FOSTERING INNOVATION TO IMPROVE PAVEMENT PERFORMANCE IN CANADA

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ABSTRACT

In an economic sector involving a strong mutual dependence of predominantly governmental agencies who are the owners of our pavement infrastructure and contractors who traditionally implement agency desires to construction and maintain that infrastructure, it is clear that the development of new and innovative design and construction takes place in a somewhat different manner than they do in a regular consumer market. An entrepreneur in a free consumer market continuously seeks new products and services and will influence the consumer to buy those new products and services through marketing. Many factors other than just technical functionality play a role in this. In addition to functionality, the value of perception, profiling and status are components that are factored in when a consumer decides to purchase a new product. The transportation sector functions very differently that this entrepreneur/consumer model. Road users typically have very little interaction with the contractors that build or maintain our roadway infrastructure and roadway users have very little to no effect on the agency's procurement processes. Agency contract regulations and procedures typically act to minimize innovation as the contracting practices of many agencies make the introduction of innovation difficult. Many agencies cannot sole source a particular contractor or supplier without significant effort which tends to reduce the environment of innovation. Further, roadway agencies often focus on the lowest price at a quality level established in advance.

This paper highlights the need for innovation and examines the barriers in place across Canada that can make successful innovation implementation difficult. Through case studies of both successes and failures from Provincial highway, municipal and private/public/partnership projects, the paper outlines changes in bidding and procurement processes, contractor development, education and risk necessary to implement new and innovative design and construction process that can cost-effectively extend the service life of our infrastructure and minimize the impact of construction on the road users.

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INTRODUCTION

Highway and municipal traffic in Canada, particularly in the major urban areas, continues to rise. In 2005, there were over 21.9 million licensed drivers and 18 million passenger vehicles in Canada [1]. In 2005, there were 2,923 roadway related deaths representing over 90 percent of all of the transportation related deaths in Canada. While this represents a 30 percent decrease in traffic related deaths since 1982, Transport Canada continues to challenge the Canadian Transportation infrastructure professionals to continue to reduce this number. The Transport Canada Road Safety Vision 2010 program intends to increase awareness of road safety issues and further reduce the number of Canadians killed or seriously injured on Canada's roads by 30 percent before 2010 [2].

In February 2004, the Canadian Automobile Association (CAA), published a national public opinion survey that asked Canadians their opinion regarding our national transportation infrastructure. The survey indicated that 35 percent of Canadians believed that the current condition of the road infrastructure was poor with an additional 28 percent saying that is was just adequate but rapidly decreasing in quality [3].

While the Transport Canada Road Safety Vision 2010 program focuses on safety improvements to vehicles, intelligent transportation systems, driver attitude to speeding, reducing impaired driving, etc., improvements to the transportation infrastructure can also improve the safety of both the drivers and construction workers. Some of the possible ways to achieve these goals are outlined in Figure 1.

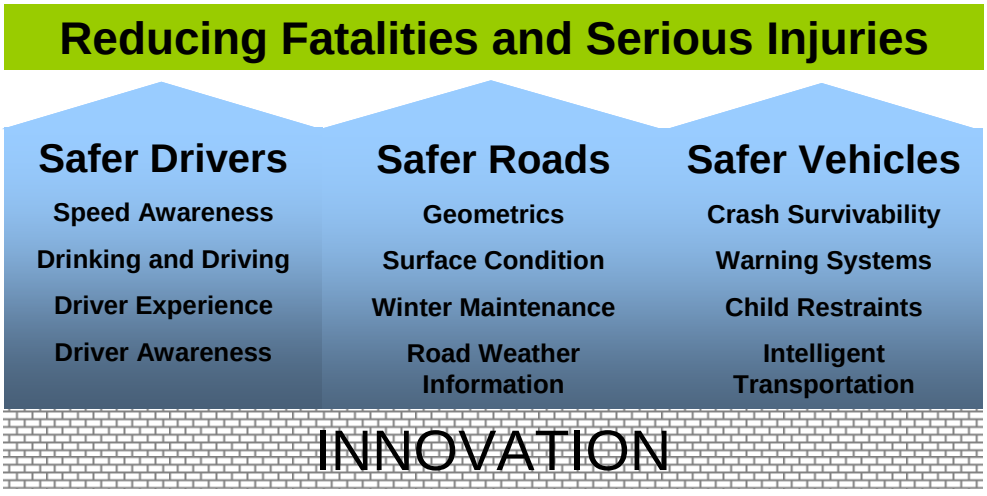

Figure 1. Innovation – The foundation for reducing fatalities and serious injuries.

