodically updated.

Executive Summary

The Performance Specifications Strategic Road Map presents both a rational discussion of performance specifications and a plan for their development as a viable contract option for highway construction. Performance specification (PS) is an umbrella term that incorporates performancerelated specifications (PRS), performance-based specifications (PBS), and warranties. In broad terms, a performance specification links the performance characteristics of the final product to those construction and materials items under the control of the contractor. Performance characteristics may include end-result elements such as product strength, bearing capacity, stability, visibility, and cracking, as well as more functional requirements such as smoothness, friction, noise reduction, chip retention, splash, and spray.

When future performance of a product is projected using construction tests and measurements linked to design via modeling, the specifications are commonly known as ***performance-related*** or ***performance-based*** specifications. When actual performance of the product is measured after a predetermined time in service, the specification structure is commonly known as a ***warranty***. When the final product is described in terms of component materials, dimensions, tolerances, weights, and required construction methodology—equipment type, size, speed, etc.—the specifications are commonly described as ***method*** or ***prescriptive*** specifications. Currently, method specifications are the most prevalent in highway construction.

Engineers have long sought relationships between a material characteristic and its impact on product performance. If clear relationships could be determined and properly translated into specification language, the benefits could be significant. Agencies could better understand quality and performance and more accurately translate design intent into construction requirements. Agencies also could target and economize inspection programs, and more rationally develop incentives and disincentives. Contractors could use materials and methods in which they have experience and confidence. With the advent of warranties, contractors are coming to grips with a similar challenge as they select materials and construction techniques to meet future product performance requirements.

Societal changes are driving procurement strategies as well. With dramatic reductions in both the numbers and experience levels of government inspectors and engineers, highway agencies are examining their roles and responsibilities. The complexity of high-speed construction, nighttime construction, and rehabilitation work under traffic—all of which the public demands—further stretches available agency resources. Traditional low-bid contracting may not be the ultimate mechanism for this type of work, as growing interest in design-build contracting and long-term warranties indicates. These contracting mechanisms also require a full examination of specification language and a clear delineation of roles, responsibilities, and risks.

This road map fully examines the performance specification issue. It outlines a mission, vision, and goals that will establish an organized framework for a movement towards performance specifications. The ***vision*** is that the performance of highway facilities will improve through better translation of design intent and performance requirements into construction specifications. The ***mission*** is to establish performance specifications as a viable contract option.

The road map outlines four strategic ***goals***:

- Identify relationships that link design and construction with product performance.
- Develop and implement performance specifications.
- Conduct a communication and training effort.
- Provide organizational support for the Performance Specification Program.

The road map also outlines major tasks for the next five years in support of these goals.

FHWA will provide administrative support to the program, but it will look to other agencies and industry to provide necessary input and support for the various initiatives.

"To attain our goals of improved quality, improved product performance, and a better environment for contractor innovation, we cannot simply identify and test those construction and materials factors that best determine product performance.

"We also must address roles, responsibilities, risks, and specification language as well to determine how best to deliver that product. ***Freedom to innovate with accountability to deliver*** *is the driving force behind the performance specification movement."*
- Ted Ferragut, TDC Partners, Ltd

Chapter 1
Examining the Issues

A Brief History

In the early 1900s, the idea of mobility was paramount in the minds of the American people. As travel modes transitioned from ships to wagons to trains to automobiles, the road became the focal point of transportation. Toll roads connected major cities and industrial areas. Public road-building jurisdictions were small, numerous, and unconnected. In the art of road building, little was known about factors that contributed to the success or failure of the road. Under these circumstances, the first option for governing agencies was to require a maintenance guarantee. The contractor promised to do any needed road maintenance and repairs for a specified time period after construction.

Formation of the American Association of State Highway Officials (AASHO) in 1914, followed by a general uprising from the contracting community over warranties and proprietary items, led to the development of a new order of road-building specifications and brought about a certain level of uniformity in State specifications. This was the birth of method specifications. In a method specification framework, work was done in a prescribed way, with maximum control in the hands of the agency. The contractor followed the script – provided materials, equipment, and followed directions.

In the mid-1960s, after noting rather high construction and materials variability in the controlled AASHO Road Test[1], industry leaders determined that method specifications by themselves did not properly control the construction process. Practitioners asked researchers to come up with a new way of addressing these issues. FHWA tackled the specification issue, noting that a properly crafted specification should clearly answer five questions:

- What do we want?
- How do we order it?
- How do we measure what we ordered?
- How do we know we got what we ordered?
- What do we do if we don't get what we ordered?

While most practitioners believed that method specifications reasonably captured best practices at the time, they did not outline an effective sampling and testing program to determine overall compliance. With equipment and material requirements defined, many believed that method specifications inhibited innovation and could not deal with rewarding a contractor for "better-than-minimum" practice. Finally, they also believed that method specifications as written could not consistently deal with work that was outside the bounds of "reasonably close conformance."

[1]A 7-mile long full-scale test road near Ottawa, IL, aimed at gathering data on significant variables affecting pavements and short-span bridges. The project was designed and managed by the Bureau of Public Roads, the American Association of Highway Officials and the Highway Research Board in the late 50s and 60s and still provides valuable pavement data.

Could a new specification with an "end-result" approach lead to more innovation? Could it lead to better handling of non-complying material and a more accurate assessment of in-place quality? As practitioners asked themselves those questions, the construction research approach of the 1970s became, "Don't tell them how to do the job; tell them what you want and let them go."

In theory, an end-result specification should allow contractors more freedom to implement their own procedures, choose their own equipment, and conduct site-specific process control programs. The transportation agency would allow this freedom, but establish a more structured sampling and testing program on the in-place product. And so the journey toward performance specifications began.

