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Technology Ready for Implementation

from the
AASHTO Research Advisory Committee

to the
AASHTO Technology Implementation Group

Study SD2002-00
Final Report

Prepared by
SD Department of Transportation
Office of Research
Pierre, SD

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16. Abstract

This report contains brief descriptions of technology that states feel ready for application in the transportation industry. The descriptions were provided by individual members of the American Association of State Highway & Transportation Officials (AASHTO) Research Advisory Committee in response to a request from the AASHTO Technology Implementation Group (TIG).

Each description follows the format prescribed by AASHTO Technology Implementation Group for its Innovative Technology Evaluation Process, which is used to select technologies that should receive TIG's particular implementation emphasis in the next year.

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California Automated Roadside Debris Vacuum

Stage I Preliminary Assessment

(check yes or no)	Yes	No
1. Does the innovation meet the definition of technology* as defined by the AASHTO Technology Implementation Group? (*Technology will include processes, products, techniques, procedures, and practices.)	Yes	
2. Does the technology offer opportunities for performance improvement?	Yes	
3. Is it potentially a high payoff technology (return on investment, widespread application)?	Yes	
4. Has a stakeholder successfully used this technology?	Yes	
If yes to all of the above, move to Stage II		

Stage II Questionnaire on Technology Selection Process

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A. Meeting Customer/Stakeholder Needs (35 points)

1. Describe the technology proposed for implementation.	The technology proposed for implementation is a remote controlled robotic vacuum arm that is to be integrated with a commercial vacuum truck system. The complete system is known as the Automated Roadway Debris VACuum (ARDVAC) System.
2. Describe how the technology meets or solves a problem of the customer or stakeholder.	To help make litter removal safer and five times more efficient, the Advanced Highway Maintenance and Construction Technology (AHMCT) Research Center has produced ARDVAC. It integrates an easily controlled, dexterous attachment with a commercial vacuum system. It is designed to be an add-on feature for existing, commercially available sewer and ditch cleaning trucks. Implementing the ARDVAC system into a maintenance operation will allow for more regular collections of litter and greatly reduce the hazardous manual labor involved in this task.
3. Describe the intended user group(s) of the proposed technology.	The main customer for this technology is the California Department of Transportation, Division of Maintenance but it is available to all DOTs, Cities and Counties of the nation.
4. Describe the principal beneficiaries if different from the user groups.	
5. Describe the significance of the need or problem.	Roadway litter removal is labor intensive, dangerous to workers, and costs the nation over half a billion dollars a year. Highway workers are exposed to fast moving traffic while removing debris This is a manual labor-intensive operation, which results in high level of injuries and work compensation costs. Statistics indicate that from 1990 to 1997 Caltrans incurred over three million dollars in Work Compensation alone due to injuries related to the retrieval of debris along highways.

B. Effectiveness/Impact Analysis (30 points)

1. Provide a brief synopsis of development history and results of relevant testing.	This project was initiated by the AHMCT Research Center, at the request of its main customer, California DOT Maintenance Division. In order to speed up the commercialization of the project a private sector partner (Clean Earth Environmental Group) joined the project. The prototype was completed in a one-year period and during the second year it became commercially available.
2. Identify the effectiveness of the technology and its impact beyond the intended customer/stakeholder.	The technology's effectiveness and impact to California Transportation is evident with Caltrans Division of Maintenance wanting to acquire several ARDVAC units for deployment throughout California and with the project being the recipient of the 2002 California Transportation Foundation Tranny Award for the Highway Management category
3. Evaluate the direct impacts, secondary impacts, any limiting factors, and associated risks.	The direct impact of the ARDVAC technology is the noise generated by the machine However, the impact is miniscule compared to the benefits of the ARDVAC, such as improved safety of roadside maintenance workers and efficiency of operation.
4. Identify the breadth of the applications and dimensions of the potential market.	The breadth of the applications are safe and efficient mechanical ways of collecting light debris along roadways, especially in difficult to reach areas that traditionally requires manual labor The users (roadside maintenance workers) and industry (the provider as well) are involved with the focus of the applications The marketability of the product has the potential of extending well beyond California and being available on an international basis.

C. Implementation (20 points)

1. Describe the state of the technology: • Extent of use • Availability of standards and specifications • Scope of experience • Availability of experienced practitioners	Clean Earth Environmental Group has completed the commercialization process and is ready to sell ARDVAC.
2. Is the technology proprietary or patented?	The State of California and the Federal Government have the right to produce and purchase this technology for non-commercial use. Clean Earth Environmental Group acquired the patent rights from University of California, Davis.
3. Suggest pathways or techniques for implementation.	The pathway to implementation was chosen early on by developing ARDVAC in partnership with a private company.
4. What is required to implement this technology? • Training • Equipment • Funding • Permits • Expert assistance • Partners	The implementation is simple if funding is available to purchase a vacuum vehicle. The training is simple; it involves a single operator and the use of a joystick to manipulate the articulated nozzle.

5. How long would it take to implement the technology?	The technology is ready and set to go.
6. Are you willing to aid in the promotion of this technology? Are there others? Please identify.	The California DOT will be willing to promote the technology, the AHMCT Research Center is available to demonstrate the next generation and the private sector partner, Clean Earth Environmental Group, can sell you one.
7. Are you aware of any legal, environmental, or social implications associated with this technology? If so, please describe them: • Change in law or regulation • Hazardous materials • Potential to impact the environment	No

D. Costs (15 points)

1. What costs are associated with the implementation of the technology and who bears them? • To the implementing agency • Startup costs to the user • The industry	FHWA, the State of California and Clean Earth Environmental Group paid the research of the technology. Clean Earth Environmental Group incurred the cost of commercialization. The State of California will purchase the few first units, which are more expensive than when large numbers are sold.
2. Are there maintenance and operations costs associated with this technology once implemented? Please identify.	Yes, there will be maintenance costs associated with ARDVAC. The addition of an articulated nozzle to an existing vacuum truck will add to the standard operating cost of the vacuum truck
3. Are there other costs associated with the implementation of this technology? Please identify. • Environmental costs • Social costs	No

Florida Drilled Shaft Grouting in Sand

Stage I Preliminary Assessment

(check yes or no)	Yes	No
1. Does the innovation meet the definition of technology* as defined by the AASHTO Technology Implementation Group? (*Technology will include processes, products, techniques, procedures, and practices.)	♦	
2. Does the technology offer opportunities for performance improvement?	♦	
3. Is it potentially a high payoff technology (return on investment, widespread application)?	♦	
4. Has a stakeholder successfully used this technology?	♦	
If yes to all of the above, move to Stage II		

Stage II Questionnaire on Technology Selection Process

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A. Meeting Customer/Stakeholder Needs (35 points)

1. Describe the technology proposed for implementation.	Title: Pressure grouting the tips of drilled shafts constructed in sand. General: This is a method of improving the end bearing capacity of drilled shafts constructed in sandy soils The methodology incorporates both a design procedure as well as construction guidelines.
2. Describe how the technology meets or solves a problem of the customer or stakeholder.	When deep foundations are constructed in sandy soils in urban areas two issues arise: (1) vibrations and noise from driven piles are not well tolerated, or (2) drilled shafts are costly as they require deep excavations in order to develop enough side shear capacity In such conditions, the end bearing is typically discounted due to the excessively large displacements required to mobilize a reasonable capacity. Post grouting the tip provides the capacity at reduced depths.
3. Describe the intended user group(s) of the proposed technology.	Any heavily loaded foundation that is typically supported by deep foundations could use this method Local, State, Federal, and private projects requiring large capacity foundations can benefit from this methodology.
4. Describe the principal beneficiaries if different from the user groups.	Aside from aiding the budgetary constraints of transportation departments, the end user (public taxpayers) are an obvious beneficiary.
5. Describe the significance of the need or problem.	The cost of foundations constructed near sensitive historic structures, medical institutions (e.g. laser eye surgical centers), or congested urban neighborhoods can be significantly increased due to restricted construction work hours or by requiring more costly drilled shafts that develop virtually all of the capacity from side shear.

B. Effectiveness/Impact Analysis (30 points)

1. Provide a brief synopsis of development history and results of relevant testing.	A multi-year USF research program funded by the FDOT has reviewed the world-wide use of tip grouting, evaluated the effectiveness of its use through full-scale load test programs, and developed a rational design method Subsequently, two bridge projects have adopted its use via a thorough Value Engineering Analysis.
2. Identify the effectiveness of the technology and its impact beyond the intended customer/stakeholder.	Aside from providing shorter, less expensive, faster to construct foundations, and a means to mitigate sensitive construction issues, this method provides a performance evaluation of each and every drilled shaft on the basis of the foundation response during the post grouting process.
3. Evaluate the direct impacts, secondary impacts, any limiting factors, and associated risks.	The direct impact of this method is measured by the reduction in foundation cost Although the shaft construction is identical to present methods, an additional step is required for the grouting The grouting does not impede construction as it is performed while subsequent shafts are constructed The quality assurance (risk management) is maintained by monitoring the response of the shafts during grouting, which has shown to be a relatively reliable load test.
4. Identify the breadth of the applications and dimensions of the potential market.	This technology can be used by all forms of construction requiring high capacity foundations It is particularly advantageous in areas where driven piles are problematic (i.e. urban sites, sensitive areas, or where dense surface soils underlain by loose soils).

C. Implementation (20 points)

1. Describe the state of the technology: • Extent of use • Availability of standards and specifications • Scope of experience • Availability of experienced practitioners	This method has been used world-wide for over 30 years for various reasons; however, no design approach has ever been published prior to this study Use in the U.S. has been minimal prior to this study As a result of this study, however, a design and construction specification has been drafted and is presently in use Again, world-wide experience is well-documented; although little in the U.S Many of the international construction firms operated in the U.S. have overseas experience (e.g. Bauer or Keller).
2. Is the technology proprietary or patented?	Although many of the international firms have their proprietary grouting methods, the concept is not limited to those methods and is presently being used in the U.S. without proprietary or patent infringements The results from the
3. Suggest pathways or techniques for implementation.	To further strengthen the design method, projects should be identified in a variety of geographical localities where the method is viable (both economically as well as practically). At such sites, conduct design phase test programs of both grouted and un-grouted shafts to verify the anticipated performance improvement and extend the limits of the present U.S. experiences and database.
4. What is required to implement this technology? • Training • Equipment • Funding • Permits • Expert assistance • Partners	In each of the geographic regions deemed appropriate for this method (regions with a preponderance of cohesionless bearing strata), presentations should be given to train local authorities on the design approach and construction techniques Therein, on-site grouting demonstrations can be conducted with emphasis on routine data collection, inspection, and quality assurance mechanisms Expert assistance can therein be provided as necessary.

5. How long would it take to implement the technology?	The design seminars can be conducted in a relatively short time frame, but the timeframe for on-site training/demonstrations will be dictated by local construction availability or can be obtained at a specified training site (e.g. UCF/FDOT Deep Foundations Test Site in Orlando, Florida).
6. Are you willing to aid in the promotion of this technology? Are there others? Please identify.	Both the University of South Florida and the Florida Department of Transportation are willing to provide qualified personnel for the promotion of this technology.
7. Are you aware of any legal, environmental, or social implications associated with this technology? If so, please describe them: • Change in law or regulation • Hazardous materials • Potential to impact the environment	No adverse legal, environmental, or social implications are associated with this technology.