INNOVATION

The Merriam-Webster dictionary defines innovation as the act of introducing something new such as a new idea, method or device. Clearly, the introduction of innovation in the transportation arena, whether in management methods or construction techniques, can produce considerable benefits when it comes to improving safety, reducing construction time and costs.

Once an innovation has been thoroughly mastered, it culminates in standardization. Standards must not be perceived as obstacles to innovation, but rather as the outcome of the process. Standards reflect the state of the art, as determined by consensus. They enable the transportation agency to clearly state objectives in terms of expected results. Contractors and suppliers can then refer to them in order to clearly define the goal that the agency wishes to attain.

A few specific methods can be considered in order to encourage innovation, such as performance specifications. However, in meeting these specifications, innovations must have reached a very advanced stage of development or evolution in order to be used, due to the guarantees associated with this type of contract mechanism. Competition, the competencies of each party, and sound risk-sharing are also preconditions for the use of performance specifications.

Many other means of a more general nature can be adopted by agencies that are interested in stimulating technological progress in pavements, regardless of the development stage of a particular innovation. Examples of potential forms of action include:

- Properly manage commonly used techniques and tools, or in other words, tightly control design standards and construction quality, with a view to building longer lasting pavements and planning the reuse and recycling of materials from existing pavements and existing structures; and
- Adopt laws, regulations, and contractual requirements that foster the emergence of innovations and their market launch so that they remain competitive after introduction.

The aim of technological progress is not simply to help reduce the direct costs of pavement maintenance and rehabilitation but rather also to contribute to sustainable development and to reduce the impact of construction work on the travelling public, construction workers and to people living adjacent to the roadway.

Transportation Innovation Around the World

Many agencies are very active in promoting innovation for transportation projects. A brief outline of a few innovation initiatives are described below.

<u>Netherlands</u>

The Dutch “Road to the Future” project sponsored by the Dutch Road Authority, Rijkswaterstaat, has virtually the same goals as the Transport Canada Road Safety Vision

2010 program. One of the key components of the system is rapidly introducing new pavement maintenance and rehabilitation techniques by minimizing or sharing the risks and liabilities associated with the introduction of new innovations. Some very interesting innovations that came directly from the Road to the Future program include:

- Rollpave;
- ModieSlab; and
- Temporary bridge structures.

Rollpave (Figure 2) is a prefabricated asphalt mat which is approximately 30 mm thick which is placed on top of a roadway that already has sufficient structural capacity to accommodate the design traffic. Rollpave is designed to allow repairs to be completed about 50 percent faster than conventional construction. Rollpave provides a low noise wearing course which is comparable to 2-layer porous asphalt (noise reduction of about 6 dBA from conventional dense graded asphalt layers).

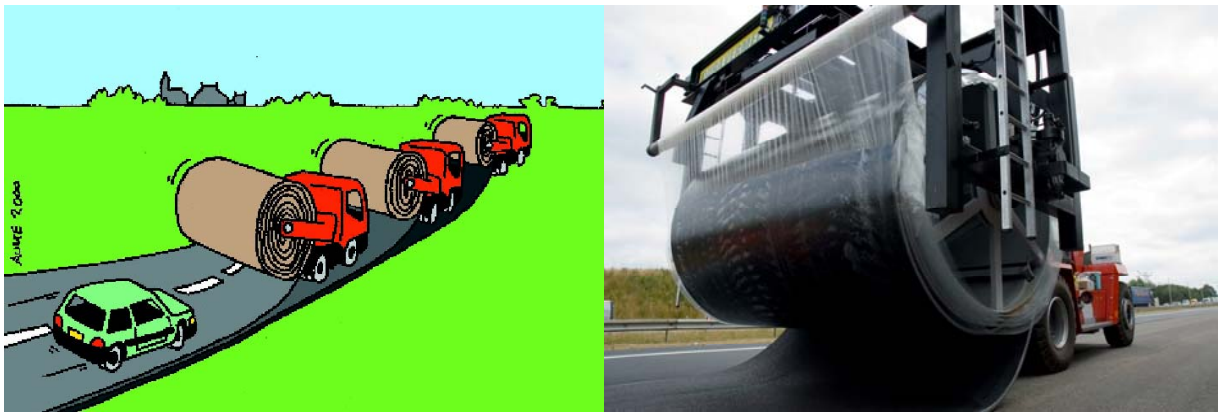

Figure 2. Rollpave for rapid surface course placement.