While the concept appears simple, researchers posed many difficult questions as a prelude to their work:

1. What is an in-place property? Thickness? Density? Modulus? Stiffness? All of them?
2. What in-place properties most directly influence product performance?
3. What tests best measure these properties? How many? With what variability?
4. What is an in-place product? The base or the pavement? The paint or the stripe?
5. What is product performance? Distress? Remaining life? Failure?
6. What is the value of the product if one or more of the tests show non-compliance? Rework? Replace? Accept at a reduced value? And what if the tests show exceptional results—much better than specified?
7. What elements of construction are contractor-controlled versus agency-controlled?
8. What elements of construction are totally beyond the contractor's ability to control or influence?

A major output from this research was ***statistically based*** quality control specifications. They addressed the issues of testing and test variability, sample size, lot size, estimates of the total population, percentage within limits, and pay factors. While most agreed that this new approach did a better job of addressing contractor compliance, it did not necessarily address product performance. Why? For the most part, the specifications measured what COULD be measured, not what SHOULD be measured. The drivers of product performance and the test procedures needed to measure the performance characteristics did not exist.

The critical connection to product performance came about in the early 1980s. What if it were possible to connect product performance to a life cycle cost analysis (LCCA)? LCCA establishes performance relationships between the designed product, costs, and future preservation, maintenance and repair strategies. For pavements, this appeared to researchers to be a key approach. If the design calculations were examined closely, they should include factors that focus on key performance characteristics—strength, thickness, modulus, etc. Would it be possible to recalculate the LCCA using as-built test results and then compare them to the original LCCA? This would provide a ratio that linked costs and time-to-rehabilitate. For example, if the pavement was built one inch shy of the design thickness, the as-built LCCA would show that the projected pavement life was reduced by a certain percentage, triggering an earlier rehabilitation strategy. Researchers were now on their way to determining analytically the performance aspect of the pavement. The ratio of the as-built costs to the as-designed costs also gave them a more rational approach to pay factors. And, of course, this puts pressure on the designers to assure that they are theoretically correct with formulas and assumptions proven over time.

Is it about contractor compliance? Or about product performance?

The process gets more complicated when other pavement performance characteristics—such as density, smoothness, skid, segregation, stripping, durability, and noise—are considered. All of these characteristics are important, although maybe not equally. All have an impact on pavement performance and are interrelated. Some characteristics are inputs into the equation or model used to design the pavement originally. Some are not. Some are clearly under the control and responsibility of the contractor. Some are not. Some can be tested quickly and easily, while others involve test that are slow and late in the process. And some performance properties are tied to agency specifications that require the contractor to use a certain technique or material.

For the past 20 years, FHWA, AASHTO, and contractors have been on a journey to sort out and understand this complicated issue. Performance-related specifications have been identified as a high-priority area in every major research plan developed over the past decade by FHWA, AASHTO, and various industry groups. Much of the current national research has focused on asphalt and concrete pavement systems. But much of the above could relate to bridge decks or other highway products.

While the performance specification framework for pavements is relatively mature, this leads to questions about how this methodology translates to other highway products. Bridges, earthwork, retaining walls, and many other highway products do not have direct connections to a life cycle cost analysis methodology or to a clear design formula or model. And while the performance specification framework for pavements aids in determining values, it does not directly address roles, responsibilities, and ways to create an innovative atmosphere.

In 1991, a milestone asphalt pavement study tour of European countries initiated a U.S. discussion of new contracting mechanisms, including the possible impact that warranties might have on product performance and contractor innovation. In 1995, FHWA clarified its approach to warranties and set the direction for their future application. Warranties appeared to be another way that agencies could address product performance. While PRS concepts were emerging for experimental use in concrete pavements, agencies could, if they wanted to, simply invoke a warranty clause and bypass all the apparent complexities associated with PRS – and in the process transfer risk to the contractor.

Many activities have been initiated over the past several years, further validating interest in new approaches to specifications. In 2000, the National Cooperative Highway Research Program, under AASHTO sponsorship, initiated a contract on performance-related specifications for asphalt mixes, continuing work begun on the WesTrack[2] Superpave project.

---

[2] WesTrack refers to an experimental road test facility constructed in Nevada that continues the development of performance related specifications for hot mix asphalt.

Also in 2000, the Indiana DOT completed the first experimental project based on FHWA's model PRS for concrete pavement. In 2002, an international scanning study focused on the growing use of long-term asphalt pavement warranties in Europe that allow routine maintenance and preservation during the performance period. In 2003, another international scan on superior materials found significant movement toward performance specifications (functional specifications) in several European countries.

Interrelated Issues

All of these factors contribute to a realignment of conventional roles and responsibilities, and provide new opportunities to examine product performance and construction contracting.

Specification Language. The objective of all specification writers is to translate the transportation agency's intentions into clear, legally defensible instructions for the contractor. Today, more than ever, specification writers recognize that this objective also must allow the contractor to exercise ingenuity and creativity in complicated rehabilitation and reconstruction projects. Projects built under traffic conditions complicate the normal sequence of operations, equipment selection, site access, construction speed, and safety to the worker and traveling public. Less-prescriptive specifications could be a way to allow the contractor to exercise more creativity to meet the demands of a particular project. This is even more justifiable for the growing number of unique projects with special quality and performance requirements – integration of work zone management with construction sequencing, for example.

Inspection Staff. State DOTs—indeed, nearly all public agencies—have seen a dramatic decrease in the numbers and experience levels of inspectors and engineers in their workforce. This has led to more contractor quality control programs and agency testing of as-built products.

Construction Duration and Speed. In urban areas where traffic congestion is a major issue, nearly all construction products go into service immediately. This is a radical departure from the practice of allowing 100 percent completion before the project opening. New approaches to construction product testing and construction acceptance have become necessary to satisfy the needs of the traveling public.

Public Response to Highway Quality and Performance. The public, including elected officials, are asking why so many highway facilities always seem to be under construction and need so much attention. They compare highway products with commercial products and insist on more contractor accountability through a warranty or guarantee or even open product testing. "Get in, stay in and do it right, get out, and stay out" will be driving the industry for years to come.

