COUNTRY REPORT: CANADA
Pressures for Change: New Developments and Emerging Issues in Canadian Geometric Design

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ON BEHALF OF THE GEOMETRIC DESIGN STANDING COMMITTEE OF
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ABSTRACT

This paper examines the continuing evolution of Canada's geometric design practices across the country in the decade since the publication of the last major revision of the national Geometric Design Guide for Canadian Roads by the Transportation Association of Canada in 1999. Since that time a number of incremental revisions to the guide have been released that recognize the improved state of knowledge in areas such as: the selection of design speed; horizontal and vertical alignment design consistency; modern roundabout design; intersection sight distance guidance; cost-effectiveness warrants for roadside barrier; and a number of other issues.

At the start of our paper, we outline both the changes noted above, and the broader evolution of Canadian geometric design practice that has taken place in the last ten years. We also highlight a set of key vectors for change that continue to evolve and note that that the need to manage these and other shifts in practice has become more challenging as the field continues to evolve rapidly in response to a number of critical pressures. These pressures include: the continuing emergence of new knowledge from research; public pressures for more sustainable and community-oriented design practices in constrained and sensitive situations; a growing recognition of the need to strengthen human factors guidance with the geometric design practice framework; and the continuing need to develop road designs that are both cost-effective and efficient.

The second section of the paper highlights the impacts of these emerging issues through a discussion of the practical design responses of various Canadian jurisdictions to them. These responses are reviewed through a series of examples from across the country that both illustrate and underline the importance of these pressures, and the needs they generate for new design policies and approaches that respond to them. Critical gaps in our knowledge and design policies are identified.

In the final part of this paper we discuss a new Canadian initiative that has the potential to initiate major changes to Canada's national Geometric Design Guide. This initiative is framed in the recognition of the critical change vectors identified in the discussion at the beginning of this paper. The importance of knowledge sharing, and its potential for nourishing this revision initiative, are discussed.

1 INTRODUCTION: THE CANADIAN ROAD SYSTEM

1.1 Overview

Roads provide the economic backbone of any country. They define its economic, political, and social fabric, the relationships between its parts, and the foundation for all other aspects of its transportation system. As others have noted before, roads represent the only true independent mode of transport.

Geography and history help define the kinds of road network that develops over time in a country as well as the kinds of technology and design approaches that are used in its deployment. Before embarking on any discussion of geometric design, it is instructive to look at the nature of a nation's road network and the uses that its citizens make of it.

1.2 Some key characteristics of Canada's road network

In the year 2000, the Canadian government established the Canada Transportation Act Review Panel. In carrying out their work, the panel summarized a number of key characteristics of Canada's road and highway network (*1*).

- About 65% of Canada's almost 1 million km of roads and highways are unpaved and in rural areas;
- Canadians drive about 270 billion vehicle kilometres per year;
- 75% of road travel occurs on only 25% of the network;
- 40% of road travel occurs on just 5% of the network;
- Highway 401, through the centre of Toronto, carries in excess of 350,000 vehicles per day – making it one of the busiest roads in the world;
- Most of the provincial highway network, including the Trans-Canada Highway (TCH) sees fewer than 3000 vehicles per day;
- Traffic has grown faster than the road network, and faster in particular than the capacity of arterial, expressway, and freeway systems around Canada's major cities;
- Since the 1990's truck traffic has actually grown faster than national economic output: a situation that is generally attributed to both innovations in logistics management (just-in-time delivery etc.) and the onset of North American Free Trade.
- Traffic congestion has become a serious problem in major metropolitan areas.

In addition to these observations, it is worth noting that the sheer size and significant physical and climatic differentiation of Canada – 10 million km^2 spanning 41° of latitude and 6 time zones from east to west - results in a wide variety of road types and technologies being deployed across the country in response to what are often singular and specific needs. In this context, developing national uniform approaches to road design and traffic engineering practices can represent a real challenge. Thus it is not surprising that the administrative instruments that have evolved to help facilitate coordination and harmonization among the 14 jurisdictions (10 provinces, 3 territories, and the federal government) within the country represent a combination of formalized institutional structures and a group of somewhat more amorphous facilitating bodies. The precise roles of the latter continue to evolve to fit both shifting political strengths, and in some cases, very specific national challenges and priorities that must be addressed quickly and effectively.