ModieSlab (Figure 3) stands for Modular, Intelligent, Energy Slab. Prefabricated concrete slabs are anchored on a grid of piles making construction very rapid. Each Slab consists of two layers of porous concrete with different properties attached to a reinforced concrete base. Drainage channels located between the two layers of concrete are provided to channel rainwater. The same channels can also be used for road cleaning or for installing intelligent detection and signaling systems. This technology has also been used to install a piping system for cooling the roadway during the summer and warming it during the winter, keeping it snow and ice free.

Figure 3. ModieSlab prefabricated concrete pavement.

The temporary bridge concept (Figure 4) involves the placement of a temporary bridge structure to permit traffic to continue to travel, at reduced speed, while an expansion joint is repaired. The "high variant" temporary bridge structure allows sufficient clearance for construction workers to complete pavement and construction joint repairs. The "low variant" version is only slightly above the pavement surface and is used to allowed repairs to properly cure.

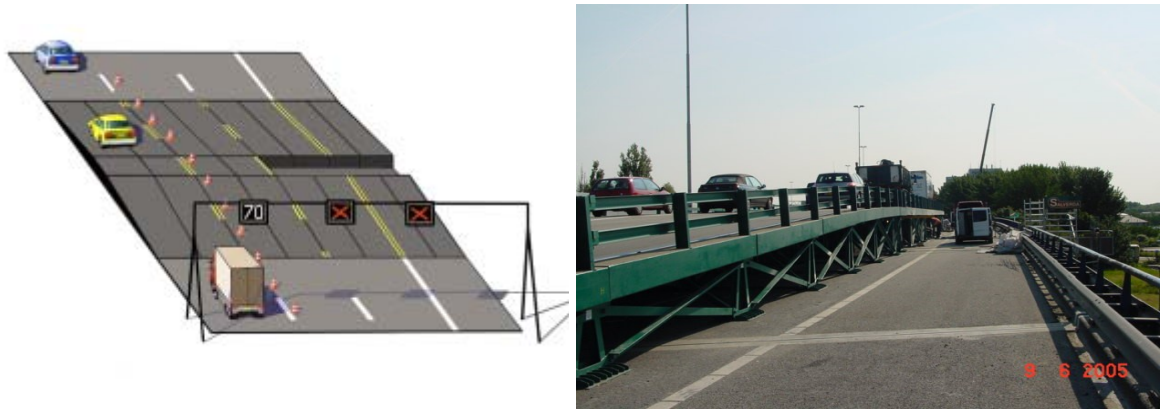

Figure 4. Temporary bridge structures for joint repairs and worker safety.

The Dutch Road to the Future project sponsors contractor competitions which are then ranked and funded by the Rijkswaterstaat to prototype and evaluate the benefits of the innovation.

The Dutch also have one of the largest noise innovation programs in Europe. Their innovation in this area has included silent tires, new types and concepts of road surfaces and noise barriers. The focus for the Dutch innovation program is similar to their other innovation projects on products that are ready to implement, make a significant contribution to noise reduction and are less expensive than current noise mitigation measures.

France

The French have traditionally embraced innovation in pavement design and construction. The French "Charter of Innovation" is administered by the Laboratoire Central des Ponts et Chaussées (LCPC) and similar to the Dutch program, is designed such that the government and industry share the risk of experiments to develop new and innovative products. Requests for proposals are issued annually for new products and procedures and test sections are typically constructed. The firm constructing the innovation then shares the costs of construction and conducting follow-up performance monitoring with the LCPC.

The French program is significantly involved in pavement preservation and pavement surface restoration techniques. They typically use four year warranties with pavement preventive maintenance techniques requiring the contractor to repair any non-compliant sections based on specific pavement performance indicators. Contractor responsibility for completing repairs decreases with time. French innovation techniques were recently transferred to Ontario during the France-Ontario Innovative Technologies Exchange Conference held in Toronto in 2003.