Chapter 2
Performance Specifications

The Umbrella

Performance specification (PS) is an umbrella term incorporating performance related specifications (PRS), performance-based specifications (PBS), and warranties. In the broadest terms, a performance specification defines the performance characteristics of the final product and links them to construction, materials, and other items under contractor control. Performance characteristics may include items such as pavement smoothness or strength, bridge deck cracking or corrosion, chip seal stone retention, embankment slope stability, etc.

Snapshot. When future performance of a product can be estimated using key construction tests and measurements linked to the original design via modeling and life cycle costs, the specification structure is commonly described as ***performance-related*** or ***performance-based***.[3] When the condition of the product is measured after some predetermined time, the specification structure is commonly known as a ***warranty***. When the final product is described in terms of component materials, dimensions, tolerances, weights, and required construction methodology—equipment type, size, speed, etc.—the specifications are commonly known as ***method*** or ***prescriptive*** specifications. Currently, method specifications are the predominant specification type used in U.S. highway construction.

PRS

In softened technical terms, PRS are specifications that use quantified quality characteristics and life cycle cost relationships correlated to product performance. In management terms, a PRS is the bridge between design, construction quality, and long-term product performance. So how does one determine that a specification is performance related? Some fundamental and suggested requirements are offered to sort this out.

PRS: Fundamental Requirements

Quality Characteristics and Accountability. Critical quality characteristics should be readily measurable and clearly tied to product performance. Construction contractors should be held accountable only for those quality characteristics under their control.

Performance Predictions. Prediction tools, including modeling and databases, should be verified, calibrated, validated, and otherwise made appropriate for local conditions.

[3] From this point on in the report, PRS is assumed to include PBS. For all practical purposes, the distinction between the two is not relevant at the program level, but should be considered at the research and engineering level. For more information, see http://gulliver.trb.org/publications/circulars/ec037.pdf.

Life Cycle Cost Analyses (LCCA). Life cycle cost analyses should be used to compare the as-designed product section to the as-built section. The LCCA should be based on a clear, well-documented, and realistic preservation, rehabilitation and maintenance decision tree.

Acceptance Plans. Acceptance plans should be statistically based with clearly defined risks. If necessary, pay determination should be made in a timely fashion to allow for prompt corrective action. Sampling and testing plans should properly address material, operator, and testing variability and improve confidence in the results.

Simple and Clear Language. Performance-related specifications should be written simply, clearly, and succinctly for today's busy construction workforce.

PRS: Suggested Requirements

Add Performance and Subtract Method. As PRS end-result criteria are added to a contract for a specific quality characteristic, they should be accompanied by a corresponding reduction in prescriptive or method elements, giving the contractor more freedom to innovate, improve quality, and clarify roles and responsibilities. Add density and eliminate roller requirements, for example. Or add in-situ smoothness and eliminate concrete paver string line requirements.

Quick and Timely Testing. Testing should incorporate standardized tests using nondestructive techniques to measure the product in situ, better quantifying the quality characteristics and enhancing 24-to-48-hour, if not instant, turnaround of information. This also could be the driver to harness computer technology, such as PDAs (personal digital assistants), wi-fi (wireless fidelity) networks, voice recognition, and high-speed linkage to asset management systems.

Process Control. The contractor should be given reasonable latitude to develop and implement a process control plan that can be verified by the transportation agency, especially for those quality characteristics included in the acceptance plan.

Mechanistic Models. Performance prediction techniques used in PRS should be based on mechanistic models and be the same models used in the design process. Asset management systems should track the same assumptions used in the design and construction process.

LCCA and User Costs. User costs should be considered in developing appropriate pay factors. The impact can be high, however, and will require sound judgment when applied. Both the owners and the contractors need to understand the impact on customer satisfaction.

Warranties

Warranties can be divided into two areas: materials and workmanship (M&W) warranties and product performance warranties. M&W warranties call for contractors to correct defects in work elements within their control. The M&W concept is referenced in many State regulations and codes, but it is not directly referenced in highway specifications and has been invoked rarely.

The performance warranty is a recent concept and requires the contractor to correct defects if the product does not perform to some desired quality level over a certain time in service. Product performance warranties are somewhat controversial, exponentially so as the length of the warranty period extends beyond three years. The controversy stems from the concept of risk allocation and the financial burdens that accompany partial or complete product failures.

Following is a step-by-step process for developing a warranty:

1. Establish what gain is expected and how success of the program will be measured.
2. Define the product service life.
3. Establish a warranty period and describe the condition of the product at the end of the warranty, including expected remaining service life.
4. Describe the sampling and testing plan that will be used to monitor quality during construction and measure quality at the end of the warranty period.
5. Eliminate method or prescriptive requirements that conflict with performance requirements or intent. This includes material selection, mix designs, etc.
6. Establish some thresholds where warranties are invalidated—traffic, weather, inadvertent maintenance, etc.
7. Establish a contract bonding, insurance, or retainer requirement to hold the contractor financially accountable.
8. Establish a repair protocol should the product show early distress.
9. Establish a mediation board to resolve conflicts.
10. Pay according to a pre-determined pay schedule, including incentives and disincentives.
11. Monitor, measure, and feedback into the performance models.

M&W warranties of less than three years generally require the contractor to focus on construction quality. With a performance warranty, the contractor may have more latitude in selecting materials, processes, and design choices. This requires the contractor to have much more than a working knowledge of the product. This means sorting through various combinations of materials or manufactured products and pricing alternate products. Should the contractor provide a higher-cost, longer-life, more-than-meets-the-warranty threshold product or a lower-cost, shorter-life, just-meets-the-warranty product? What is the risk versus costs? What impact will this have on contract award? Price obviously matters in a low-bid contract, but it also matters in emerging procurement options such as design-build and best-value contracting.