D. Costs (15 points)

1. What costs are associated with the implementation of the technology and who bears them? • To the implementing agency • Startup costs to the user • The industry	Costs associated with the implementation of this technology would include (1) initial training and related expenses, and (2) load tests that would need to be conducted Current FDOT practice is to conduct two statnamic load tests *per project*: one prior to post grouting and one afterwards Choice of load testing methods (static or statnamic) would be at the discretion of the implementing agency Further, as the agency becomes more confident in the process, the use of load testing could be eliminated Industry partners should experience reduced costs: for example, smaller drill rigs could be used as a result of drilling shorter shafts.
2. Are there maintenance and operations costs associated with this technology once implemented? Please identify.	No.
3. Are there other costs associated with the implementation of this technology? Please identify. • Environmental costs • Social costs	No Environmental and social costs should be reduced For example, shorter drilled shafts would result in less drill material used and less drill mud excavated Shorter shafts would also result in less noise and less vibration produced during the construction process.

Illinois Interlayer Stress-Absorbing Composite

Stage I Preliminary Assessment

(check yes or no)	Yes	No
1. Does the innovation meet the definition of technology* as defined by the AASHTO Technology Implementation Group? (*Technology will include processes, products, techniques, procedures, and practices.)	X	
2. Does the technology offer opportunities for performance improvement?	X	
3. Is it potentially a high payoff technology (return on investment, widespread application)?	X	
4. Has a stakeholder successfully used this technology?	X	
If yes to all of the above, move to Stage II		

Stage II Questionnaire on Technology Selection Process

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A. Meeting Customer/Stakeholder Needs (35 points)

1. Describe the technology proposed for implementation.	Prevention of reflective cracking through asphalt overlays by use of Interlayer Stress-Absorbing Composite (ISAC) technology
2. Describe how the technology meets or solves a problem of the customer or stakeholder.	The common use of 2- to 3-inch thick AC overlays are susceptible to reflection cracking from cracks and joint in the underlying pavement Once on cracking reaches the surface of the pavement, water can enter the system and cause deterioration and eventually create potholes
3. Describe the intended user group(s) of the proposed technology.	Owners of highway pavements, airport pavements, parking lots, bridge decks and even recreation facilities such as outdoor tennis and basketball courts.
4. Describe the principal beneficiaries if different from the user groups.	
5. Describe the significance of the need or problem.	Reflective cracking through AC overlays often shortens the life of an otherwise sound overlay requiring major rehabilitation If the life of the overlay can be extended, fewer road repairs will be required, thus less traffic disruption and lower cost to the owner.

B. Effectiveness/Impact Analysis (30 points)

1. Provide a brief synopsis of development history and results of relevant testing.	Started in 1992 as a cooperative research study between the Illinois DOT and University of Illinois at Urbana Champaign to develop a system to mitigate reflective cracking Laboratory testing was used to help develop the needed properties of the composite layer Field testing on highway and airport pavement of the finished product indicate a substantial reduction or elimination of reflective cracking compared to an untreated sections.

2. Identify the effectiveness of the technology and its impact beyond the intended customer/stakeholder.	Limited field test data from 6 sites indicates that reflective cracking can be reduced 90% or eliminated in the first 2 years of application and still reduces cracking 75% after 6 years The technology is relatively easy to incorporate into the existing overlay process on any project The product can extend the overall life of AC overlays on any type of facility.
3. Evaluate the direct impacts, secondary impacts, any limiting factors, and associated risks.	The only limiting factor at this time for ISAC is its cost This is currently being addressed by the University of Illinois by a licensing effort to get more manufactures interested in the production of the materials and marketing.
4. Identify the breadth of the applications and dimensions of the potential market.	Approximately 1/4 of the each highway dollar is spent on overlays There is an extensive market and potential use of the material if price is appropriate.

C. Implementation (20 points)

1. Describe the state of the technology: • Extent of use • Availability of standards and specifications • Scope of experience • Availability of experienced practitioners	The ISAC technology has been fully developed, been field tested on six pavements in Illinois The University of Illinois is currently offering license opportunities to commercial companies A paper on ISAC and experiences with it was presented at the 2002 Annual TRB meeting dating from development and field trials since 1994 The material uses “roll-out” technology similar to other fabrics so there is a broad base of experience in the application of the material.
2. Is the technology proprietary or patented?	Patented – however, rights are within guidelines of Federally funded intellectual property discoveries and usage.
3. Suggest pathways or techniques for implementation.	Current efforts are to license venders to market the material
4. What is required to implement this technology? • Training • Equipment • Funding • Permits • Expert assistance • Partners	Partnering and marketing of the ISAC material.
5. How long would it take to implement the technology?	Currently available in limited supplies Increased supplies in 6 to 8 months.
6. Are you willing to aid in the promotion of this technology? Are there others? Please identify.	The University of Illinois has an effort - see link for more information. http://www.otm.uiuc.edu/technology/isac.htm

7. Are you aware of any legal, environmental, or social implications associated with this technology? If so, please describe them: • Change in law or regulation • Hazardous materials • Potential to impact the environment	none

D. Costs (15 points)

1. What costs are associated with the implementation of the technology and who bears them? • To the implementing agency • Startup costs to the user • The industry	Cost to be born by University and vender.
2. Are there maintenance and operations costs associated with this technology once implemented? Please identify.	No
3. Are there other costs associated with the implementation of this technology? Please identify. • Environmental costs • Social costs	No

Kansas Air Void Analyzer

Stage I Preliminary Assessment

(check yes or no)	Yes	No
1. Does the innovation meet the definition of technology* as defined by the AASHTO Technology Implementation Group? (*Technology will include processes, products, techniques, procedures, and practices.)	X	
2. Does the technology offer opportunities for performance improvement?	X	
3. Is it potentially a high payoff technology (return on investment, widespread application)?	X	
4. Has a stakeholder successfully used this technology?	X	
If yes to all of the above, move to Stage II		

Stage II Questionnaire on Technology Selection Process

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A. Meeting Customer/Stakeholder Needs (35 points)

1. Describe the technology proposed for implementation.	Use of the Air Void Analyzer to determine the spacing factor of entrained air voids in portland cement concrete (especially in pavements) in real time.
2. Describe how the technology meets or solves a problem of the customer or stakeholder.	We had experienced premature failure of the paste along the longitudinal joints of our PCCP The air-void spacing factor was found to be inadequate for these prescriptive mixtures Current QC/QA mixtures have better spacing factors but some still require more water reducer for better mixing.
3. Describe the intended user group(s) of the proposed technology.	State DOTs, federal agencies that administer construction contracts, cities, and counties.
4. Describe the principal beneficiaries if different from the user groups.	The users of the roadways, bridges, and airports would benefit from longer lasting construction.
5. Describe the significance of the need or problem.	States in the wet freeze-thaw area of the country that are experiencing freeze-thaw damage to the paste have a need to determine the air-void spacing factor of concrete and make adjustments as soon as possible.

B. Effectiveness/Impact Analysis (30 points)

1. Provide a brief synopsis of development history and results of relevant testing.	Air-void spacing factors in concrete are checked before (in trial mixtures) and during the project Inadequate spacing factors are addressed by adjusting the type and dosage of both the air entraining agent and the water reducer.
2. Identify the effectiveness of the technology and its impact beyond the intended customer/stakeholder.	This technology allows the agencies to have concrete that is durable (does not deteriorate) in the freeze-thaw environment The public benefits through reduced cost and reduced user delays.

3. Evaluate the direct impacts, secondary impacts, any limiting factors, and associated risks.	Concrete will be very long lasting, precluding the need for premature reconstruction No risks come from using this technology Its use eliminates risk.
4. Identify the breadth of the applications and dimensions of the potential market.	Any construction experiencing freeze-thaw damage to the paste is an indicator of a problem Potential problems may exist in all areas that experience freeze-thaw cycles.

C. Implementation (20 points)

1. Describe the state of the technology: • Extent of use • Availability of standards and specifications • Scope of experience • Availability of experienced practitioners	Currently used only by Kansas on an on-going basis All necessary standards and specifications are available Extensive testing has been done by the Kansas DOT and the FHWA Concrete Mobile laboratory Training of competent technicians is easily accomplished.
2. Is the technology proprietary or patented?	The Air Void Analyzer is a patented device.
3. Suggest pathways or techniques for implementation.	Advertising and promotion of the technology.
4. What is required to implement this technology? • Training • Equipment • Funding • Permits • Expert assistance • Partners	Training, equipment and funding will allow implementation of this technology.
5. How long would it take to implement the technology?	Two weeks.
6. Are you willing to aid in the promotion of this technology? Are there others? Please identify.	Yes The distributor of the equipment also provides training A power point presentation and a video are available.
7. Are you aware of any legal, environmental, or social implications associated with this technology? If so, please describe them: • Change in law or regulation • Hazardous materials • Potential to impact the environment	Positive environmental and social impact, due to longer life of portland cement concrete pavements.

D. Costs (15 points)

1. What costs are associated with the implementation of the technology and who bears them? • To the implementing agency • Startup costs to the user • The industry	Equipment and training $20,000 borne directly by the entity doing the testing (government or industry) Some additional costs may occur for adjustment of mixture parameters.
2. Are there maintenance and operations costs associated with this technology once implemented? Please identify.	Ongoing testing requires technician time and consumable supplies of about $15/test.
3. Are there other costs associated with the implementation of this technology? Please identify. • Environmental costs • Social costs	None, just benefits.

Kansas Fiber Reinforced Polymer Bridges

Stage I Preliminary Assessment

(check yes or no)	Yes	No
1. Does the innovation meet the definition of technology* as defined by the AASHTO Technology Implementation Group? (*Technology will include processes, products, techniques, procedures, and practices.)	x	
2. Does the technology offer opportunities for performance improvement?	x	
3. Is it potentially a high payoff technology (return on investment, widespread application)?	x	
4. Has a stakeholder successfully used this technology?	x	
If yes to all of the above, move to Stage II		

Stage II Questionnaire on Technology Selection Process

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A. Meeting Customer/Stakeholder Needs (35 points)

1. Describe the technology proposed for implementation.	Fiber Reinforced Polymer (FRP) or composite materials are used in lieu of portland cement concrete with steel reinforcement for bridge decks and in some case other superstructure components FRP materials specifically formulated for this application are not subject to corrosion or other environmental damage and are estimated to have a design life of 100 years Typical bridge deck sections weigh about 25% of a typical concrete deck.
2. Describe how the technology meets or solves a problem of the customer or stakeholder.	FRP bridges will save costs on a lifecycle basis (and on a first cost basis in certain special situations), extend the time between bridge closures for maintenance and the time out of service for construction FRP bridges are fabricated offsite and delivered to the construction site. Installation time on deck replacements is measured in days and accomplished with light duty equipment In special cases, where the substructure is sound but carrying a narrow and/or lightweight concrete deck, first costs are less because the existing substructure can be reused with a new FRP deck designed to current width and load capacity requirements.
3. Describe the intended user group(s) of the proposed technology.	The intended user groups are the local, state, and federal agencies responsible for bridge construction and maintenance, design consultants and contractors who adopt the technology
4. Describe the principal beneficiaries if different from the user groups.	Additional direct beneficiaries would be all highway users, materials suppliers of fiberglass and resin and taxpayers The indirect beneficiaries would be all consumers of products hauled over the structures.
5. Describe the significance of the need or problem.	Structures on our roadway system account for a considerable capital investment and annual expenditures on maintenance, construction and reconstruction Any new design/material system that reduces installation time, first or lifecycle costs and/or extends maintenance cycles will yield considerable savings to the public both in reduced users costs and convenience In special cases where the existing substructure is in satisfactory condition, installation and user cost savings for a FRP bridge deck replacement can be considerable.