Finland

In Finland, the National Technology Agency (Tekes) established the Infra National Programme which was designed to foster innovative procurement practices for new markets and international competitiveness. The program sponsored numerous projects completed by the government, universities and the private sector including:

- The development of sustainable development guidelines, working methods, products and materials;
- Ground penetrating radar data analysis and evaluation;
- Automated road maintenance equipment;
- Quiet road surfaces;
- Sensor technology for infrastructure condition monitoring;
- Performance requirements for maintenance contracts;
- Transportation project procurements and innovative contracting methods; and
- New technologies for the management of underground infrastructure.

On of the goals of the project was to strengthen Finnish entrepreneurs, create new business activities, enhance and expand Finnish research internationally and improve cooperation between research and business entities.

United States

In the United States, there are several transportation innovation programs sponsored by the Federal Government and by individual state agencies. The Federal Highway Administration (FHWA) established the Highways for Life (HfL) program. The purpose

of the HfL program is to invest in innovation to extend the life of highway infrastructure and to "get in, get out and stay out". The three goals of HfL are:

- Improve safety during and after construction;
- Reduce congestion caused by construction; and
- Improve the quality of the highway infrastructure.

Ultimately, the FHWA believes that there are many currently available innovations that if adopted, would result in significant benefits to the agency, contractors and travelling public. Examples of HfL innovation programs include:

- Prefabricated bridge elements systems;
- Precast modular concrete panels;
- Precast, prestressed concrete bridge approach slabs;
- Two-lift concurrent asphalt and concrete;
- Work zone safety and traffic flow initiatives;
- Moveable barriers in work zones;
- Full road closures;
- Self Propelled Modular Transporters (SPMT's);
- Innovative contracting techniques (I/D, lane rental, A+Bx, A+B+C, "locked" incentive date);
- Construction scheduling optimization; and
- Self-consolidating concrete.

Many of these techniques originated in Europe and were 'brought' to North America as a result of 'study tours' completed by FHWA and state highway representatives over the years.

Individual State highway agencies also promote innovation. For example, the Minnesota Department of Transportation has an innovative contracting department that has published innovative contracting guidelines [4] and promotes techniques such as design/build, A+B bidding, lane rental, warranties, pay for performance, incentives/liquidated savings, and new technologies such as pre-cast concrete pavements, intelligent compaction and remote machine control.

Many contracting agencies have experimented with contractual requirements and incentives to motivate construction contractors to complete the work as early as possible. The ultimate goal is successfully completing the work while minimizing the inconvenience to the traveling public. Success is often based on how clearly the contracting agency can describe its goals and formulate performance-based contractual requirements that reflect these goals.

The Arizona Department of Transportation (ADOT) used a performance-based contract provision for the reconstruction of the 21-kilometer State Route 68 design-build project. Arizona DOT provided a $400,000 travel time budget item in the contract as an incentive for the design-builder to schedule all work zone activities to minimize inconvenience to

the traveling public. ADOT believed the incentive would be sufficient for the design/ builder to plan and schedule all work zone activities in accordance with ADOT's goals.

Arizona DOT's contract provision stated that the average travel time though the work zone must not exceed 27 minutes. Further, the design-builder was required to propose a system for measuring and recording vehicle travel times through the work zone. This system had to be functional 24 hours a day, seven days a week. The average travel speed was measured over a ten-minute period. If the motorists experienced three consecutive ten-minute periods where the average travel speed exceeded 27 minutes, the design-builder was assessed a disincentive of US $21.50 per lane per minute.

Value Engineering (VE) is a creative, organized approach whose objective is to optimize cost and/or performance of a facility or system. Through a fairly rigorous series of evaluation procedures, unnecessary expenditures are avoided, resulting in improved value and economy. The Value Engineering approach is directed toward analysis of functions. It is concerned with elimination or modification of anything that adds costs to an item without contributing to its required functions. During this process all expenditures relating to design, construction, maintenance, operation, replacement, etc., are considered. The Florida Department of Transportation (FDOT) used VE for the I-10 Escambia Bay Bridge Replacement project due to Hurricane Ivan in 2004. As a result of the VE exercise, the project bids came in US $20 million under original estimates. Subsequently, FDOT has made extensive use of Value Engineering and Design/Build procurement for transportation infrastructure projects.

Many highway agencies are using constructability reviews to incorporate construction expertise into the early design phases of a project, thus ensuring a biddable, constructible and cost effective design. In addition to reductions in cost and overall construction time, contracting agencies have found that a formal review of constructability often discloses issues that might not become evident until the physical work actually starts. For example, constructability reviews have been successfully used to identify alternate material sources, additional construction staging areas, different ways of addressing environmental mitigation and various ways of staging the actual construction of the project.