This process is the reverse of the PRS process, in which the transportation agency makes the decisions on material type, layer requirements, etc. Not surprisingly, however, both parties need a working knowledge of what drives performance. The fundamental approach in PRS may be applied by a contractor in response to a warranty requirement as well.

PRS and Warranties

The comparison between performance-related specifications and warranties is a natural. Both address product performance and improvement in contractor end product compliance and innovation, and both have an impact on the interrelated issues mentioned previously. The impacts on the contractor and the transportation agency, however, are different in each scenario. The following chart outlines the issues and the requirements under each.

Requirements **Y = Yes N = No S = Should**	**PRS**		**WARRANTY**	
	Owner	**Cont.**	**Owner**	**Cont.**
Determine performance requirements through data or models	Y	N	S	Y
Develop a clear sampling and testing plan	Y	N	Y	Y
Remove method or prescriptive requirements	S	N	S	-
Reduce inspection workforce during construction	S	N	S	N
Extend the final contract completion date	N	N	Y	Y
Monitor and adjust for in-service traffic levels & environment	N	N	S	S
Determine in advance the price of nonconformance	Y	N	Y	N
Increase post-construction workforce responsibilities	N	N	Y	Y
Have detailed knowledge of existing support conditions	S	N	Y	Y
Invoke additional contractor bonding or insurance requirements	N	N	Y	Y

In the future, agencies will have two different approaches to address quality. Each method has its positives and negatives.

Method Specifications

One of the most difficult issues facing the adoption of performance specifications is the impact they have on method or prescriptive specifications. A recent review of select transportation agency standard specifications showed that use of method specifications remains common, with more than 400 prescriptive requirements in the standard specification book. They vary from minimum tire pressure in a rubber-tired roller to paver string line requirements. The difficulty comes when the specification includes both a prescriptive and end-result requirement—a roller specification and an end-result density requirement, for example.

Method specifications have been a mainstay in transportation construction for many years. What is the most commonly accepted principle behind a method specification? If the contractor follows the prescription, then the work product has a high probability (if not a sure bet) of being accepted by the agency and a good probability of performing well in service. What are some of the other impacts of method specifications?

Decision Aids. A method specification tells the contractor exactly what the agency has decided about a certain topic.

Knowledge Tools. Method specifications tell both parties what is considered good practice and, by omission, what is not good practice.

Minimum Acceptable Values. Terms like "no less than" or "at least" show the lowest allowable value that will be accepted by the agency.

Restrain Decision Makers and Force Fair Treatment. Method specifications give BOTH parties protection over arbitrary decision making. In fact, they serve to prevent arbitrary decision-making by the agency as much as the contractor.

Difficult to Change. Method specifications are difficult to change once imposed and set into practice, which is both good and bad. It is good in that training, equipment procurement, and testing programs can be developed around the concepts, but it is bad in that an obviously minor or insignificant method specification is often difficult to remove.

Unintended Negative Consequences. It may be that the agency wants to allow flexibility but is constrained by the method requirements. The contractor, in turn, may want to introduce an innovative concept but is inhibited by having to address each method specification point by point.

Red Tape. While one method specification may be judged as a safeguard to both parties, when does a series of method specifications become overbearing—the definition of red tape?

Minimum Quality Equals Maximum Quality. While method specifications clearly define MINIMUM acceptable behavior, they may also, as a result of the low-bid process, define MAXIMUM performance levels as well.[4]

Distinguishing a Quality Contractor. Method specifications (in harmony with low-bid contracting) have a way of grouping all contractors under one quality umbrella. They reduce the ways contractors can differentiate themselves in the quality arena.[5]

---

[4] This is one reason that incentive clauses were created and added to method specifications.
[5] This is yet another reason why incentive clauses were created.

Specifications and Contracts

Several key questions need to be answered about how these three types of specifications will work in the future. Will the highway specification book be filled with performance specifications and void of all method requirements? Will the book contain a blend of specifications? Or will it have different types of specifications for different types of contracts—method specifications for less-critical subjects and performance specifications for design-build, for example. Or will method specifications always be used to control those illusive long-term durability issues?

A window to the future might be the European Union (EU) process for improving trade and competition among European countries. The EU is providing the stimulus for the highway industry to develop functional highway specifications for contracts (tenders). Functional specifications are a cross between end-result and performance specifications and define the final in-place product with some specificity. Method specifications gradually are being removed, especially those that relate to material composition and installation procedures. Industry and government are working on many of these specifications and acknowledge to the complexity of the issue.

In addition, many European countries have moved to functional contracts with specific language on performance of the in-place product over time. This includes everything from retroreflectivity of a pavement marking in service to litter pickup in rest area waste containers. The United Kingdom's Highways Agency bases 80 percent of a contract decision on quality factors and 20 percent on cost. In 2003, this will change to a 100 percent quality award. The dollars will be negotiated after the award, and the specifications all will be functional.

Some European countries are increasingly using design-build-operate-maintain (DBOM) contracts that may extend for 20 to 30 years. These contracts are performance based, including eventual turnback to the agency at a required performance standard or benchmark.

The drivers in Europe to move to these types of contracts are the same as those in the United States:

- To pull the private sector into the innovation equation.
- To address the reduction in government personnel.
- To allow the remaining governmental workforce to focus more on performance requirements for the transportation system.

Is everybody in Europe happy about this movement? No. Is everybody in Europe seeing the long-range vision the same way? No. But they are working on the issue and already are seeing fruits of their labor in several key technology areas.

What does this mean to the United States? Is Europe a window to our future? Maybe. Should the United States copy what Europe is doing? Not at all. The European construction industry is structured differently than the U.S. industry, and the social implications cannot be dismissed. But it does mean that the United States has a real-life laboratory to learn about performance specifications and performance contracts. With a watchful eye, the United States could learn from Europe's organization efforts, experiment with its specifications, and dismiss those that would bear little fruit.