B. Effectiveness/Impact Analysis (30 points)

1. Provide a brief synopsis of development history and results of relevant testing.	The first FRP bridge constructed on a public roadway was constructed in Russell County, Kansas during 1997 Since then two bridge decks on K-126 in Crawford County, Kansas were designed and installed in 1999 Over $1, 000,000 for research and development has been contracted to date by KSDOT to test, design, evaluate and refine the honeycomb system in use. Evaluations made to date show the decks constructed have met and usually exceed expectations Crash testing of the bridge rail connection design will be accomplished yet this spring A research project is currently underway to design and construct a temporary reusable bridge for use on detours. Six other states (KS, OH, CA, NY, WV, MO, IA) that are known to have constructed FRP bridges on public roadways likely have similar research, development and evaluation efforts underway.
2. Identify the effectiveness of the technology and its impact beyond the intended customer/stakeholder.	The technology was adapted to use by the highway industry and actual field installations made in a period of about 3 years With a crash-tested bridge rail connection, the designs will be adaptable to more applications If costs can be reduced through larger volumes of use and resultant automation, then markets for more routine structural elements used by government and industry may also evolve.
3. Evaluate the direct impacts, secondary impacts, any limiting factors, and associated risks.	Impacts to the environment will be minimal for the foreseeable future because potential use until the market matures will be limited to those installations that save on initial costs and special applications where extra expenditures are justified for time savings If large numbers of traditional structures are constructed with FRP, the cement, steel and aggregate industries will be minimally effected Traditional bridge contractors and designers not willing to adapt to the new technology could be impacted Limiting factors are the ability to codify standards and provide training to practitioners who will design, construct and maintain FRP bridges Risks associated with using the technology are thought to be minimal if competent trained people are involved Social benefits will accrue from actual construction/maintenance cost savings and reduced user costs due to less construction time and maintenance activity.
4. Identify the breadth of the applications and dimensions of the potential market.	FRP materials can potentially be used to build nearly any structure but realistically, applications will be limited in the near future to those that save on first costs and/or construction time in critical locations. These locations will be those where the existing substructure can be reused with a new bridge deck or shorter structures with abutments in good condition.

C. Implementation (20 points)

1. Describe the state of the technology: • Extent of use • Availability of standards and specifications • Scope of experience • Availability of experienced practitioners	Seven states (KS, OH, CA, NY, WV, MO, IA) are known to have constructed a FRP bridge(s) on public roadways during the 6 years the technology has been under study by state government transportation agencies The technology has been used in other outside applications (such as water tank roofs, docks, corrugated roofing, airplanes, and boats) for over 30 years. Experienced practitioners for highway structures are generally limited to those in the states listed, manufacturers, faculty who specialize in the topic area and a few design consultants Ohio has the most active construction program with a goal to build 100 bridges Materials standards and design standards are available and used by other industries To date, AASHTO standards and specifications specific to use by the transportation industry have not been adopted Plans and specifications for bridges constructed to data should be available.
2. Is the technology proprietary or patented?	Specific section designs developed by private sector companies are proprietary. New methodologies and methods could be developed using the basic materials by those with the expertise needed to do so.

3. Suggest pathways or techniques for implementation.	Building on the current interest group(s), create a TWG (or lead states team) with associated technical committees that integrates as many active committees and groups as possible Committees should include industry and academia representatives. For implementation to be most effective, all stakeholders need to be integrated into one two or three-tier committee structure.
4. What is required to implement this technology? • Training • Equipment • Funding • Permits • Expert assistance • Partners	For a state to implement, a core group of research, design, materials, construction and maintenance staff will need to be trained For widespread training, training courses will need to be developed If existing suppliers are used, then minimal, if any, new fabrication equipment is required. Contractors currently have the equipment needed for field installation Ideally, a state would use an experienced design consultant and manufacturer for the initial installation.
5. How long would it take to implement the technology?	Implementation on a limited basis has occurred in 7 states during the last 6 years Implementation for specialty applications should be possible in the remaining states over the next 5 years Full implementation (all structures) is probably not practical in the foreseeable future.
6. Are you willing to aid in the promotion of this technology? Are there others? Please identify.	Yes. Yes The FHWA, AASHTO SOM and SOB&S, industry associations, current manufacturers, existing regional users groups and possibly states that have built FRP bridges are others that are very likely to aid with promotion.
7. Are you aware of any legal, environmental, or social implications associated with this technology? If so, please describe them: • Change in law or regulation • Hazardous materials • Potential to impact the environment	No.

D. Costs (15 points)

1. What costs are associated with the implementation of the technology and who bears them? • To the implementing agency • Startup costs to the user • The industry	Costs are primarily for training of DOT staff, consultants and contractors Each group will bear the costs of the training and associated travel Development of training course(s) could be borne by the FHWA (NHI) A Transportation Pooled Fund project using 100% SPR funds could also be initiated by interested states (or a set fee allocated to all states) to develop training and demonstration packages and pay for travel costs TRB or the FHWA should be the lead agency on the project since it is national in scope and would hopefully involve a large percentage of states The DOT Research Section would make annual evaluations of initial installations for a number of years and make the associated reports Costs estimated at $2,000 per structure annually (after year of construction) would be eligible for Federal SPR reimbursement. Once the initial training was completed and experience gained most practitioners should be able to maintain technical expertise by reading technical manuals and literature, participating on the national users group, and technical meetings Cost is estimated at $2,000 per year per affected staff person mainly for travel and registration expenses. Major refinements in the technology might require attending additional NHI or similar training courses Course costs at a central location and staff travel is estimated at $10,000 per NHI course provided.
2. Are there maintenance and operations costs associated with this technology once implemented? Please identify.	Maintenance costs of these structures should be much less than conventional structures but key replacement components would still need to be stocked for damage repairs if needed Training Maintenance Bridge Crews to make field repairs would be a first time cost to agencies.
3. Are there other costs associated with the implementation of this technology? Please identify. • Environmental costs • Social costs	No Environmental and social costs should be less.

Maine Full Depth Reclamation

Stage I Preliminary Assessment

(check yes or no)	Yes	No
1. Does the innovation meet the definition of technology* as defined by the AASHTO Technology Implementation Group? (*Technology will include processes, products, techniques, procedures, and practices.)	X	
2. Does the technology offer opportunities for performance improvement?	X	
3. Is it potentially a high payoff technology (return on investment, widespread application)?	X	
4. Has a stakeholder successfully used this technology?	X	
If yes to all of the above, move to Stage II		

Stage II Questionnaire on Technology Selection Process

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A. Meeting Customer/Stakeholder Needs (35 points)

1. Describe the technology proposed for implementation.	A rational and practical mix design system for full depth reclamation.
2. Describe how the technology meets or solves a problem of the customer or stakeholder.	Full depth reclamation (FDR) is a cost effective, in-place recycling technique being used by many transportation agencies for roadway rehabilitation. This technique is made even more cost effective by use of stabilizing additives such as emulsion, cement, foamed asphalt. However there is no accepted mix design procedure for selection of the amount of additive which hinders the full usage and cost effectiveness of FDR.
3. Describe the intended user group(s) of the proposed technology.	Transportation agencies such as state, county and municipal DOT's.
4. Describe the principal beneficiaries if different from the user groups.	More economical treatments for our highways result in savings to the public.
5. Describe the significance of the need or problem.	Development and implementation of a rational and practical mix design procedure will optimize the FDR treatment. Many agencies will be able to implement this immediately as the procedure uses standard hot mix asphalt laboratory equipment.

B. Effectiveness/Impact Analysis (30 points)

1. Provide a brief synopsis of development history and results of relevant testing.	The mix design procedure was developed in partnership with Worcester Polytechnic Institute and the University of New Hampshire Recycled Materials Resource Center. Extensive laboratory testing and numerous test sections were constructed and evaluated on an actual FDR project along Rt. 201 in Caratunk, ME. The mix design procedure was refined as a result of expert task group input, analysis of test sections and further lab testing on samples from other states DOT FDR projects.

2. Identify the effectiveness of the technology and its impact beyond the intended customer/stakeholder.	The mix design procedure identifies the optimum additive amount for FDR mixes. In the case of Caratunk, it was found that our typical emulsion amount was below the optimum. A test section with the optimum emulsion amount was constructed and is being evaluated for performance. Additional lab testing indicated improved performance when emulsion and cement is added. A test sections for this was constructed as well.
3. Evaluate the direct impacts, secondary impacts, any limiting factors, and associated risks.	The mix design procedure can be used effectively to determine the most economical additive and amount for a given FDR project material. In the past FDR projects in Maine were treated with a standard emulsion amount. However, as the FDR material varies from project to project, a mix design procedure that can select the proper additive and amount is critical.
4. Identify the breadth of the applications and dimensions of the potential market.	Full depth reclamation is used by many state and local transportation agencies across the nation. The developed mix design system could potentially be implemented immediately by any agency that already has a Superpave Gyratory Compactor.

C. Implementation (20 points)

1. Describe the state of the technology: • Extent of use • Availability of standards and specifications • Scope of experience • Availability of experienced practitioners	The mix design system has been developed and refined at the Worcester Polytechnic Institute materials laboratory. Experienced laboratory technicians should be able to complete the procedure easily as it uses standard hot mix asphalt lab procedures with the exception of an inexpensive device used for sealing compacted specimens for determining bulk density.
2. Is the technology proprietary or patented?	No
3. Suggest pathways or techniques for implementation.	Development of AASHTO Guidelines through the Subcommittee on Materials.
4. What is required to implement this technology? • Training • Equipment • Funding • Permits • Expert assistance • Partners	The final report (not completed yet) will include step by step procedures. A sealing device is required for compacted samples in determining bulk density. For experienced hot mix asphalt lab personnel and those labs with a Superpave Gyratory Compactor no formal training is needed.
5. How long would it take to implement the technology?	Could be implemented immediately.
6. Are you willing to aid in the promotion of this technology? Are there others? Please identify.	Yes, Also Rajib Mallick of WPI.

7. Are you aware of any legal, environmental, or social implications associated with this technology? If so, please describe them: • Change in law or regulation • Hazardous materials • Potential to impact the environment	No

D. Costs (15 points)

1. What costs are associated with the implementation of the technology and who bears them? • To the implementing agency • Startup costs to the user • The industry	The only cost would be for the sample sealing device mentioned above which meets ASTM D6752-01 InstroTek, Inc. of NC is the only company with this technology, the Corelok device. The unit costs approximately $5,000. Corelok is also distributed by PINE instrument and Phil Palilla, QC Resources of CT.
2. Are there maintenance and operations costs associated with this technology once implemented? Please identify.	No
3. Are there other costs associated with the implementation of this technology? Please identify. • Environmental costs • Social costs	No

Missouri Work Zone Strategies

Stage I Preliminary Assessment

(check yes or no)	Yes	No
1. Does the innovation meet the definition of technology* as defined by the AASHTO Technology Implementation Group? (*Technology will include processes, products, techniques, procedures, and practices.)	X	
2. Does the technology offer opportunities for performance improvement?	X	
3. Is it potentially a high payoff technology (return on investment, widespread application)?	X	
4. Has a stakeholder successfully used this technology?	X	
If yes to all of the above, move to Stage II		

Stage II Questionnaire on Technology Selection Process

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A. Meeting Customer/Stakeholder Needs (35 points)

1. Describe the technology proposed for implementation.	Reducing Motorist Delays in Work Zones – Operational and Organizational Strategies to minimize road user delay in work zones. The project results focus on increasing road user convenience for the public, increasing work zone safety for the motorist and worker, and increasing the level of communication to the public about upcoming projects and alternate routes MoDOT has developed guidelines and processes in order to shift work to night, off-peak hours and weekend-only work when possible, and set appropriate speed limits in work zones MoDOT new processes are designed to speed up project completion by reducing the number of days for lane closures, providing additional incentive and disincentives for contractors, and setting the appropriate and continuous number of working days MoDOT organizational changes are designed to manage work zones with district and a statewide work coordination system, to review maintenance and commercial utility/permit work activities, and make changes to the project letting process to improve safety and convenience in work zones.
2. Describe how the technology meets or solves a problem of the customer or stakeholder.	The technology will decrease road user delays, frustration and confusion in work zones Work zones have been identified as a major concern for the traveling public. By identifying and then avoiding work during peak traffic volume times, providing greater communication with the public, and managing our work more, the traveling public should encounter reduced delays resulting from work zones.
3. Describe the intended user group(s) of the proposed technology.	The technology will be used by internal operations, project development and public information and outreach within the DOT. Our industry partners will also be a major part of this implementation The traveling public is the beneficiary of this technology.
4. Describe the principal beneficiaries if different from the user groups.	Primary beneficiaries include the traveling publics that are frustrated by delays resulting from work zones. Societal and economic benefits can also be expected through reduced road user charges related to delays.