The North Carolina DOT has determined that constructability reviews have been effective on major rehabilitation and new construction contracts on high-volume, urban freeways with environmental mitigation concerns. The NCDOT utilizes representatives from the North Carolina Contractor's Association for constructability reviews. The NCDOT initially found that constructability reviews resulted in significant decreases in contract time, as well as reductions in contract costs, road user costs and improvements in the traffic control plan.

The Caltrans Division of Research and Innovation tests and evaluates transportation innovations and like the Finnish Road Administration assists California entrepreneurs in marketing their transportation innovations worldwide. Caltrans has also developed manuals and procedures to assist in the evaluation of pavement maintenance treatments to

determine the best utilization and construction techniques as well as performance indicators to determine benefits.

Many other U.S. States have similar innovation programs.

Transportation Innovation in Canada

In Canada, transportation innovation can also be found at several levels of government and industry. For example, the Canada Revenue Agency provides all Canadian controlled corporations with access to the Scientific Research and Experimental Development (SR&ED) program which is a federal tax incentive program to encourage research and development that will lead to new, improved or technologically advances products or processes. The Canada Foundation for Innovation (CFI), is a Government of Canada crown corporation created in 1998 to fund research infrastructure in Canada. The agency provides funding for universities, colleges and non-profit research institutions to advance Canadian research and technology. Other federal government agencies such as the National Research Council (NRC) complete basic research through pooled fund studies, or in the case of Transport Canada, though major federal programs such as the Canada/U.S. border initiative. The Transportation Association of Canada (TAC) is a national association of Canadian transportation agencies, consultants and contractors that is dedicated to improving the transportation infrastructure in Canada. TAC members help to sponsor transportation research and development that is typically carried out by universities and consultants.

Innovation programs vary significantly at the Provincial highway agency level. While most highway agencies had significant research and development programs at one time, all except for perhaps Québec have abandoned direct agency transportation research. While many still fund some research and innovation, it is typically through universities or other non-profit organizations. The majority of highway agencies across Canada have outsourced transportation design, pavement and bridge maintenance activities and transferred responsibility for this work to the private sector.

In British Columbia, the British Columbia Innovation Council (BCIC) is a crown corporation with a mandate is to accelerate and expand science and technology-based economic development. Their involvement in the transportation infrastructure business is minimal. The Insurance Corporation of British Columbia (ICBC) frequently partners with BC Highways to complete research to reduce roadway accidents and in some cases funds construction work at high accident risk locations.

In 2005, Alberta Transportation established the Minister's Award for Transportation. The purpose of this award was to recognize excellence in transportation innovation with a specific focus on roads and bridges. Saskatchewan Highways and Transportation have sponsored innovation demonstrations, for example to help increase the efficiency of equipment working on the provincial highway network.

Some agencies like the Ontario Ministry of Transportation (MTO), sponsor "innovation" seminars where agency, consultant, university and contractor personnel have reviewed and recommended specific promising innovations for development and implementation. Transport Québec (MTQ) established the Centre québécois de transfert de technologie routière (CQTTR), now called the Centre québécois de transfert des technologies des transports (CQTTT) which was established to transfer knowledge and promote transportation expertise. The MTQ also regularly sponsors transportation innovation projects and contributes financially to demonstration and technology advancement projects.

The Innovation Environment

While nearly all highway agencies recognize that the promotion of innovation is an important component in the delivery and maintenance of transportation infrastructure, the environment of innovation differs from agency to agency. While many highway agencies are engaged in basic research and actively promote and finance private sector innovation proposals, others 'tag' on to research projects developed by others or wait for someone else to develop and implement an innovation before adopting it for their own agency. In Europe, contractors tend to be much more vertically integrated with significant technical and financial capabilities and work in an environment that strongly fosters innovation. The move to Public/Private/Partnership type transportation project delivery mechanisms in Canada and the United States has helped promote innovation through the introduction of closely measured infrastructure performance requirements that pushes the concessionaire/contractor to innovate to enhance profitability.

Contract regulations typically act to minimize innovation as the contracting practices of many agencies make the introduction of innovation difficult. Many agencies cannot sole source a particular contractor or supplier without significant effort which tends to reduce the implementation of innovation. Further, roadway agencies often focus on the lowest price at a quality level established in advance.