1.3 Geometric design in Canada: A snapshot of where we are

Since the last major revision to the national Geometric Design Guide for Canadian Roads (GDG) in late 1999 geometric design practices in Canada continue have continued to evolve, although it is evident that the rate of that evolution has taken place in two distinct stages. In the initial years up to about 2005, the pace was significant as reported in our last Country Report in Chicago (*2*). Since then, the output of revisions and additions to the guide has slowed considerably in spite of a growing body of relevant knowledge emerging from various American and international sources. Nonetheless, this new and available knowledge has enabled Canadian discussion on a number of basic technical issues for which new guidance either has been included, or is being considered for inclusion in revisions and additions to the guide. The areas touched upon in these various discussions include intersection sight distance, minimum radii on steep downgrades, cost-effectiveness-based roadside barrier warrants, generalized design guidance for modern roundabouts, and additions to the "Design Philosophy" chapter of the GDG to accommodate context sensitive design approaches in specific situations.

Unfortunately, consensus still eludes the Canadian design community on more significant issues of concern discussed in the 2005 Canadian country report to the 3rd International Symposium on Highway Geometric Design. These unresolved topics include: the accommodation of vulnerable road users; guidelines on design exceptions and design flexibility; and the provision of improved levels of guidance and specific tools for the explicit evaluation of the safety impacts of design decisions. In addition, Canadian designers have expressed significant interest in receiving more comprehensive and specific guidance in the GDG for the geometric design of both simple and complex high-volume modern roundabouts as the deployment of such facilities becomes more commonplace in Provinces such as Quebec and British Columbia: both early adopters of this design option.

Ironically, as pressures for resource development grow in remote parts of the Country, designers are also seeking more in-depth coverage of the geometric design of low-volume and resource roads: subjects that were present in the GDG in past editions, but for which specific guidance has – to a significant degree – been withdrawn in recent years. There is also growing recognition of the contribution that the human factors sciences can make in helping geometric design guidelines better address all road user needs from a design standpoint – particularly in complex and constrained situations involving legacy infrastructure.

2 VECTORS FOR CHANGE REDUX

2.1 General thoughts

In earlier country reports to this symposium we have highlighted the pressures for change in the traditional way in which we have executed the geometric design of our roadway systems. These pressures are not unique to Canada, but tend to be similar among countries where the automobile culture has strong traditional roots. Perhaps because of their territorial expanse Canada, the United States, and Australia all share this legacy.

In Canada, the degree of change needed to shift our thinking on geometric design is significant. As we note earlier in this report, the pace of change in our geometric design practices in Canada in the past five years has not kept up with the various pressures that are creating this need, and in 2010 we find that the primary vectors for change cited in our 2005 report continue to assert themselves on two distinct fronts that reflect “technical” and “public value” communities of interest. However, at the same time, we find that our understanding of the types of changes we need to effect and their implications for our geometric design practices have shifted.

2.2 Technical vectors for change

The continuing technical change vectors that appear to be of particular interest in Canada include the following.

- In many of Canada’s large cities travel demand is increasing to the point where capacity improvements are needed but legacy infrastructure constraints do not allow us to respond adequately. While the concept of geometric design guidelines and policies has traditionally provided us with a design framework that was reasonably robust and flexible, we now find our ability to deploy roadway improvements that reflect our traditional practices is becoming more and more constrained by physical limitations, cost effectiveness concerns, and in many cases, even constructability issues. Such constraints often force us to develop innovative responses that move us outside the comfort zone created by traditional design responses. In these cases, we must be able to recognize and evaluate changes in road safety explicitly across the real continuum of performance that we know exists. Only by so doing can we adequately and appropriately allocate priorities, choose between technical alternatives, and manage our risk exposure. This change vector provides an external “push” for change.
- It is clear that emerging road safety research and knowledge have begun to provide us with practical and reliable tools to address safety performance forecasting problems for both simple and complex entities within our road and roadside designs. While many lessons are yet to be learned as we moved these tools through the deployment process, the availability of this new knowledge has provided both individual practitioners and road agencies with new toolsets that in many cases can help professionals pursue innovative design ideas. This change vector provides an internal “pull” for change.
- The use by the majority of road agencies in Canada of operational reviews, road safety audit processes, and risk analysis techniques continues to grow to the point where they have not only become a necessary and generally accepted cornerstone for benchmarking safety performance, but also provide the technical foundation needed to allow agencies to move to performance-based design approaches: particularly in constrained or difficult situations. This change vector provides an internal “pull” for change.