5. Describe the significance of the need or problem.	This year MoDOT will have more than 700 active construction projects throughout the state Additionally, in national and statewide customer satisfaction surveys, work zones are identified as one of the top concerns for the traveling public. The public has very little tolerance for delays, especially work zone delays.

B. Effectiveness/Impact Analysis (30 points)

1. Provide a brief synopsis of development history and results of relevant testing.	Two work zone teams were formed to review national work zone best practices, develop strategies for Missouri, and provide for implementation of selected strategies throughout the department and with our construction partners Participation and cooperation throughout the organization and with our construction partners was achieved in order to make the organizational and operational changes to effectively reduce work zone delays while increasing safety. MoDOT Work Zone guidelines were developed; champions from all working units were selected to ensure buy-in and implementation. The organizational and operational strategies were promoted at all meetings and within working units Information concerning the changes was promoted through internal publications and through the media to inform the public. The MoDOT teams used subjective benefit/cost analysis to determine the various benefits and costs associated with selected organizational and operational changes
2. Identify the effectiveness of the technology and its impact beyond the intended customer/stakeholder.	Thus far, implementation has proceeded as planned Work zone delay is reduced by working during night and off-peak hours as well as the result of better management of contracting and coordination Coordination of work zones has improved through increased levels of communication within the department, with our construction partners and with the traveling public The traveling public is experiencing reduced delay and frustration in work zones Safety can be expected to increase by limiting work zone/ traveler exposure through working during times with decreased traffic volumes and limiting the number of days to complete the work.
3. Evaluate the direct impacts, secondary impacts, any limiting factors, and associated risks.	Direct impacts are positive and will result in reduced customer delay and frustration Safety is expected to improve with the adoption of best management practices and reducing traffic exposure to work zones. Limiting factors include the types of work that can be conducted at nighttime, development of best practices for nighttime work and traffic volumes on some roads that always make work zones inconvenient Risks include perceived safety issues involved with nighttime construction and drivers, and changes for construction and maintenance employees from normal daytime operations to nighttime and weekend work.
4. Identify the breadth of the applications and dimensions of the potential market.	The applications of these operational and organizational changes span all units within the DOT and include our external construction partners All 700 of our construction projects will be evaluated for changes to adhere to our new work zone guidelines All State DOT's will establish protocols to reduce customer delay and increase safety as traffic volumes and public perception of our activities continue to increase.

C. Implementation (20 points)

1. Describe the state of the technology: • Extent of use • Availability of standards and specifications • Scope of experience • Availability of experienced practitioners	We will evaluate all of our work zones for application for new work zones guidelines A handful of states have enacted similar strategies and the interest in work zone best practices to reduce delay is at an all time high as State DOT's move to maintenance of their systems rather than new-build Other countries have established similar guidelines and Nova Scotia has contacted us concerning our experiences There are best practices in use across the U.S to decrease work zones delays and increase safety Standards and specifications are lacking especially concerning nighttime work Experience in this area is limited but growing exponentially The availability of experienced personal, especially with nighttime work and establishing the value of decreased road user delay is limited.
2. Is the technology proprietary or patented?	No
3. Suggest pathways or techniques for implementation.	Complete participation and buy-in throughout the State DOT and with construction partners so that practices will be established to reduce work zone delay and increase safety Exemplar communication with employees, construction partners and the public.
4. What is required to implement this technology? • Training • Equipment • Funding • Permits • Expert assistance • Partners	Training is required to establish nighttime work practices and disseminate best practices to measure delay Additional equipment will be necessary for night operations such as reflective clothing and devices, light banks, channelization devices, etc Additional software is also required to calculate delay and report work zone activities Additional funding is expected to be needed for night work wage differentials, additional equipment, and to pay for reduced construction days in contracts Expert assistance is only developing in this area State DOT's can be expected to require additional information considering the limited experience available in their own operations and across the country Construction partners play a vital role in implementation of this change. Construction partners are needed for buy-in for the new agenda, and to promote, and establish work zone operation that impact the public less.
5. How long would it take to implement the technology?	Implementation is immediate and on-going operation It can be expected that best practices will be established and adopted each year as we learn more.
6. Are you willing to aid in the promotion of this technology? Are there others? Please identify.	Yes, all management in our department are willing to promote work zone changes to reduce customer delay and increase safety Steve McDonald, State Traffic Engineer mcdons@mail.modot.state.mo.us Ernie Perry, Research and Development Specialist perrye@mail.modot.state.mo.us
7. Are you aware of any legal, environmental, or social implications associated with this technology? If so, please describe them: • Change in law or regulation • Hazardous materials • Potential to impact the environment	Social, physical and family implications with DOT and the construction industry's work force relating to switching from normal day to day operations to aggressive schedules and night work The work force will be asked to change their work and family life schedules Changes that can be expected include: changes in sleeping habits, family contact, and maintenance of the family unit Physical changes can also be expected that include dietary and body rhythm changes.

D. Costs (15 points)

1. What costs are associated with the implementation of the technology and who bears them? • To the implementing agency • Startup costs to the user • The industry	Costs associated with implementation will include the cost of new equipment specific for night work, more barricades and light banks, and greater employee costs associated with aggressive schedules and night work These costs will accrue to the DOT as well as construction partners Project costs may also increase with incentives offered to complete work faster Social costs in the form of road user costs can be expected to decrease. There will also be secondary costs to change administrative and organizational processes to implement and monitor changes in these work zone processes No significant increase in work zone costs have been noted from projects awarded since these provisions have been included in project proposals.
2. Are there maintenance and operations costs associated with this technology once implemented? Please identify.	Once implemented, costs will be considered the normal cost of doing business.
3. Are there other costs associated with the implementation of this technology? Please identify. • Environmental costs • Social costs	Social cost to employees is expected Our work force has predominately followed the 8-to-5 work day The new work zone guidelines will require employees to adapt to new work schedules resulting in repercussions throughout their personal lives There is an expected decrease in social costs through reduced road user costs.

Nevada FRP Seismic Retrofit

Stage I Preliminary Assessment

(check yes or no)	Yes	No
1. Does the innovation meet the definition of technology* as defined by the AASHTO Technology Implementation Group? (*Technology will include processes, products, techniques, procedures, and practices.)	x	
2. Does the technology offer opportunities for performance improvement?	x	
3. Is it potentially a high payoff technology (return on investment, widespread application)?	x	
4. Has a stakeholder successfully used this technology?	x	
If yes to all of the above, move to Stage II		

Stage II Questionnaire on Technology Selection Process

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A. Meeting Customer/Stakeholder Needs (35 points)

1. Describe the technology proposed for implementation.	Application of unidirectional FRP fabrics for seismic retrofit of non-prismatic bridge members such as flared or tapered columns
2. Describe how the technology meets or solves a problem of the customer or stakeholder.	It improves confinement and shear strength of columns with variable cross section by providing an FRP jacket without significantly increasing shear demand.
3. Describe the intended user group(s) of the proposed technology.	Owners of bridges in areas of moderate to high seismicity
4. Describe the principal beneficiaries if different from the user groups.	
5. Describe the significance of the need or problem.	Substandard bridge members need to be strengthened for earthquake forces Methods for retrofit of circular and rectangular columns with constant cross sections are already available Bridge members are often non-prismatic The new method allows the use of FRP fabrics for non-prismatic members.

B. Effectiveness/Impact Analysis (30 points)

1. Provide a brief synopsis of development history and results of relevant testing.	Through a series of U-shaped straps FRP fabrics were attached to large-scale flared bridge columns and tested on a shake table at the University of Nevada, Reno, using simulated Northridge earthquake records
2. Identify the effectiveness of the technology and its impact beyond the intended customer/stakeholder.	Both carbon and glass fibers were attempted and were both found to be effective in improving the shear capacity and confinement Comparison with steel jacket also showed that the FRP jackets were equally effective.

3. Evaluate the direct impacts, secondary impacts, any limiting factors, and associated risks.	FRP jackets are relatively easy to apply Their particular advantage is realized in bridges where working space is limited Particular attention has to be paid to quality control during installation of any FRP jacket in the field
4. Identify the breadth of the applications and dimensions of the potential market.	The methods can be used for retrofit of all substandard bridge members with variable cross sections.

C. Implementation (20 points)

1. Describe the state of the technology: • Extent of use • Availability of standards and specifications • Scope of experience • Availability of experienced practitioners	The method has been used on the columns of a 16-span viaduct in Reno, Nevada. A step-by-step method relying on existing seismic retrofit standards has been developed and may be used. Installers of FRP jacket should be able to apply the new method without any difficulty.
2. Is the technology proprietary or patented?	No.
3. Suggest pathways or techniques for implementation.	The information about research and successful implementation of the method should be made available to interested parties.
4. What is required to implement this technology? • Training • Equipment • Funding • Permits • Expert assistance • Partners	The Unviersity of Nevada, Reno, published a report prepared for and used by NDOT in 2000 The report outlines the design and application method.
5. How long would it take to implement the technology?	None Ready for implementation
6. Are you willing to aid in the promotion of this technology? Are there others? Please identify.	Yes.
7. Are you aware of any legal, environmental, or social implications associated with this technology? If so, please describe them: • Change in law or regulation • Hazardous materials • Potential to impact the environment	No Nothing over and above implications for any FRP fabric installation

D. Costs (15 points)

1. What costs are associated with the implementation of the technology and who bears them? • To the implementing agency • Startup costs to the user • The industry	The method can save money compared to steel jackets in areas with limited working space because the proposed method does not require demolition of existing facilities under the bridge The cost of the new technology is comparable to that of standard FRP installation.
2. Are there maintenance and operations costs associated with this technology once implemented? Please identify.	Nothing over and above any cost for standard FRP jackets
3. Are there other costs associated with the implementation of this technology? Please identify. • Environmental costs • Social costs	No.

New Jersey Crash Notification System

Stage I Preliminary Assessment

(check yes or no)	Yes	No
1. Does the innovation meet the definition of technology* as defined by the AASHTO Technology Implementation Group? (*Technology will include processes, products, techniques, procedures, and practices.)	X	
2. Does the technology offer opportunities for performance improvement?	X	
3. Is it potentially a high payoff technology (return on investment, widespread application)?	X	
4. Has a stakeholder successfully used this technology?	X	
If yes to all of the above, move to Stage II		

Stage II Questionnaire on Technology Selection Process

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A. Meeting Customer/Stakeholder Needs (35 points)

1. Describe the technology proposed for implementation.	The research project involved the development of a low cost crash notification system for automobiles. The device that was developed includes a GPS, and wireless modem to call local 911 or emergency incident response unit, as well as, accelerometers that can tell the emergency unit the severity and direction of the impact even if the person is badly injured.
2. Describe how the technology meets or solves a problem of the customer or stakeholder.	The technology provide vital notification to the emergency response units even when the driver is unable The information provided helps the emergency response unit locate the accident and estimate the type of impact (front, side, rear) as well as the severity of the impact (force).
3. Describe the intended user group(s) of the proposed technology.	The technology was developed to provide an after-market product that could save human life.
4. Describe the principal beneficiaries if different from the user groups.	
5. Describe the significance of the need or problem.	The first hour after a accident is considered the “golden hour” Persons receiving medical attention in that time period have a good chance of survival In some rural area, especially at night, most if not all of this critical time can elapse without emergency notification This technology provides the means of notification that can make the difference between life and death.