The result of the agency design/bid/build procurement process is that developments and innovations take place in an arena that differs from the regular consumer market. In general, it is true that an entrepreneur will not make an investment in solutions unless they improve his/her business and/or profitability.

The best opportunity for innovation is providing an entrepreneur with the freedom to make choices. This is possible if the agency challenges the designer/contractor to develop creative solutions by using end performance specifications which allows the designer/contractor the ability to select a wide variety of solutions provided the end performance requirements are met. For example, for Ohio Department of Transportation (ODOT) concrete pavement construction projects, the contractor can elect to saw and seal concrete transverse joints or simply sawcut them. However, if the joints do not perform adequately according to a strict performance requirement, the contactor is required to repair or replace the affected concrete slabs. End performance specifications provide an entrepreneur with the freedom to introduce innovations. However, it is important for

both parties to have certainty about the price/performance ratio of an innovation. This means that the performance must be a known factor by means of some form of validation.

In all cases, the criteria used by the agency to tender a project are important and the financial pre-conditions must be clear. These pre-conditions determine the freedom for innovation given to the entrepreneur. If contracting takes place on the basis of the lowest price, the freedom for innovations is less than if contract award is made on the basis of the best value. If general social advantages are also involved as a criterion, several developments are possible, for example matters such as environmental pollution or aesthetics.

The method of concrete procurement and financial incentives/disincentives and also promote innovation. For example, lane rental or A+B bidding stimulates the creativity of an entrepreneur because he/she can gain a financial advantage for better contract performance. The stability of the contract award criteria does play an important role here as an entrepreneur must have the certainty that the investment costs for innovation can be recouped and often this is not possible for a single project.

Promoting Innovation

Innovation can ‘pave the way’ to making our engineers and contractors competitive on the world market while cost-effectively extending the service life of our transportation infrastructure while minimizing the impact of construction on the road users. By fostering collaboration between government agencies, industry and academia, it is possible to ‘partner’ to develop new policies, processes, and procedures to reduce time and cost and improve the safety of our infrastructure.

While innovation ultimately leads to a benefit which can include a reduction in cost, it is important to recognize that an investment in innovation is necessary to achieve the ultimate benefits. This typically requires some basic fundamental research and partners who are willing to take risks to develop the innovation. These risks can be financial, technological and commercial.

Barriers to innovation are always financial and in many cases relate to agency procurement processes. For example, until the 1990s, it was literally against the law for many U.S. highway agencies to use the design/build procurement method to deliver transportation projects. The U.S. Federal Acquisition Regulations (FAR) clauses precluded the use of design/build.

Since 1990, the FHWA has allowed the State DOTs to evaluate non-traditional contracting techniques under a program titled "Special Experimental Project No. 14 (SEP-14) - Innovative Contracting". The ultimate goal of the SEP-14 was to allow transportation agencies the use of alternate contracting, enabling them to accelerate construction projects in a cost-effective manner while maintaining product quality and contractor’s profitability.

Originally, the contracting practices approved for evaluation were: cost-plus-time bidding, lane rental, design-build contracting, and warranty clauses. After a period of evaluation, the FHWA decided that all four practices were suitable for use as operational practices (non-experimental).

Today, SEP-14 remains as a functional experimental program that may be used to evaluate promising non-traditional contracting techniques. In fact, the term "alternative contracting" may be a better descriptor than "innovative contacting" as some of these techniques are widely used and are no longer considered to be innovative by some contracting agencies. In 2002, the title of SEP-14 was changed from "Innovative Contracting" to "Alternative Contracting".

Section 1307 of the U.S. Transportation Equity Act for the 21st Century (TEA-21) required the FHWA to develop regulations to allow the design/build project delivery system in the federal-aid highway program. The Design-Build Contracting Final Rule was published in the Federal Register on December 10, 2002 and became effective on January 9, 2003. Subsequent modifications required by section 1503 of SAFETEA-LU resulted in revisions published in a final rulemaking on August 14, 2007.

SUMMARY AND CONCLUSIONS

In summary, it can be stated that developments can be directed and regulated on various levels:

- Legal framework;
- Agency procurement, innovation and research policy framework; and
- Contract conditions and allotment criteria.

The awareness that a problem exists and that someone must be willing to pay for the solution is the primary factor in determining an effective solution. The market will not do anything that worsens its competitive position. In its role as regulator, policy maker and agency, the government has various instruments available to direct development and promote innovation. The market will typically respond with creative solutions to arrive at the best solution at a reasonable profit.

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