It is thus not surprising that these technical vectors for change highlight three distinct needs of the road design community:

- A need for a more formal structure for defining defensible design flexibility that can extend our current thinking about the limits of the design domain in a variety of situations;
- A continuing need to develop and deploy robust safety analysis tools that can support performance-based flexible design approaches. At present, these tools are often deployed only in particularly challenging design situations, since their application can often demand specialized expertise and require both additional time and resources. There is a clear need to move such tools from this "specialist" realm, into the mainstream world of practical/production design.
- The need for well-defined, reliable, cost-effective, and practical performance-based design approaches that can be used in mainstream production design activities. Because of their inherent underlying complexity, the problem of developing such approaches is non-trivial. As noted in our 2005 Country report, it appears that true expert systems and the use of "intelligent agents" in software may help us overcome this challenge in the mid-term, but in the interim, adequate solutions and training techniques have yet to be developed and deployed by most agencies.

2.3 Public vectors for change

Since 2005, the public vectors for change in Canada continue to reflect changing community values. It is evident however, that the central public vector for change is now clearly articulated by government as a desire to move quickly and convincingly to a sustainable model of road transportation. While road agencies in Canada are enthusiastic about the concept, the execution of such sustainability strategies over the full spectrum of road deployment and maintenance activities lacks both definition and cohesion.

From a geometric design standpoint however two of the three key public vectors for change that we cited in our 2005 report still stand as the primary influences that are broadly based and supported by the public across Canada:

- Community pressures for context sensitive solutions to design challenges in both urban and rural areas. Coupled to the concept of "flexible design" discussed earlier, these pressures often result in political responses that can substantively influence final design choices. Without a well-defined and defensible approach to performance-based design, responding to requests for such a design approach can be very difficult indeed.
- The need to fully incorporate into the geometric design process, the explicit consideration of vulnerable road users (VRU's). Accommodating pedestrians, cyclists, disabled persons, and other vulnerable road users more appropriately within the road environment is becoming a high and widely supported priority in our country. The trend that we described in our 2005 Country report continues to flourish in Canada, with many municipal jurisdictions now adopting the approach of assigning design priority to the needs of pedestrians, cyclists, other road users, public transit, goods movement, and private motor cars, in that order. Unfortunately, the safety implications of the design decisions resulting from such priority assignments are not always well understood, since predictive models of VRU safety performance are still very much in their infancy.

Both of these emergent public vectors for change reinforce the needs arising from our technical vectors for change. In each case, improved tools and understanding are keys to ensuring appropriate risk management and hence, decision-making.

3 A BRIEF CROSS-COUNTRY PERSPECTIVE

3.1 Background

There is no national road authority in Canada. Instead, constitutional responsibility for all roads generally rests with the Provinces and we build a uniform consensus on geometric design practices across our country through the Transportation Association of Canada (TAC), a not-for-profit organization that is funded by the Federal Government, Provincial and Territorial Governments, Municipal Governments, and the private sector. TAC – under the technical guidance of its Geometric Design Standing Committee – produces and publishes the Geometric Design Guide for Canadian Roads.

Three Canadian Provinces (Ontario, Quebec, and Alberta) also publish their own distinct geometric design guides which are generally based on the TAC GDG, and these often introduce additional detail, or variations on design practices that are appropriate to their particular road environments. While the system sounds complex, it is the coordination and general direction provided by the TAC Guide that ensures that Canadian drivers experience a

consistent geometric design environment across the country. Some perspectives on current geometric design issues in various parts of our country are noted below.