B. Effectiveness/Impact Analysis (30 points)

1. Provide a brief synopsis of development history and results of relevant testing.	The development went through several prototypes. The final version was crash hardened and tested. Even after simulated crashes, the unit was able to provide the necessary information.
2. Identify the effectiveness of the technology and its impact beyond the intended customer/stakeholder.	This after-market product can be retrofit on any automobile for a low cost (approximately $300).

3. Evaluate the direct impacts, secondary impacts, any limiting factors, and associated risks.	The only limitation that was identified was due to the use of wireless modem and the possibility of the crash occurring in a "dead" zone where no cells are available.
4. Identify the breadth of the applications and dimensions of the potential market.	Since this technology is low cost and can be retrofit onto any vehicle, the implementation possibilities are widespread and the market potential is great

C. Implementation (20 points)

1. Describe the state of the technology: • Extent of use • Availability of standards and specifications • Scope of experience • Availability of experienced practitioners	The current project did not include manufacturing of the system beyond the prototype phase.
2. Is the technology proprietary or patented?	The system will be patented by the university
3. Suggest pathways or techniques for implementation.	Once manufactured, the system can be sold through Vehicle store chains It may be difficult to approach car manufactures with the concept.
4. What is required to implement this technology? • Training • Equipment • Funding • Permits • Expert assistance • Partners	To complete the implementation, funds are needed to hire manufacture to refine the production facility, market the project, produce and distribute the product.
5. How long would it take to implement the technology?	The prototype used off the shelf part that could be assembled easily by a manufacturing facility It should take no more than 6 months to produce this product and make it available for sale Marketing could be accomplished at the same time
6. Are you willing to aid in the promotion of this technology? Are there others? Please identify.	While NJDOT funding the initial development, Rowan University PI Dr. Clay Gabler would be responsible for further development, and manufacturing.
7. Are you aware of any legal, environmental, or social implications associated with this technology? If so, please describe them: • Change in law or regulation • Hazardous materials • Potential to impact the environment	I am not aware of any legal, environmental, or social implications associated with this technology.

D. Costs (15 points)

1. What costs are associated with the implementation of the technology and who bears them? • To the implementing agency • Startup costs to the user • The industry	I do not have specific details on the costs The estimate the final cost of the product is approximately $300.
2. Are there maintenance and operations costs associated with this technology once implemented? Please identify.	There are no maintenance costs associated with the product.
3. Are there other costs associated with the implementation of this technology? Please identify. • Environmental costs • Social costs	

New Jersey Portable Seismic Pavement Analyzer

Stage I Preliminary Assessment

(check yes or no)	Yes	No
1. Does the innovation meet the definition of technology* as defined by the AASHTO Technology Implementation Group? (*Technology will include processes, products, techniques, procedures, and practices.)	X	
2. Does the technology offer opportunities for performance improvement?	X	
3. Is it potentially a high payoff technology (return on investment, widespread application)?	X	
4. Has a stakeholder successfully used this technology?	X	
If yes to all of the above, move to Stage II		

Stage II Questionnaire on Technology Selection Process

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A. Meeting Customer/Stakeholder Needs (35 points)

1. Describe the technology proposed for implementation.	The technology is called the Portable Seismic Pavement Analyzer Rutgers University evaluated the technology for NJDOT on several bridges to identify areas of delamination of the concrete decks. The PSPA is a device for nondestructive evaluation of concrete bridge decks and pavements developed at the University of Texas at El Paso and produced by Geomedia Research and Development, Inc., El Paso, Texas.
2. Describe how the technology meets or solves a problem of the customer or stakeholder.	The equipment was found to more sensitive to delamination that the traditional chain drag and could be used to produce a 3-D image of the delaminated area. In addition, the equipment can be used in evaluation of elastic moduli of a deck or a pavement slab for QA/QC purposes or estimation of the strength.
3. Describe the intended user group(s) of the proposed technology.	The technology can be used to evaluate bridge decks and concrete pavements to assess the extent of rehabilitation needed both in area and extent (depth).
4. Describe the principal beneficiaries if different from the user groups.	The cost of concrete deck repair is impacted by the frequency of the repairs The PSPA detects areas that have partial delamination, unlikely to be detected by traditional methods like a chain drag, which allows these areas to be repaired the first time the bridge deck is closed without having to close the facility a second time and impact user costs.
5. Describe the significance of the need or problem.	There are an estimated 48% of the bridges nationally that have significantly deteriorated bridge decks This technology can be used to effectively identify the areas of the deck that are in need of repair without wasting funds on areas that are sound.

B. Effectiveness/Impact Analysis (30 points)

1. Provide a brief synopsis of development history and results of relevant testing.	The development history is available from the university and the manufacturer. The testing in NJ showed significant improvement in testing results over the traditional testing systems.

2. Identify the effectiveness of the technology and its impact beyond the intended customer/stakeholder.	The technology is effective and repeatable in identifying areas in need of repair It is not affected by traffic or operator fatigue Since each state has a magnitude of bridge, the potential benefit is nationwide.
3. Evaluate the direct impacts, secondary impacts, any limiting factors, and associated risks.	The only limiting impact of our study was the speed of the testing The testing took approximately half a minute to a minute per point on a 2.5 by 2.5 ft test grid By using multiple PSPA units the testing time could be significantly reduced.
4. Identify the breadth of the applications and dimensions of the potential market.	The device has applicability anywhere there is a bridge. In addition, studies at the University of Texas at El Paso have shown a wide range of applications in evaluation of flexible and rigid pavements.

C. Implementation (20 points)

1. Describe the state of the technology: • Extent of use • Availability of standards and specifications • Scope of experience • Availability of experienced practitioners	The manufacturer could provide specification on the device I am not aware of standards developed by ASTM or AASHTO for testing with this device at this time. Operation and data interpretation is simple enough, so that no extensive experience is needed.
2. Is the technology proprietary or patented?	The technology is patented by the manufacturer.
3. Suggest pathways or techniques for implementation.	I believe that the AASHTO bridge committees should evaluate the technology for more widespread implementation.
4. What is required to implement this technology? • Training • Equipment • Funding • Permits • Expert assistance • Partners	The technology is currently ready for implementation. The user needs training in the data collection and analysis Improvements to the equipment, analysis software, and standardize test procedures identified through widespread use will ensure success.
5. How long would it take to implement the technology?	The technology is ready now.
6. Are you willing to aid in the promotion of this technology? Are there others? Please identify.	I believe that the manufacturer, the University of Texas, and Rutgers University could adequately promote this technology.

7. Are you aware of any legal, environmental, or social implications associated with this technology? If so, please describe them: • Change in law or regulation • Hazardous materials • Potential to impact the environment	I am not aware of any legal, environmental, or social implications associated with this technology.

D. Costs (15 points)

1. What costs are associated with the implementation of the technology and who bears them? • To the implementing agency • Startup costs to the user • The industry	The cost are available from the manufacturer.
2. Are there maintenance and operations costs associated with this technology once implemented? Please identify.	We had no maintenance cost during the evaluation I believe that any maintenance costs would be minimal.
3. Are there other costs associated with the implementation of this technology? Please identify. • Environmental costs • Social costs	I am not aware of any other costs associated with the implementation of this technology.

Oregon Rock Catchment Design Guide

Stage I Preliminary Assessment

(check yes or no)	Yes	No
1. Does the innovation meet the definition of technology* as defined by the AASHTO Technology Implementation Group? (*Technology will include processes, products, techniques, procedures, and practices.)	X	
2. Does the technology offer opportunities for performance improvement?	X	
3. Is it potentially a high payoff technology (return on investment, widespread application)?	X	
4. Has a stakeholder successfully used this technology?	X	
If yes to all of the above, move to Stage II		

Stage II Questionnaire on Technology Selection Process

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A. Meeting Customer/Stakeholder Needs (35 points)

1. Describe the technology proposed for implementation.	The Rockfall Catchment Area Design Guide is the result of Pooled Fund Project SPR-3(032) The guide contains a set of "practitioner-friendly" design charts, which can be used to design rockfall catchment areas to meet specific rockfall retention requirements. Based on three factors – rock cut slope ratio, vertical rock slope height and catchment area slope – the design charts provide an estimate of the required ditch widths needed to retain up to 99% of rockfall
2. Describe how the technology meets or solves a problem of the customer or stakeholder.	The Rockfall Catchment Area Design Guide allows both risk assessment of existing rock slopes, and design of rock slopes to meet rockfall retention criteria based on empirical probability A designer can use the guide to determine slope/ditch configurations to retain 30 to 99% of rockfall
3. Describe the intended user group(s) of the proposed technology.	Designers of rock slopes and catchment areas, geologists and engineers responsible for rockfall issues
4. Describe the principal beneficiaries if different from the user groups.	The traveling public should realize enhanced safety Taxpayers should benefit through more cost-effective management of rockfall risk
5. Describe the significance of the need or problem.	Hundreds of millions of dollars are spent annually in the U.S. to construct and maintain rock slopes and reduce rockfall hazards along highways Rockfall occurs on slopes where rocks may free fall, bounce, roll or slide Legal claims and litigation costs resulting from injuries and deaths due to rockfall reach millions of dollars each year Current rockfall catchment design is not consistent throughout the US The limited research done prior to this study did not allow for varying rockfall retention, included only one ditch design with a non-recoverable foreslope, and was done on “rough” non-presplit slopes that contained launch features

B. Effectiveness/Impact Analysis (30 points)

1. Provide a brief synopsis of development history and results of relevant testing.	Through a joint effort funded by seven state DOT's and FHWA, the Oregon Department of Transportation (ODOT) has completed an extensive research project to develop design charts for rockfall catchment areas Researchers rolled about 11,250 rocks off five different rock cut slopes of three different heights (40, 60 and 80 feet) into three different catchment areas.
2. Identify the effectiveness of the technology and its impact beyond the intended customer/stakeholder.	This guide will allow rockfall designs that are tailored to conditions at a particular site to balance the risk of catchment failure against traffic volume, sight distance and other risk factors associated with a particular site It will also allow easy risk assessment of existing rock slopes Finally, it can be used to improve allocation of resources over a list of candidate sites for rockfall treatment.
3. Evaluate the direct impacts, secondary impacts, any limiting factors, and associated risks.	Direct impacts are improved safety for the traveling public, and more effective resource utilization by responsible agencies There has been some discussion of possible negative legal consequences of designing for less than 100% retention, when retention can be predicted
4. Identify the breadth of the applications and dimensions of the potential market.	Any highway agency that is responsible for cut slopes with rockfall potential can benefit from this guide

C. Implementation (20 points)

1. Describe the state of the technology: • Extent of use • Availability of standards and specifications • Scope of experience • Availability of experienced practitioners	The design guide is seeing limited use in the states that participated in the pooled fund study Members of the technical advisory committee are leading implementation efforts within their own states, and may be willing to assist others The guide is available on CD ROM from the ODOT Research Group, or may be downloaded from the ODOT Research Web site: http://www.odot.state.or.us/tddresearch/reports.htm
2. Is the technology proprietary or patented?	No
3. Suggest pathways or techniques for implementation.	Implementation should be straight-forward, starting and ending with acquiring a copy of the design guide.
4. What is required to implement this technology? • Training • Equipment • Funding • Permits • Expert assistance • Partners	Any qualified civil engineer, geologist or engineering geologist can use the guide It is intended to be user-friendly No special equipment, funding permits, or assistance are needed that are not already required for work related to constructing, maintaining and evaluating rock slopes
5. How long would it take to implement the technology?	For each qualified practitioner, a few hours of independent study with the design guide should be sufficient to be able to use it effectively

6. Are you willing to aid in the promotion of this technology? Are there others? Please identify.	To a limited extent, Oregon is willing to assist with promotion of this technology Representatives from other agencies that participated in the project may also be willing to help
7. Are you aware of any legal, environmental, or social implications associated with this technology? If so, please describe them: • Change in law or regulation • Hazardous materials • Potential to impact the environment	In some respects it is true that ignorance is bliss, and there may be a legal down-side to knowingly designing rock slopes with low retention probabilities Each state should seek a legal opinion on the consequences of designing for low retention.