Expected Benefits

It makes no sense to start something without clear reasons and expected benefits. Developing and implementing performance specifications offers many potential benefits. The following are some of the most important:

Improved Design-to-Construction Communication. Performance specifications could more directly connect design requirements with construction, assuring that both parties communicate effectively.

Rational Pay Factors. Pay factors could be more accurate, rational and defensible, as they would be based more on processes and less on bartering.

Improved and Focused Testing. Testing would focus on those characteristics that relate to performance.

Improved Tradeoff Analyses. Performance, quality, and costs could be uniquely connected through modeling and life cycle cost analyses with a much better way to analyze tradeoffs.

Improved Understanding of Performance. Performance specifications could lead to a better understanding of those quality characteristics that relate more directly to product performance.

Improved Quality Focus. Performance specifications could lead to improvement in the overall quality of the product in areas that caused problems previously.

Clearer Distinction in Roles and Responsibilities. Performance specifications could help clarify changes in roles and responsibilities between the transportation agency and the contractor, as well as define the levels of risk that each would carry.

More Innovative Environment. By being less prescriptive, performance specifications could create an environment that encourages innovation.

All of these benefits would apply to either PRS or warranties.

Chapter 3
Defining the Future

"There is no road map without a vision, a mission, goals, tasks, and a timeline."

Vision

Performance specifications improve the performance of highway facilities through better translation of design intent and performance requirements into construction specifications.

Mission

Establish performance specifications as a viable contract option for highway construction.

Goal 1

Identify relationships that link design and construction with product performance.

Goal 2

Develop and implement performance specifications.

Goal 3

Conduct a communications and training effort.

Goal 4

Provide organization support for the Performance Specification program.

Justification

The first goal will lead to identification of performance relationships and new tests. The second goal will lead to effective contractual language and delineation of roles and responsibilities. The third will focus on telling everybody what they need to know about performance specifications. And the final goal acknowledges that structure, accountability, and administrative support are needed to do the work effectively.

Four to six tasks have been identified to accomplish each goal, but the Technical Working Group and expert task groups will want to consider many additional subtasks. Due dates for accomplishing the goals are shown in Table 1. The Technical Working Group and expert task groups will establish more detailed timelines once a budget for the overall mission is established formally.

Goal 1. Identify relationships that link design and construction with product performance

This is the most important and most difficult element of the road map. A lot of work has been done over the past several decades on some products—pavements, for example. Little has been done on a host of other products, such as pavement preservation modeling. While progress on this goal could be slow and incremental, it needs to move forward.

Task 1.1. Identify products that are viable candidates for performance specifications. Examine European functional specifications in these key areas.

Task 1.2. Organize and prioritize the in-service performance requirements for each product.

Task 1.3. Develop mechanistic-empirical models and/or organize actual performance data that clearly link design factors to performance. Identify factors that are under the direct control of the designer and those that are under the direct control of the contractor.

Task 1.4. Develop and implement non-destructive tests that link more directly to performance and focus on 100 percent sampling and/or continuous sampling of the in situ product.

Task 1.5. Develop and implement a program in which high-speed, continuous, real-time, non intrusive testing is applied directly to construction equipment.

Task 1.6. Support advancements in life cycle cost analysis procedures and maintenance decision trees that encourage a more thorough understanding of performance and its relationship to costs.

Goal 2. Develop and implement performance specifications

As relationships are developed under Goal 1, critical elements of a specification, such as the specification language, roles and responsibilities, and risk can proceed. Tracking systems, risk manuals, trials and evaluations, and administrative mechanisms are suggested.

Task 2.1. Develop guide specification language for those products that have performance clearly identified under Goal 1, building on the specification matrix approach.
Task 2.2. Evaluate the relationship between method specifications and performance specifications with the goal of minimizing prescriptive specifications wherever possible.

Task 2.3. Develop a national website and tracking system for performance specifications and quantify improvements in quality and/or contract management.

Task 2.4. Develop a risk management manual that clearly quantifies the transfer of risk and responsibility between contractor and agency based on the responsibilities for determining and providing products and services.

Task 2.5. Implement continuous national evaluation of incentives and disincentive clauses as they relate to performance.

Task 2.6. Develop and implement a national experimental and evaluation program for innovative performance specifications applied to active projects.

Goal 3. Conduct a communications and training effort

It matters little what is accomplished in the laboratory or in the conference room unless the message is delivered. Without a knowledgeable and trained workforce, developing performance specifications becomes simply an academic exercise.

Task 3.1. Prepare and distribute a brochure that clearly defines performance specifications for both managers and practitioners in easy-to-understand language. Provide clarity on the definitions of quality and different specification types.

Task 3.2. Continuously inform managers and practitioners about ongoing developments in performance specifications through effective use of newsletters, Web sites, magazine articles, demonstration and experimental projects, flyers, etc.

Task 3.3. Develop a detailed training and outreach program that covers both performance specification principles and specific product performance requirements. The first priority is to develop a short course that presents performance specification principles. All training should work within the framework of the Transportation Construction Curriculum Council (TCCC).

Task 3.4. Develop and support a speakers' bureau of knowledgeable and available practitioners.

Goal 4. Provide organizational support for the Performance Specification Program

Nobody really likes bureaucracies and it would be nice to say the performance specification movement could be successful without some structure, but that would be unrealistic. The proposed structure aims at creating energy and synergy, establishing and managing funds dedicated to the effort, and keeping everyone moving in the same direction.

Task 4.1. Develop, maintain, and update the Performance Specifications Strategic Road Map.

Task 4.2. Establish a flexible performance specification operational structure that can respond to change, participant interest, and funds availability. The structure should deal with a movement, not a requirement.

Task 4.3. Identify those product areas for which an expert task group should be established. Provide Technical Working Group assistance to the various expert task groups to develop and execute tasks in support of the strategic road map.

Task 4.4. Provide budget and timeline for performance specification program efforts.