3.2 British Columbia

As we noted in our 2005 report, British Columbia certainly leads the country in the application of context sensitive design principles on a continuous and significant scale with the completion of the upgrading of the Sea to Sky highway that has taken place over the past few years in preparation for the hosting of the 2010 Winter Olympics. The result is both technically innovative and – because of the mountainous nature of the terrain in which this highway is located – is also physically spectacular. While no specific plans have been announced as yet, the road design community in Canada is hopeful that some level of monitoring and research will take place as the highway enters regular service, in order to help us assess the safety implications of the approach used, and learn from some of the specific measures that have been applied. At the same time, the Province – along with the Province of Quebec – has also been an early adopter of modern roundabouts in Canada: using this design option across a full range of applications from simple residential-area installations, to complex, multi-lane roundabouts that handle major traffic volumes that include a significant proportion of heavy trucks. Interestingly, the Provincial government-run insurance agency (ICBC: the Insurance Company of British Columbia) has played a significant and proactive part in supporting and promoting the Provincial Department's use of roundabouts because of their well established and significant road safety benefits.

3.3 Alberta

With a strong energy-based resource economy the Province of Alberta has in the last few years, become one of Canada's most important economic performers. Much of the pressure for progress and change in geometric design approaches in this part of Canada flows from growth in the major urban centres of Calgary and Edmonton, where both conventional and P3 models of roadway project delivery have been used to accelerate the provision of sufficient urban freeway and arterial capacity to support the ongoing growth of the Province. The publishing in 2005 by Alberta Transportation (the provincial transportation agency) of a significant addition to its Provincial Geometric Design Guide in the form of an Urban Design supplement demonstrated its commitment to sustainable transportation principles through the provision of extensive new and enhanced guidance for the design of pedestrian and cycling elements of road facilities: material that is in substantial need of an update in our National GDG

More recently, the Department also added a substantive Roadside Design supplement to its ongoing Provincial geometric design guide. This supplement is particularly notable in its introduction of Alberta-specific cost-effectiveness-based barrier warrants for the Provincial highway system.

3.4 Ontario

The highway system under the jurisdiction of the Ministry of Transportation of Ontario (MTO) is the busiest in the country, and MTO is continuing its ongoing efforts to revise significant portions of its geometric design policies. Roadside design policies requiring enhanced clear zone and barrier-free design whenever possible have been in place for more than five years and are applied selectively to new and major rehabilitation projects. Maintaining and enhancing the most sophisticated freeway system in the country in the face of continuing significant growth in traffic and congestion is a major challenge for the Ministry – particularly given the physical constraints that often limit its ability to use conventional solutions in response to such demands. Community pressures for more sustainable roadway systems that support ongoing growth in active transportation modes (walking and cycling) have also resulted in MTO launching a study that is currently underway to examine new approaches to interchange design that facilitate the interactions of such arterial-level facilities with the major connections to the freeway systems without compromising active transportation facilities that form an integral part of the community-level road networks. The results of this work are expected within the next year.

Ontario continues to be a leader in Canada in moving towards performance-based geometric design. The explicit evaluation of safety in supporting geometric design decisions remains a priority for the Ministry, and a new software application (Highway Element Investment Review Guidelines: HEIR) has been developed by the MTO to consolidate and facilitate the continuing development and deployment of these techniques by both Ministry staff and the consulting engineering community. Active participation by Ministry staff in TRB activities and an ongoing interest in both the Highway Safety Manual and its supporting Safety Analyst package both confirm a strategic commitment by this agency to the concepts of its Science of Highway Safety initiative originally deployed over 10 years ago.

In 2009, the Ministry also launched its first full-scale driver simulation study to support the design of a unique freeway termination at a multi-lane roundabout. The results of this work will be completed by the summer of

2010. They are expected not only to yield valuable project-specific benefits, but should also help establish a foundation of expertise at the University of Guelph driver simulation facility that could be used in the future for similar design-supportive applications where developing an understanding of driver behaviour in the face of complexity, is essential to the project's success.

3.5 Quebec

Quebec continues to lead the way in the development of design guidelines for, and the practical application of modern roundabout technologies in Canada. Since our 2005 Country Report, its roundabout design guide *(3)*, has been published in both English and French and has received wide dissemination within Canada.

In its larger cities, and in particular on the Island of Montreal, the Province and the City of Montreal face many of the same design challenges being addressed by the MTO, with growing congestion, physical constraints on legacy infrastructure, and community pressures for more sustainable approaches to the design of new facilities and the maintenance of existing roadways. The City is currently responding to these community pressures with the provision and improvement of both pedestrian and cycling facilities.