D. Costs (15 points)

1. What costs are associated with the implementation of the technology and who bears them? • To the implementing agency • Startup costs to the user • The industry	There are no significant costs.
2. Are there maintenance and operations costs associated with this technology once implemented? Please identify.	None, beyond the costs associated with maintenance and operations for any rock slope Ease (and cost) of cleaning is one consideration in the selection of a ditch design, but whether this will result in added costs or savings depends on the specific design decision The net consequences should be reduced maintenance costs to the extent that the guide will enable selection of lower maintenance alternatives in many instances.
3. Are there other costs associated with the implementation of this technology? Please identify. • Environmental costs • Social costs	None

South Dakota Non-Corrosive, Environmentally Benign Deicer

Stage I Preliminary Assessment

(check yes or no)	Yes	No
1. Does the innovation meet the definition of technology* as defined by the AASHTO Technology Implementation Group? (*Technology will include processes, products, techniques, procedures, and practices.)	♦	
2. Does the technology offer opportunities for performance improvement?	♦	
3. Is it potentially a high payoff technology (return on investment, widespread application)?	♦	
4. Has a stakeholder successfully used this technology?	♦	
If yes to all of the above, move to Stage II		

Stage II Questionnaire on Technology Selection Process

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A. Meeting Customer/Stakeholder Needs (35 points)

1. Describe the technology proposed for implementation.	The technology is a non-corrosive, environmentally benign road deicer. It is available in two forms, Ice Shear Liquid Deicer/Anti-Icer is (a 27% liquid solution of sodium acetate and sodium formate) and Ice Shear Solid Deicer
2. Describe how the technology meets or solves a problem of the customer or stakeholder.	The technology meets three important needs. First, it is an effective deicing and anti-icing material that can provide safe roads in winter. Second, the material is non-corrosive, making it especially suitable for use on high-cost, steel-reinforced structures and roadways. Third, the material contains no chlorides and has minimal environmental impact.
3. Describe the intended user group(s) of the proposed technology.	Intended user groups are state and local transportation agencies and airport authorities.
4. Describe the principal beneficiaries if different from the user groups.	In addition to the transportation agencies that use the material, principal beneficiaries are operators of motor vehicles and aircraft.
5. Describe the significance of the need or problem.	The need is significant, because the cumulative costs of chloride deicers with respect to corrosion of reinforcing steel and automobiles and their impact on the environment represent a significant economic impact and environmental impact.

B. Effectiveness/Impact Analysis (30 points)

1. Provide a brief synopsis of development history and results of relevant testing.	Ice Shear is the result of alternative deicer research that was originally directed at producing CMA from dolomite and biomass. Ice Shear is a sodium acetate-sodium formate deicer that can be used in both solution and solid forms as an alternative to sodium, calcium and magnesium chloride. Ice Shear does not cause corrosion of reinforcing steel in concrete and is only mildly corrosive to exposed steel. Ice Shear is biodegradable and environmentally safe and does not cause deterioration of concrete.

2. Identify the effectiveness of the technology and its impact beyond the intended customer/stakeholder.	Ice Shear is an alternative environmentally acceptable deicer for use in sensitive areas. It can also be used for deicing critical structures and in urban areas where salt usage has a maximum negative impact. The only limiting factor is the cost of the material, which should be less than CMA with much greater effectiveness.
3. Evaluate the direct impacts, secondary impacts, any limiting factors, and associated risks.	Direct impacts would be improved safety in winter, reduced corrosion to highway and airport facilities, and significantly less environmental harm due to deicing and anti-icing activity.
4. Identify the breadth of the applications and dimensions of the potential market.	Ice Shear can be used as a substitute for magnesium chloride solution in anti-icing applications and as a replacement for sodium chloride solid deicer. The estimated market is somewhere between 5 and 10% of the existing chloride based deicer market.

C. Implementation (20 points)

1. Describe the state of the technology: • Extent of use • Availability of standards and specifications • Scope of experience • Availability of experienced practitioners	Ice Shear was originally developed as a more effective alternative than CMA using sodium instead of calcium. Ice Shear was determined to be the active ingredient in a deicer made from sawdust and washing soda at high temperatures. Ice Shear is a synergistic mixture of acetate and formate, which works much more effectively and has a lower eutectic than either by itself. Ice Shear liquid was tested in Colorado, Minnesota and South Dakota as a direct substitute for magnesium chloride. Ice Shear solid has only been tested in the laboratory using the SHRP protocols, but works as well as sodium chloride at melting ice. Ice Shear has been tested for toxicity and environmental impact and has no drawbacks. Ice Shear is noncorrosive to steel in concrete and does not damage concrete, unlike magnesium chloride.
2. Is the technology proprietary or patented?	Yes The patent is held by SDDOT and licensed to FMC Corporation.
3. Suggest pathways or techniques for implementation.	Implementation would be accelerated by providing forums for informing potential users. Pilot applications would be required for the solid material. A current market survey to project potential use would be advantageous.
4. What is required to implement this technology? • Training • Equipment • Funding • Permits • Expert assistance • Partners	This technology will use existing equipment, require no permits, and utilize procedures developed by SHRP. FMC will provide manufacturing assistance.
5. How long would it take to implement the technology?	Ice Shear solution can be used immediately. Commercialization of Ice Shear solid may take from 2 to 5 years.
6. Are you willing to aid in the promotion of this technology? Are there others? Please identify.	Yes. FMC Corporation could also help.

7. Are you aware of any legal, environmental, or social implications associated with this technology? If so, please describe them: • Change in law or regulation • Hazardous materials • Potential to impact the environment	Based on results of extensive testing, the material is more environmentally acceptable than other deicing materials. We are not aware of any other legal or social implications.

D. Costs (15 points)

1. What costs are associated with the implementation of the technology and who bears them? • To the implementing agency • Startup costs to the user • The industry	Beyond the costs of the material itself, there is no difference in operational costs compared to other liquid deicers. TEA-21 explicitly allows federal funding for use of the material on Federal Aid system (sections 133(b) and 144). Industry would have to invest to establish production facilities for solid Ice Shear. Little additional investment is required to produce liquid IceShear.
2. Are there maintenance and operations costs associated with this technology once implemented? Please identify.	Maintenance and operation costs would be no more than is already being expended to use existing liquid deicing and anti-icing chemicals.
3. Are there other costs associated with the implementation of this technology? Please identify. • Environmental costs • Social costs	No

Texas Ground Penetrating Radar

Stage I Preliminary Assessment

(check yes or no)	Yes	No
1. Does the innovation meet the definition of technology* as defined by the AASHTO Technology Implementation Group? (*Technology will include processes, products, techniques, procedures, and practices.)	♦	
2. Does the technology offer opportunities for performance improvement?	♦	
3. Is it potentially a high payoff technology (return on investment, widespread application)?	♦	
4. Has a stakeholder successfully used this technology?	♦	
If yes to all of the above, move to Stage II		

Stage II Questionnaire on Technology Selection Process

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A. Meeting Customer/Stakeholder Needs (35 points)

1. Describe the technology proposed for implementation.	Non-contact Ground Penetrating Radar (GPR) TxDOT has implemented GPR technology to measure upper pavement layer thickness non-destructively and to identify sub-surface moisture problems including stripping in ACP layers GPR data also provides an overall assessment of pavement condition GPR is also used to evaluate ACP pavements prior to Falling Weight Deflectometer (FWD) surveys to identify non-homogeneous sections. TxDOT has constructed two GPR vans, which has been specially modified with a workstation and a non-contact GPR antennae mounted to the front bumper Two more vans will be built in the near future The GPR van allows collection of GPR data at highway speeds.
2. Describe how the technology meets or solves a problem of the customer or stakeholder.	GPR data provides a nearly continuous surface layer thickness estimate that can be summarized to provide information for discrete points (usually 10-ft. spacing) along a project route Closer test spacing can be achieved but require slower data collection speeds The accuracy of layer thickness estimates varies depending on whether cores are taken to calibrate the system: with cores, an accuracy of +/- 3% is possible, without cores the accuracy is approximately +/- 5%. GPR provides a more complete picture of how layer thickness varies along the route when compared to layer thicknesses determined from cores or Dynamic Cone Penetrometer (DCP) tests Due to the amount of time required for coring, only a few cores can be collected Also, coring or DCP tests require traffic control if the road is currently open to traffic GPR data collection is non-destructive and non-contact therefore is capable of being conducted at highway speeds This means that data collection does not interfere with normal traffic operations and does not require expensive traffic control operations. Some projects require cores for laboratory test purposes GPR data can provide the pavement engineer with a 'picture' of the subsurface pavement condition that can then be used to select coring locations more effectively

	We have found that GPR data enhances and supplements Falling Weight Deflectometer (FWD) for project-level evaluations For some types of analyses, GPR data is an effective screening tool that can be used to select test locations for stop-and-go operations such as the FWD GPR data has also been used in an emergency situation to locate subsurface damage due a water main break The GPR van was driven slowly over the affected area to determine the extent of damage and possible presence of voids GPR data was also helpful in determining the surface layer thickness so that repair materials could be ordered. TxDOT has primarily used GPR for data collection on flexible pavements Although there has been some success with GPR data collection on rigid pavements it has been very limited.
3. Describe the intended user group(s) of the proposed technology.	Pavement design engineers benefit directly from GPR data since it provides a sufficiently accurate measure of existing ACP pavement surface layer thickness for applications such as modulus back calculation, linear-elastic layered theory analysis, pavement design, and load-zone and super-heavy load analysis In addition, GPR data can provide information about the location of moisture damage and stripping in ACP layers so that lab and pavement engineers can select coring locations more effectively.
4. Describe the principal beneficiaries if different from the user groups.	Accurate layer thickness data is crucial for certain pavement analysis procedures such as modulus back-calculation; linear-elastic layered theory analysis and pavement design and analysis procedures Inaccurate ACP surface layer thickness estimates can lead to poor modulus back-calculation results; incorrect recommendations on load-zone and super-heavy analyses and incorrect pavement remaining life estimates. In the absence of GPR data, pavement engineers must rely on construction plans that may be out of date and do not provide information about variations in as-constructed layer thickness Cores can provide accurate thickness measurements for specific locations, but it is expensive to collect enough cores to accurately represent a lengthy project Also, coring requires traffic control that is expensive and affects normal traffic operations In summary, GPR data can be used to identify section breaks along a project route based on layer thickness Thin layers less than 2.5” thick may be difficult to analyze and usually requires signal processing.
5. Describe the significance of the need or problem.	Accurate layer thickness data is crucial for certain pavement analysis procedures such as modulus back-calculation; linear-elastic layered theory analysis and pavement design and analysis procedures Inaccurate ACP surface layer thickness estimates can lead to poor modulus back-calculation results; incorrect recommendations on load-zone and super-heavy analyses and incorrect pavement remaining life estimates. In the absence of GPR data, pavement engineers must rely on construction plans that may be out of date and do not provide information about variations in as-constructed layer thickness Cores can provide accurate thickness measurements for specific locations, but it is expensive to collect enough cores to accurately represent a lengthy project Also, coring requires traffic control that is expensive and affects normal traffic operations In summary, GPR data can be used to identify section breaks along a project route based on layer thickness Thin layers less than 2.5” thick may be difficult to analyze and usually requires signal processing.