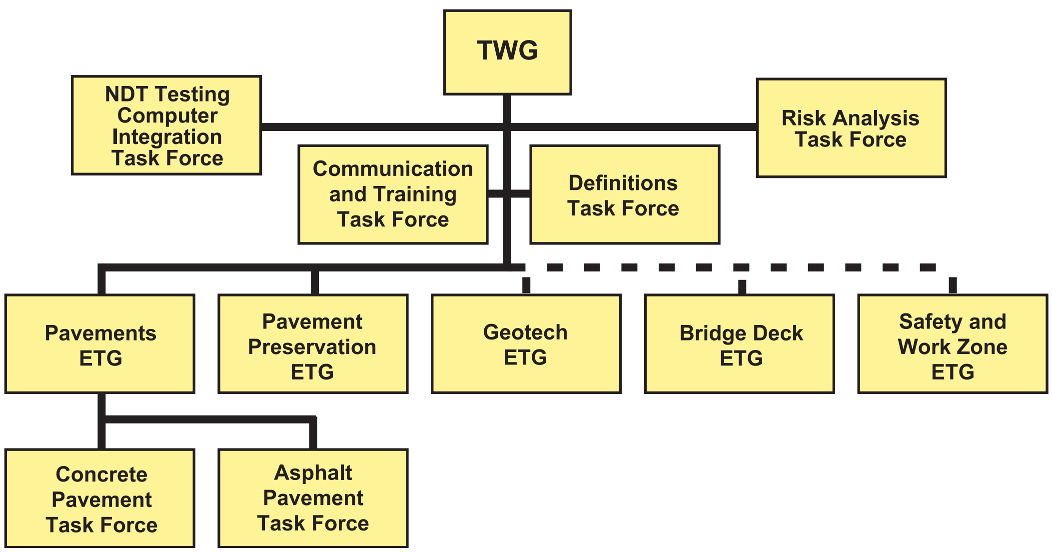
Task 4.5. Support the development of comprehensive technical research programs for each of the specific expert task group product areas.

Task 4.6. Identify groups, committees, and organizations with interest in performance specifications and promote cooperative efforts.

Chapter 4
Organization and Management

Management Structure

An organization or a movement? The Performance Specification Program is a combination of both elements. The program has established a Technical Working Group to establish and oversee the road map and its execution. Fundamental to the road map is the identification and formation of expert task groups that will do the bulk of the technical work specific to that discipline. In the diagram below, boxes connected with solid lines represent structure in place, while those with dotted lines are anticipated.



Working Group and Task Group Membership

The Technical Working Group will consist of representatives from FHWA, State DOTs, industry, and academia with background, expertise, and interest in promoting the performance specification concept. Each expert task group will have one representative on the Technical Working Group. Membership will be flexible. As emphasis on various goals and tasks changes, Technical Working Group membership will change appropriately. It is expected that the Technical Working Group will average 14 representatives.

Current members include five representatives from State DOTs, five from FHWA, four from the pavement industry, and one from academia. Among the DOT members are representatives from the AASHTO Subcommittees on Materials and Construction, and the Joint Task Force on Pavements. Included in the FHWA membership are representatives from the Offices of Pavement, Bridge Technology, Infrastructure, and Research and Development. Finally, members should represent disciplines with active expert task groups.

With disciplines such as geotechnology, safety, bridges, etc., it is expected that the membership will be adjusted to reflect the diversity of the mission and the particulars of each group.

The Technical Working Group will assemble task forces as required to help guide the program. A Definitions Task Force would build on work done by the Transportation Research Board Committee on Management of Quality Assurance, which manages the Glossary of Highway Quality Assurance Terms. The task force would review the definitions in the glossary and recommend updates to reflect PRS and warranty developments. A Communications and Training Task Force would develop a broad outreach program that covers the full spectrum of PS activities and work with the TCCC. A Non-Destructive Testing and Computer Integration Task Force would look at innovations in both of these areas and recommend ways to incorporate them into the various PS activities. Finally, a Risk Analysis Task Force would look at the transfer of roles and responsibilities between transportation agencies and contractors as a result of PS developments. Thi task force would organize risk management through a quantitative approach that includes a manual and guidelines.

Administrative Support

It is important for at least one organization to take responsibility for the overall program, but in the process allow for the many disciplines involved to participate and cooperate. The FHWA Office of Asset Management will serve as the program's administrative arm. In accepting this role, it will maintain the road map, prepare status reports, and support the activities of the Technical Working Group. The Office of Asset Management also will provide in-house and consultant services, as necessary, to support the effort.

Roles and Responsibilities

The Technical Working Group will guide the program and provide technical support and make recommendations to the FHWA, the states, and industry on how best to accomplish the goals and tasks presented in Chapter 3. The expert task groups will do the same within their specific program areas. The TWG will have the added responsibility of determining if performance principles, definitions, training, and outreach efforts initiated by the expert task groups are reasonably consistent and in harmony with the overall definition of the program. The TWG will also make final recommendations to FHWA and other stakeholders implementing PRS.

Timeline

How long will this performance specification development effort go on? In reality, it is a long-term process. The road map covers the next five years. Table 1 shows the major activities that will be integrated into the goals and tasks presented in Chapter 3. Table 2 outlines the significant accomplishments expected over the same time period.

It should be recognized that the entire program is based on volunteerism by the DOTs and industry and that dependencies abound. It is up to the major national organizations to support the key activities.