3.6 The Atlantic Provinces

The four Atlantic Provinces of Canada – Nova Scotia, New Brunswick, Prince Edward Island (PEI), and Newfoundland/Labrador – are less densely settled than other Canadian jurisdiction. Because they were the first settled areas of the country, significant portions of their network are also older than in many other parts of the country. Medium to low volume roads are also common, and as such, the cost-effectiveness of design solutions is an important consideration for both new and 3R/4R design projects.

The design and deployment of both single and multiple-lane versions of modern roundabouts is being actively pursued in both Nova Scotia and PEI. Municipalities in both of these provinces are also beginning to use this technology to a significant degree. Both of these Provinces have also successfully calibrated the Interactive Highway Safety Design Model (IHSDM) although they have not used these tools as part of any specific design or planning project.

4 LOOKING AHEAD: A NEW INITIATIVE

4.1 Scoping the need for change and adaptation

In Sections 2.2 and 2.3 of this report, we have already discussed the primary vectors for change in geometric design in Canada. In response to these pressures, at its Annual Conference in 2009 the Transportation Association of Canada approved a scoping study that will begin to shape the directions for formal change to our national geometric design guide, the GDG. The scoping study will be comprehensive and will be completed by the spring of 2011. A critical objective of this scoping study is to help shape the future direction of the GDG in a manner that recognizes the vectors for change that are present in the country and how these reflect: the needs of the technical user community; the requirement to accommodate the varying ways in which different Canadian jurisdictions tackle similar geometric design challenges; and the desire to take advantage of new knowledge that already exists nationally and internationally that can be adapted to our purpose. The results of the scoping exercise will be used as the basis for the terms of reference for the next major revision to Canada's national geometric design guideline document.

While it is premature to speculate on the findings of the scoping study, it is probably safe to assume that the key avenues of investigation may reflect the vectors for change noted earlier and – among other things – will include:

- An assessment of the need for and availability of tools and approaches that are supportive of the concepts of both context sensitive and innovative design, and most importantly, performance-based design strategies and tools that provide strong guidance to designers who must deal with the substantial problem of working at and beyond the limit boundaries of the design domain;
- Explorations of the requirement for and assessment of available alternative rational and defensible guidelines for the development of design exceptions – particularly as they might apply to the challenges of dealing with the need to upgrade legacy road infrastructure situated in physically constrained design situations;
- A review of the need for and availability of geometric design approaches that recognize and better deal with the needs of vulnerable road users in specific and defensible ways;

- A review and assessment of the need for improved and expanded guidance on the use of modern roundabouts, including in particular complex high-volume junctions with significant volumes of heavy commercial traffic;
- An exploration and assessment of the need for a human-centered approach to design that incorporates substantive and practical guidance based on the human factors sciences.
- A review of new and innovative ways of publishing and deploying the GDG to help broaden the accessibility of this knowledge to a full range of public, private, and educational institutions.

4.2 A knowledge sharing approach

The scoping exercise will necessarily identify and evaluate relevant sources of knowledge that can be used to nourish the development any recommended set of revisions. New knowledge in geometric design is evolving and available both within Canada and abroad. In Canada, three Provincial jurisdictions (Ontario, Québec, and Alberta) currently maintain their own geometric design policy documents. All of these possess a common core of knowledge and guidelines, but in many areas also provide for unique approaches to various design challenges. Such differences often signal opportunities for sharing knowledge to mutual advantage and a wide variety of potential knowledge sources that can nourish this scoping effort appear to exist internationally as well. A few examples of the latter follow.

A current initiative in the US through the combined efforts of TRB and AASHTO is currently proceeding through a major strategic assessment of geometric design research needs in that country (*4*). In Britain in 2007, the Department for Transport issued a comprehensive Manual for Streets that provides new advice for the design of residential streets geared to the principles of the accommodation of cyclists and pedestrians, principles of sustainability in transportation and communities, and recognizing the important role that such road have in the creation of sustainable and inclusive public spaces (*5*) . Australia, through AustRoads, currently has one of the most accessible and continuous revision and publishing/deployment models for its road standards, including those related to geometric design. In Europe and the Nordic countries, principles of human-centred design and self-explaining roads have changed some of the basic elements of the road design process.

While these examples represent but a small fraction of the breadth of knowledge that is available and emerging in the world in the science of geometric design, they serve well to emphasize the commonality of the issues that link us all in our efforts to design sustainable, relevant, and practical roads that provide the foundation for the economic and social fabric of our society.

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