B. Effectiveness/Impact Analysis (30 points)

1. Provide a brief synopsis of development history and results of relevant testing.	Ground Penetrating Radar has been under development in Texas since the early 1990s TTI designed and fabricated a non-contact GPR antennae equipped van, developed the GPR analysis software 'COLORMAP' as well as the data collection software "RADAR2K" and developed performance based specifications for the GPR antennae and support equipment that has been adopted by TxDOT Using the TTI specifications, TxDOT purchased components and assembled two GPR vans that are similar to the TTI prototype unit Both non-contact and ground-coupled GPR test methods and equipment have been researched and developed by TTI through TxDOT's research program The non-contact antenna is used to evaluate pavement conditions within 12" – 18" of the surface The ground-coupled antennae must be in contact with the ground during testing and is used for investigation of subsurface conditions at greater depths of several feet TxDOT has elected to implement the non-contact GPR antennae technology in-house We purchase ground-coupled GPR antennae data collection and analysis services through an Interagency Contract with TTI.
2. Identify the effectiveness of the technology and its impact beyond the intended customer/stakeholder.	During on-site verification of calibration of the non-contact antenna readings are taken by directing the antenna at a metal plate placed on the ground There has been some discussion to restrict the use of non-contact radar because it can be directed at air traffic and may affect aircraft instrument readings. The TxDOT GPR vehicles are equipped with a Global Positioning System (GPS) and a cell phone. To date TxDOT has observed no effect on the GPS or the cell phone during GPR surveys. The fact that GPR data collection is conducted at highway speeds enhances safety to the travelling public by reducing impacts on traffic operations.
3. Evaluate the direct impacts, secondary impacts, any limiting factors, and associated risks.	To our knowledge, GPR testing does not pose any effects or impacts on the environment The GPR signal is focussed directly into the pavement at relatively low power levels and therefore, poses little risk to humans.
4. Identify the breadth of the applications and dimensions of the potential market.	GPR is applicable to highway and airport pavement management applications and could potentially be used by State DOTs, large municipalities, airport authorities and other agencies responsible for managing pavement networks GPR measurements taken on flexible pavements have been very successful; concrete pavements have had limited success.

C. Implementation (20 points)

1. Describe the state of the technology: • Extent of use • Availability of standards and specifications • Scope of experience • Availability of experienced practitioners	TxDOT has implemented two GPR vans and the COLORMAP GPR data analysis software and the data collection software RADAR2K for statewide use. TxDOT is currently building two more GPR vans and is developing a CD-ROM based training program In addition, data collection and analysis support is provided to TxDOT by the Texas Transportation Institute – Texas A&M University TTI owns/operates one GPR van and provides analysis and software development support for the COLORMAP software TTI also has a suite if ground coupled GPR antennas and provides TxDOT support in the data collection and analysis of ground coupled GPR surveys. TxDOT has developed a specification for the non-contact GPR antenna, which is available to other DOTs upon request At least two other state DOTs (North Carolina and Florida) have also implemented GPR technology. TxDOT currently uses GPR data for project level evaluations to support forensic investigations, rehabilitation and/or reconstruction projects, research, and in some cases, load zone and super heavy load analysis Training classes on the COLORMAPS software have been given by TTI/TxDOT to TxDOT pavement engineers in the districts and divisions
2. Is the technology proprietary or patented?	Yes. Vendors (e.g. Pulse Radar (TX), Penetradar (NY) & Geophysical Survey Systems Inc. (NH), Wavebounce, Inc. (TX)) market non-contact antennae that might be patented. To date, only two GPR antenna vendors have been able to meet TxDOT's performance specifications The analysis software used by TxDOT (COLORMAP) is licensed by TTI; other analysis packages or techniques may or may not be proprietary TxDOT also uses GPR data collection software that is licensed by TTI.
3. Suggest pathways or techniques for implementation.	Regional, FHWA pooled-fund studies could provide a means for DOTs to share resources in implementing GPR technology.
4. What is required to implement this technology? • Training • Equipment • Funding • Permits • Expert assistance • Partners	Implementation could be accomplished in different ways depending on an agency's needs TxDOT built two GPR vans (in-house) using information and specifications developed by TTI TxDOT also uses GPR data collection and analysis software developed by TTI However, a GPR van could be purchased from a vendor and operated by a DOT GPR data collection and analysis software could also be purchased and training provided to the agency by the vendor A vendor could provide GPR data collection and analysis services as a packaged service; in this case the results of the GPR analysis would be provided to the agency which may require training for interpretation and use of the results. It is important to recognize that GPR data collection and analysis requires experienced personnel that are permitted to work with the technology on a continuing basis If personnel are exposed to only periodic use of GPR equipment and the analysis software this can result in loss of expertise that may lead to errors in data collection and analysis.
5. How long would it take to implement the technology?	National implementation would be dependent on the availability of funds to purchase equipment and software and provide training to pavement engineers within each DOT The manufacturing capabilities of the current GPR antennae firms might be a factor regarding how fast GPR technology could be implemented A rough estimate would be that national implementation would take 5 – 10 years.

6. Are you willing to aid in the promotion of this technology? Are there others? Please identify.	Yes. TxDOT would be willing to participate in an AASHTO sponsored demonstration of GPR data collection and analysis capabilities Neither TxDOT nor TTI can support multiple DOT implementation of GPR technology; however we will be glad to share our experiences and provide support on software and hardware implementation questions TxDOT would also be willing to participate in a GPR User's Group. Various State DOTs that currently use GPR technology may be willing to help Also, there is a biennial, International Conference on GPR technology, which may be a venue for soliciting help in implementation The 2002 conference is being hosted by the University of California, Santa Barbara and Bechtel Nevada. http://www.cssip.uq.edu.au/~gpr2000/
7. Are you aware of any legal, environmental, or social implications associated with this technology? If so, please describe them: • Change in law or regulation • Hazardous materials • Potential to impact the environment	To our knowledge, GPR testing does not pose any effects or impacts on the environment The GPR signal is focussed directly into the pavement at relatively low power levels and therefore, poses little risk to humans.

D. Costs (15 points)

1. What costs are associated with the implementation of the technology and who bears them? • To the implementing agency • Startup costs to the user • The industry	The agency that implements GPR technology will probably bear the costs since the agency will accrue the benefits The cost of a GPR van varies depending on whether it is purchased off-the-shelf or built in-house Costs for the GPR van could vary from $ 150,000 to $ 250,000 or more depending on the number of antennae employed, the vehicle configuration and other factors Purchase of GPR data collection services from a vendor may be more practical for DOTs that do not anticipate extensive use of this technology Funding for development of GPR technology in Texas has primarily been through the TxDOT research program Additional funding needs have been budgeted by the DOT as part of the normal operating costs of the Construction Division – Materials and Pavements Section An FHWA pooled-fund study might provide a means for states to purchase a GPR van for shared use on a regional basis The pooled-funds could also be used to purchase data collection and analysis software and training for the participants.
2. Are there maintenance and operations costs associated with this technology once implemented? Please identify.	Routine maintenance of TxDOT GPR vans is about $ 3000 to $ 5000 per year Training on GPR data collection and analysis is approximately $ 25,000 per year. Each year all GPR antennas are brought to TTI to check their performance Additional hardware and software research and development is funded through Interagency Contracts and the TxDOT research program These functions provide continued development of GPR technology and cost approximately $100,000 to $200,000 per year on average.

3. Are there other costs associated with the implementation of this technology? Please identify. • Environmental costs • Social costs	

Utah Design-Build Process

Stage I Preliminary Assessment

(check yes or no)	Yes	No
1. Does the innovation meet the definition of technology* as defined by the AASHTO Technology Implementation Group? (*Technology will include processes, products, techniques, procedures, and practices.)	X	
2. Does the technology offer opportunities for performance improvement?	X	
3. Is it potentially a high payoff technology (return on investment, widespread application)?	X	
4. Has a stakeholder successfully used this technology?	X	
If yes to all of the above, move to Stage II		

Stage II Questionnaire on Technology Selection Process

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A. Meeting Customer/Stakeholder Needs (35 points)

1. Describe the technology proposed for implementation.	Design-build has been shown to be an effective contracting method in Utah and other states for certain types of transportation projects Large projects, such as the reconstruction of I-15 in Salt Lake County costing $1.4 billion, and smaller projects that meet certain criteria can benefit by using design-build methods.
2. Describe how the technology meets or solves a problem of the customer or stakeholder.	Projects constructed using design-build can be completed in less time, since the design can be overlapped with the construction This can result in savings to the traveling public due to reduced delays The occurrence of claims is reduced by having the design and construction completed by the same contractor. The risk associated with a project is shared more evenly by the owner and contractor.
3. Describe the intended user group(s) of the proposed technology.	Any agency with a mission to design and construct public facilities may benefit from the use of the design-build concept.
4. Describe the principal beneficiaries if different from the user groups.	The public can often benefit from the use of design-build contracting in the form of reduced delays related to the needed time for design and construction.
5. Describe the significance of the need or problem.	Public agencies are looking for ways to reduce the impacts of construction projects to the traveling public Innovative contracting methods can achieve these goals in many instances Construction claims by contractors often significantly increase the cost of a project where traditional contracting methods are used.

B. Effectiveness/Impact Analysis (30 points)

1. Provide a brief synopsis of development history and results of relevant testing.	The Utah DOT has been studying design-build and other related innovative contracting methods for four years A great deal has been learned related to topics such as best value selection of a contractor, performance specifications, QC/QA, owner controlled insurance, innovative construction processes, public relations, methods to accelerate settlement of fills, and organizational structures. Reports and other information are available on many of these topics.
2. Identify the effectiveness of the technology and its impact beyond the intended customer/stakeholder.	Many large projects result in significant user costs due to delays through the construction zone Further, traffic control costs have grown for these projects Design-build methods have been shown to reduce these costs by completing projects in less than half of the time required for traditional contracting methods.
3. Evaluate the direct impacts, secondary impacts, any limiting factors, and associated risks.	The time needed to design and construct a project can be reduced Care should be taken to ensure that quality is not compromised Techniques are available to enhance quality control and quality assurance The overall cost to design and construct the facility may not be reduced
4. Identify the breadth of the applications and dimensions of the potential market.	Processes are available to identify if design-build is a viable technique for use based on various project factors Other innovative contracting techniques can also be selected for use based on this process

C. Implementation (20 points)

1. Describe the state of the technology: • Extent of use • Availability of standards and specifications • Scope of experience • Availability of experienced practitioners	UDOT and other agencies have significant experience with design-build contracting The I-15 Reconstruction Project in Salt Lake County was completed in four years and under budget The project would have taken nine years to complete using traditional methods. Utilizing lessons learned from UDOT's first design-build project, additional projects have been completed using design-build techniques UDOT personnel and experts in consulting firms in the region have developed knowledge about innovative contracting methods Design-build contracting by UDOT has been very successful.
2. Is the technology proprietary or patented?	No
3. Suggest pathways or techniques for implementation.	An experienced consultant can greatly aid a transportation agency in the initial phases of the implementation process Expertise can be acquired within the agency over time.
4. What is required to implement this technology? • Training • Equipment • Funding • Permits • Expert assistance • Partners	The agency should identify a project that can benefit from the use of design-build based on innovative contracting criteria Projects with time constraints are often good candidates Contract with a consultant to help develop a plan for the project Approximately one-third of the design should be accomplished to allow contractors to intelligently bid on the project The needed documents and processes to select and contract with a design-build contractor are prepared Issues that will need to be addressed are QC/QA, design evaluation, right-of-way issues, specifications, public relations, partnering, and organizational management.
5. How long would it take to implement the technology?	Design-build methods can be engrained into the contracting processes of the agency in a short period of time under the direction of a qualified consultant.
6. Are you willing to aid in the promotion of this technology? Are there others? Please identify.	UDOT personnel are willing to participate in technology transfer of this program, produce industry contacts, and deliver reports on the subject (UDOT report numbers UT-98.06, UT-98.10, UT-98.16, UT-99.13, UT-00.04, and UT-01.08).