Table 1. Activities Timeline

Performance Specification Program
Major Activities

	Pre-2003	2003	2004	2005	2006	2007	2008
National and International Outreach Efforts	FL DOT PRS Workshop		National Workshop	International Performance Symposium		National Workshop	International Performance Symposium
TWG Meetings	2	2	2	2	2	2	2
ETG Meetings	2	4	6-10	6-10	6-10	6-10	6-10
National Research Initiatives			F-SHRP (anticipated)				
			FHWA (anticipated)				
	NCHRP AC						
Outreach Activities	PRS Database Newsletter, Articles, Flyers						
Construction Projects	Experimental and Demonstration Projects						
Specification Database	National Specification Database Performance Specification Section						

Table 2. Accomplishment Timeline

Performance Specification Program
Major Accomplishments by 2008

By the end of:	The program should:
2004	Establish a formal Technical Working Group management, structure, and financial support system within FHWA. Establish four to eight permanent technical expert task groups with strategic plans in operation. Implement a quarterly newsletter program. Complete and distribute a management brochure. Implement a fully operational performance specification database.
2005	Connect to a nationally funded research effort through FHWA's R&D and/or AASHTO's F-SHRP. Develop a detailed, comprehensive research plan for each expert task group. Develop and implement expert task group outreach plans. Draft performance specifications for select technical items in each expert task group area. Initiate experimental and demonstration projects.
2006	Conduct the first International Specification Symposium. Identify and evaluate risk methodology. Evaluate additional modeling, performance data, and construction relationships.
2007	Implement major research and deployment efforts.
2008	Complete draft performance specification book. Complete draft warranty manual. AASHTO Complete draft risk manual. Adoption
2009-2020	A viable contract option

Chapter 5
A Viable Contract Option

Time changes things. Resources change. Performance requirements for products change. And roles and responsibilities change. The Performance Specifications Strategic Road Map began by describing what all good specifications should address:

- What do we want?
- How do we order it?
- How do we measure what we ordered?
- How do we know we got what we ordered?
- What do we do if we don't get what we ordered?

The first bullet is the most critical. If that question is not answered clearly and succinctly, a specification writer may go down a technical path that could lead to a waste of time, effort, and resources.

Today, transportation agencies must evaluate the very nature of the procurement process for products and services and must describe what they want in a different way. The people have changed, the experience is lacking, and the need for innovation and creativity in the construction process must include contractors and suppliers. From design-build and best-value contracting to warranties, contract maintenance and beyond, highway agencies are looking for innovative ways to deliver highway products in partnership with contractors, suppliers, and designers.

Start with the fundamental question of "what do we want?" A stone? Asphalt and stone? A mixture of asphalt and stone? A pavement composed of mixture? Or a transportation platform that is quick to place, strong for heavy loads, comfortable to ride, aesthetically pleasing, quiet, safe, and durable for the next 20 years? The procurement journey starts here.

The communication mechanisms for construction are plans, estimates, and specifications. Connecting the design intent to the eventual performance of a product requires a clear description of the product desired. Once that is defined, the technology, science, and computer power can be unleashed. Then mix this with a whole lot of business savvy.

The overall vision of this plan is that performance specifications become viable contract options. The plan outlines the first five years of activities. Will all of the work be accomplished in that time? Of course not. But if the plan is successful, the highway industry will have the momentum to continue to make progress. A fully operational organizational structure will be in place. First-generation model specifications in select technology areas will be established. New and innovative test procedures will be designed. Some surprise products may even be ready to evaluate. We may even see evidence that innovation is occurring as desired. And the industry will be in a better position to determine if performance specifications are viable contract options.

The Performance Specifications Strategic Road Map ends the way it opened:

> *"To attain our goals of quality, improved product performance, and a better environment for contractor innovation, we cannot simply identify and test those construction and materials factors that best determine product performance.*
>
> *"We also must address roles, responsibilities, risks, and specification language, as well to determine how best to deliver that product.* ***Freedom to innovate with accountability to deliver*** *is the driving force behind the performance specification movement."*

Let the journey continue.

Appendix 1
Postscript

Since FHWA floated the idea of creating a Performance Specification Road Map, one national workshop, two Technical Working Group Meetings, two Expert Task Group meetings, and many hours of internal staff meetings have taken place. Following is a summary of accomplishments, decisions, etc., that led to the development of this Road Map.

National Workshop

In May 2000, under the sponsorship of FHWA and the Florida DOT, approximately 50 attendees from industry, academia, and transportation agencies met to discuss performance-related specifications. At this time, little research or implementation was occurring. Meeting attendees supported the continued research and implementation of PRS and the concept of a national organization to manage the process. The attendees identified PRS "rules" to help focus on key elements of a PRS structure.

The group also noted that many DOTs were expressing interest in warranties. Warranties were considered another option for addressing product performance and quality issues. Finally, the group raised awareness that the issue of method specifications should be discussed along with performance requirements.

Technical Working Group

Two Technical Working Group meetings were held, one in 2001 and another in 2002. The working group focused on establishing expert task groups and reviewing progress in both the concrete and asphalt PRS programs. The group recommended a management structure, and discussed the application of PRS to items such as bridge decks, traffic striping, geotechnology, pavement preservation, and traffic maintenance through work zones. The group recognized that each topic required a different approach to PRS and that the models/ life cycle cost analysis approach developed under the concrete pavement PRS may not apply to other products. The working group helped distinguish between warranties and PRS in further detail and strongly recommended tracking warranties along with PRS activities. The group also recommended developing a newsletter and brochure to advise senior management about the program. They cautioned that the "black box" concept of models was a difficult concept and that clear management tools were needed. The group also evaluated a matrix concept that showed different specification structures for method, end result, PRS, and warranty specifications. The group acknowledged that to really create an atmosphere for innovation, method specifications might have to be relaxed. All agreed that this has many potential downside risks.

The Technical Working Group also recommended that the expert task groups for asphalt and concrete pavements be combined into one group because the structures are similar, differing only in the specific distresses addressed.

Concrete Pavement Expert Task Group

When the Concrete Pavement Expert Task Group met in July 2002, it thoroughly reviewed the work done by FHWA and the Indiana DOT to develop and evaluate the PRS jointed-pavement specification. The PRS, known as PaveSpec 3.0, includes transverse cracking, transverse joint spalling, faulting, and smoothness as the performance drivers. The INDOT evaluation process has been well documented and includes some of the most insightful details yet compiled on a PRS specificion. The models/life cycle cost analysis approach was effective in helping INDOT and the contractors focus on the impact that material and construction characteristics may have on long-term quality.