7. Are you aware of any legal, environmental, or social implications associated with this technology? If so, please describe them: • Change in law or regulation • Hazardous materials • Potential to impact the environment	Some states have laws or rules counter to the use of design-build and other innovative contracting processes The Utah State Legislature passed new rules allowing UDOT to choose a contractor based on advantages in addition to the bid amount proposed

D. Costs (15 points)

1. What costs are associated with the implementation of the technology and who bears them? • To the implementing agency • Startup costs to the user • The industry	Consulting costs may be significant to establish design-build concepts and processes for the agency and for specific projects These consulting expenditures are often necessary for large projects in any case during the design process Design-build requires a change in an organization's climate Many aspects of the design, construction and management processes are modified
2. Are there maintenance and operations costs associated with this technology once implemented? Please identify.	Feedback mechanisms and lessons learned documentation are important to improve innovative contracting methods over time Developing expertise within the agency is invaluable When responsibility for quality control is transferred to a contractor, the issue of long-term maintenance must be considered and managed.
3. Are there other costs associated with the implementation of this technology? Please identify. • Environmental costs • Social costs	No

Utah Global Positioning System Surveying

Stage I Preliminary Assessment

(check yes or no)	Yes	No
1. Does the innovation meet the definition of technology* as defined by the AASHTO Technology Implementation Group? (*Technology will include processes, products, techniques, procedures, and practices.)	X	
2. Does the technology offer opportunities for performance improvement?	X	
3. Is it potentially a high payoff technology (return on investment, widespread application)?	X	
4. Has a stakeholder successfully used this technology?	X	
If yes to all of the above, move to Stage II		

Stage II Questionnaire on Technology Selection Process

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A. Meeting Customer/Stakeholder Needs (35 points)

1. Describe the technology proposed for implementation.	Global Positioning Systems (GPS) are being used more in project design, construction, and maintenance by transportation agencies Automating conventional surveying operations can be accomplished through triangulation with satellites that can identify locations rapidly and accurately.
2. Describe how the technology meets or solves a problem of the customer or stakeholder.	The use of GPS has resulted in increased person-hour productivity, and lower overall costs than traditional survey methods. Labor reductions of 60 to 90% can be achieved The accuracy of the data is better or at least comparable to traditional methods if used properly. UDOT has reorganized based on the implementation of this technology, resulting in the shift of personnel to other tasks.
3. Describe the intended user group(s) of the proposed technology.	Users have been identified in many UDOT Divisions, including Planning, Construction, Design, Maintenance, Right of Way, Traffic & Safety, Environmental, and the GIS Unit.
4. Describe the principal beneficiaries if different from the user groups.	The benefits can also be passed on to the customers and stakeholders of the users of the technology
5. Describe the significance of the need or problem.	Budget constraints are putting pressure on transportation officials to deliver the same level of service to the public at a lower cost This technology can significantly reduce labor costs. Data gathered in an inaccurate manner can severely limit the quality of decisions made by transportation officials The precision of the location of gathered data is enhanced in some cases.

B. Effectiveness/Impact Analysis (30 points)

1. Provide a brief synopsis of development history and results of relevant testing.	JUB Engineers, Inc. of Orem, Utah was contracted to conduct a research project to evaluate the effectiveness of GPS technology in transportation operations The implementation of the study findings has led to improvements in UDOT's operations and organization.

2. Identify the effectiveness of the technology and its impact beyond the intended customer/stakeholder.	The cost reductions achieved can be passed on to customers including the taxpayer The shift of personnel to other programs has had a positive impact on those activities. The more simple data gathering techniques allow collection of data which was impractical before This technology allows more information to be gathered on agency assets and inventory.
3. Evaluate the direct impacts, secondary impacts, any limiting factors, and associated risks.	Most personnel utilizing the technology have expressed an increase in their productivity, improved safety of the data gathering, and enhanced morale of the staff. Some resistance to change was observed Reassignment of personnel to other duties required some training.
4. Identify the breadth of the applications and dimensions of the potential market.	Virtually any process requiring location referencing or surveying can benefit by utilizing GPS equipment and processes Further uses will likely be identified in the future.

C. Implementation (20 points)

1. Describe the state of the technology: • Extent of use • Availability of standards and specifications • Scope of experience • Availability of experienced practitioners	Survey grade GPS equipment was purchased for each of UDOT's four Region offices. Training was provided to users, who seemed to become proficient with the equipment in 6 to 12 months of on the job use The new equipment has been utilized since the summer of 1999 with positive results. Resource grade equipment was placed in divisions requiring less precision at a lower cost This has improved the accuracy of the location of various transportation assets It has also enabled the use of GIS processes to improve management techniques and decision-making
2. Is the technology proprietary or patented?	Equipment and training is available from various manufacturers and suppliers.
3. Suggest pathways or techniques for implementation.	A survey grade GPS unit should be acquired for demonstration purposes A survey crew can easily compare the time and personnel needed to conduct a typical survey with GPS equipment vs conventional methods
4. What is required to implement this technology? • Training • Equipment • Funding • Permits • Expert assistance • Partners	An initial investment in equipment is necessary This investment can be recovered in about one year of operation. Training is required for users, which is available from the equipment suppliers It is recommended that an organizational/management entity be established to oversee GPS usage Scheduling of the equipment is needed, and a GIS data warehousing process can make data available throughout the organization for many uses.
5. How long would it take to implement the technology?	This program can be implemented in 6 to 12 months, including purchase of the equipment, training sessions, and development of expertise.
6. Are you willing to aid in the promotion of this technology? Are there others? Please identify.	UDOT personnel are willing to participate in technology transfer of this program, produce industry contacts, and deliver a report on the subject (UDOT report number UT-99.10).

7. Are you aware of any legal, environmental, or social implications associated with this technology? If so, please describe them: • Change in law or regulation • Hazardous materials • Potential to impact the environment	This technology has less environmental impact to sensitive locations due to the fewer number of people required in the survey crew, and the reduced time spent on site.

D. Costs (15 points)

1. What costs are associated with the implementation of the technology and who bears them? • To the implementing agency • Startup costs to the user • The industry	Survey grade GPS equipment can be purchased for $50,000 to $60,000 This cost includes a single base unit and one rover Additional rover units will cost approximately $25,000 each Training costs are low. Resource grade GPS units can be purchased for around $10,000 or less depending on the specific use and accuracy needed.
2. Are there maintenance and operations costs associated with this technology once implemented? Please identify.	Maintenance of the equipment is minimal.
3. Are there other costs associated with the implementation of this technology? Please identify. • Environmental costs • Social costs	Limited costs are expected for software, data storage, and information processing.

Washington State Ramp Metering Algorithm

Stage I Preliminary Assessment

(check yes or no)	Yes	No
1. Does the innovation meet the definition of technology* as defined by the AASHTO Technology Implementation Group? (*Technology will include processes, products, techniques, procedures, and practices.)	X	
2. Does the technology offer opportunities for performance improvement?	X	
3. Is it potentially a high payoff technology (return on investment, widespread application)?	X	
4. Has a stakeholder successfully used this technology?	X	
If yes to all of the above, move to Stage II		

Stage II Questionnaire on Technology Selection Process

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A. Meeting Customer/Stakeholder Needs (35 points)

1. Describe the technology proposed for implementation.	A ramp-metering algorithm based on “fuzzy logic” control.
2. Describe how the technology meets or solves a problem of the customer or stakeholder.	Overall, the fuzzy logic algorithm reduced total travel time system-wide, increasing flow in comparison to previous algorithms. It is also easier to use.
3. Describe the intended user group(s) of the proposed technology.	Operators of ramp metering systems.
4. Describe the principal beneficiaries if different from the user groups.	Those operating vehicles on the roadway system.
5. Describe the significance of the need or problem.	Improved traffic operations are vital to achieving the most effective and efficient use of the highway system.

B. Effectiveness/Impact Analysis (30 points)

1. Provide a brief synopsis of development history and results of relevant testing.	WSDOT has sponsored research since 1994 to improve its ramp-metering algorithm. The fuzzy logic algorithm (FLA) was tested online within two corridors for a 4-month period. The tests showed that on one corridor, the new algorithm decreased mainline congestion noticeably and increased flow. On the other, the ramp queues decreased significantly but mainline congestion increased only marginally.
2. Identify the effectiveness of the technology and its impact beyond the intended customer/stakeholder.	The FLA was so effective that it was implemented on all ramp meters in the greater Seattle area. It produced not only operational advantages but is easier to use. It reduces total travel time system wide, increasing flow in comparison to our previous metering algorithms.

3. Evaluate the direct impacts, secondary impacts, any limiting factors, and associated risks.	The direct impact is improved system-wide travel time. A secondary benefit is ease of calibration. Although the controller code itself is relatively simple, the interface between the system software, control algorithm, filed devices and user interface may need considerable customizing.
4. Identify the breadth of the applications and dimensions of the potential market.	Regions that will see the most benefit from this type of logic are those with ramp queue detection, the need to balance mainline objectives with queue objectives, and over saturation both on the mainline and ramps.

C. Implementation (20 points)

1. Describe the state of the technology: • Extent of use • Availability of standards and specifications • Scope of experience • Availability of experienced practitioners	The algorithm was implemented on 126 ramps in the greater Seattle area. When properly tuned, the algorithm can expertly handle incidents, special events, poor data and unusual weather without the need to modify the control parameters. A training manual, providing a detailed description of the algorithm, was developed to assist freeway operation engineers with implementation. A software manual was also developed to train programmers.
2. Is the technology proprietary or patented?	The University of Washington owns the code.
3. Suggest pathways or techniques for implementation.	The training manual describes the algorithm design in detail. The procedure for optimizing the algorithm's performance is described. The manual also contains numerous examples of implementation and tuning.
4. What is required to implement this technology? • Training • Equipment • Funding • Permits • Expert assistance • Partners	The code is customized for WSDOT's system; it is not "plug and play." Successful implementation requires knowledge of the site specifics, with controller inputs determined as described in the training manual. The concepts behind this algorithm are transferable, but the algorithm may need modification depending on detector types, detector placement, sampling frequency and control objectives.
5. How long would it take to implement the technology?	It would take approximately 6 months to one year to implement this algorithm in a ramp meter system that was already operating under demand responsive, centralized control.
6. Are you willing to aid in the promotion of this technology? Are there others? Please identify.	WSDOT could provide technical advice and assistance to other agencies interested in adopting this algorithm The developer, Professor Deidre Meldrum of the University of WA, might be interested in contracting for installation of the algorithm.
7. Are you aware of any legal, environmental, or social implications associated with this technology? If so, please describe them: • Change in law or regulation • Hazardous materials • Potential to impact the environment	No

D. Costs (15 points)

1. What costs are associated with the implementation of the technology and who bears them? • To the implementing agency • Startup costs to the user • The industry	The only costs, assuming a central computer system adequate to run the algorithm, would be the staff time that the implementing agency would need to devote to installation and testing of the new algorithm.
2. Are there maintenance and operations costs associated with this technology once implemented? Please identify.	Maintenance and operations costs would not increase due to the installation of this algorithm.
3. Are there other costs associated with the implementation of this technology? Please identify. • Environmental costs • Social costs	No