The expert task group developed a detailed list of further research needed to continue to develop the PaveSpec 3.0 PRS. The more strategic recommendations include the following:

- Development of a continuously reinforced concrete pavement PRS.
- Development of a concrete overlay PRS and building of new design models developed for whitetopping and ultra-thin whitetopping.
- Conversion of the PaveSpec 3.0 models to the 2002 Design Guide models.
- Better display of the maintenance rehabilitation decision tree.
- Development of additional quality characteristics, including tie bars, dowel bar alignment, saw-cutting factors, durability (scaling, mix optimization issues), temperature gradient issues, and drainage. These elements need to be prioritized.
- More thorough examination of models limitations.
- Additional development of rapid, non-destructive testing procedures for construction control and measurement.
- Advanced LCCA model, including a more robust user cost module.
- Further development of a guide specification that addresses the relationship between PRS and method specification language. Included would be a thorough review of the specification matrix recommended for development by the Technical Working Group.
- Development of outreach efforts.

Asphalt Pavement Expert Task Group

The National Cooperative Highway Research Program is developing the asphalt pavement PRS under Project 9-22. In the 1990s, FHWA and AASHTO sponsored a series of research projects to develop a PRS for hot mix asphalt (HMA). In February 2000, the WesTrack project delivered an HMA PRS in the form of an alpha-tested version of a computer program that incorporated advanced performance-prediction models for HMA and a guide specification. The alpha version of the HMA PRS included two application levels. Level I was based on material and construction properties (e.g., asphalt content; gradation; field-mixed, laboratory-compacted volumetrics; in-place air voids; and ride quality) now obtained by public agencies for materials-and-method, end-result, and quality control/quality assurance types of specifications. Direct regression equations relating these properties to pavement performance (specifically, permanent deformation and fatigue cracking) exhibited in the WesTrack experiment were the primary basis for calculating pay factors in the Level I HMA PRS.

The Level II HMA PRS uses a more sophisticated, mechanistic-empirical analysis of the results of laboratory performance tests, as well as the WesTrack property-performance relationships, to determine pay factors. Regardless of whether the Level I or Level II performance model is used, the HMA PRS calculates pay factors by comparing the life cycle cost of the as-designed and as-built projects. This method is a significant improvement over current specifications, as the HMA PRS provides tools for objective calculation of equitable, consistent pay factors and mirrors the concrete pavement PRS specification.

The project included two phases. The first called for a comprehensive beta test program for the HMA PRS software and field trials. The second called for integrating the HMA performance models from the 2002 Pavement Design Guide into the HMA PRS software. The revised software package should be available in early 2004 for further field evaluation.

The Technical Working Group recommended that the asphalt PRS and the concrete PRS be managed together in one expert task group. The group should provide guidance on field evaluations, communication documents, and training, as well as work to keep the specification structures the same.

Pavement Preservation Expert Task Group

The Pavement Preservation Expert Task Group met in October 2002. It was the first time this subject had been discussed formally by a DOT-industry group. The group noted that the concrete and asphalt PRS specification structures were not really applicable to the typical pavement preservation structure. Little to no modeling research has been done in this area, hindering the ability to make predictions. In addition, many DOTs have skipped the PRS approach and jumped to material and workmanship warranties. The group recommended the following:

- Pavement preservation topics should be divided into smaller, more workable subject areas, such as microsurfacing, chip seals, surface treatments, fog seals, etc.
- End-result specifications should be developed for one topic, e.g. chip seals, that address using new test procedures and reducing method specification requirements.
- The matrix approach should be used to develop specification options.
- An incentive-based warranty guideline specification should be developed to determine if it would help create a better bidding environment and more innovation in the process.

Other Expert Task Groups

Plans are being developed to implement expert task groups for geotechnology work items and bridge components. This work should be addressed in late 2003.

FHWA also has plans to initiate a Work Zone Safety Expert Task Group. This work will probably lead to yet another variation of the performance specification theme: quality of services received.

Finally, other organizations are examining the use of functional specifications for maintenance contracts. These contracts could blend PRS, service performance, and even warranty specifications into one contract.

Other National Research and Planning Efforts

The PS topic has been addressed in many national research planning documents. The 2002 Construction Engineering and Management Research Program (NCHRP Web Document #51) supports a major initiative in performance-related specifications and rapid non-destructive testing programs. Research on incentives, warranties, performance specifications, and a risk manual have been proposed for inclusion in the plan for Research on Accelerating the Renewal of America's Highways (Renewal). Iowa State University, under a cooperative agreement with FHWA, is developing a detailed program to further advance PRS under the Long-Range Concrete Pavement Research Plan.

In addition, research continues to be conducted with the focus on performance of certain elements of the highway system. The Transportation Research Board Web site[1] outlines research on the following topics:

- NCHRP 453, Performance-Related Tests of Aggregates for Use in Unbound Base Pavement Layers
- NCHRP 1-19(2), Validation of Performance-Related Tests of Aggregates for Use in Hot-Mix Asphalt Pavements
- New England Transportation Consortium, Relating Hot Mix Asphalt Pavement Density to Performance
- Louisiana Transportation Research Center, Performance-Related Test for Asphalt Emulsion
- FHWA, Investigation of Aggregate Shape Effects on Hot Mix Performance using an Image Analysis Approach
- National Center for Asphalt Technology (NCAT), Accelerated Testing of Asphalt Pavements Test Road
- FHWA et al, Accelerated Performance-Related Test Facilities

The Technical Working Group—indeed, the entire transportation community—needs to understand and integrate the output of these and many other studies.

[6] http://www4.trb.org/trb/crp.nsf