# METHODS OF REDUCING COLLISIONS ON ALBERTA ROADS

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## ABSTRACT

This study, titled "*Methods of Reducing Collisions on Alberta Roads*" (*MORCOAR*), is intended to complement the Alberta Traffic Safety Plan, which includes reducing fatal and serious injury collisions.

The primary objective of this project was to develop proven, cost-effective and innovative engineering strategies to cover the range of land use, roadway and speed environments in Alberta.

Seven "objective areas" were identified; Speed Related Collisions, Collisions at Unsignalized Intersections, Collisions at Signalized Intersections, Vehicle-Wildlife Collisions, Collisions Along Roadways, Run-Off-Road Collisions, and Collisions Involving Vulnerable Road Users.

For each objective area, collision reduction strategies were developed for rural, urban, and suburban situations, for various speed categories.

Phase 1 of MORCOAR identified 33 collision reduction measures as *Highly Effective Measures,* including eight of the most effective (Priority 1).

Phase 2 developed application guidance, including the costs, benefits, and suggested 20-year implementation strategy for the 33 *Highly Effective Measures,* as well as more detailed guidance for the eight Priority 1 measures. A User Guide was also developed to ensure the proper implementation of each measure.

The benefits (expected collision reduction ranges for Alberta) and life-cycle costs of each of the *Highly Effective Measures* were derived, then a range of Benefit Cost Ratio (BCR) values were calculated and compared to produce an implementation strategy.

An implementation strategy was developed to facilitate the timely and optimal implementation of the highly effective measures identified in this study. Implementability depends on numerous factors, and was presented for the consideration of each agency and for discussion between agencies. Three time frames were identified at the outset of the study (Immediate, 1-7 years, and 7-20 years).

## 1. Background and Objectives

The Alberta Traffic Safety Plan (ATSP), first published in 2006, outlines 2010 collision reduction targets for the Government of Alberta and identifies a wide range of traffic safety strategies to meet these targets. The Traffic Safety Action Plan (2007) identifies short-term activities and strategic objectives, focused on the improvement of Alberta's quality of life and the safety and security of communities. Since its inception in 2007, the Engineering Committee has been focused on developing and implementing Alberta Transportation's Engineering Strategic Plan (ESP) in support of the ATSP.

Alberta Transportation (TRANS) commissioned Opus International Consultants (Canada) Limited (Opus) to investigate and develop engineering strategies to address the collision patterns on all Alberta highways and streets. These roadways are operated by many different road authorities including urban municipalities, rural municipalities, Counties and the Province of Alberta.

This study, titled "*Methods of Reducing Collisions on Alberta Roads*" (abbreviated as *MORCOAR*) and conducted in two phases, was intended to complement the Alberta Traffic Safety Plan, which includes reducing fatal and serious injury collisions by 30% between the years of 2008-2010 compared to the baseline years of 1996-2001. The Province is currently developing new targets for 2015 to reflect the update to Transport Canada's Road Safety Vision.

The primary objective of this project was to develop proven, cost-effective and innovative engineering strategies to cover the range of land use, roadway and speed environments in Alberta. Seven "objective areas" were clearly identified:

- Speed Related Collisions;
- Collisions at Unsignalized Intersections;
- Collisions at Signalized Intersections;
- Vehicle-Wildlife Collisions;
- Collisions Along Roadways (Links);
- Run-Off-Road Collisions; and
- Collisions Involving Vulnerable Road Users.

For each objective area, collision reduction strategies were developed for both rural and urban situations (where appropriate), for each of the following posted speed categories:

- 50 km/h or less;
- 60 km/h to 70 km/h;
- 80 km/h to 90 km/h; and
- 100 km/h or more.

Phase 1 of the MORCOAR study researched and developed engineering strategies and measures. More than one thousand separate references were researched to develop 77 'Toolbox Measures' considered to be the most applicable for the Alberta context. These were then reduced to the 33 collision reduction measures identified as *Highly Effective Measures,* including eight of the most effective (Priority 1), for the development of more detailed guidance.

Phase 2 developed application guidance for the 33 *Highly Effective Measures,* as well as more detailed guidance for the eight Priority 1 measures. The costs, benefits, and suggested 20-year implementation strategy was then developed for each *Highly Effective Measure*. Additionally, a User Guide was developed to ensure the proper implementation of each measure.

## 2. Alberta Road Agency Survey

TRANS and several municipal road agencies were contacted at the outset of Phase 2 to determine the extent to which each of the *Highly Effective Measures* are currently in use, and the effectiveness of each measure within their jurisdiction and whether the application guidance they have is sufficient. This information was used to modify and finalize the list of *Highly Effective Measures*.

## 3. List of Measures by Context

The 33 *Highly Effective* Measures were divided among the appropriate *land use* and *speed* contexts. The purpose of distinguishing the measures in this manner was to encourage that they be implemented in the most effective way in order to maximize their benefit.

The land use contexts identified for this study were "Urban," "Rural," and "Suburban". For the purpose of this study, *urban* roads generally refer to low speed roads with raised curbs and *rural* roads are defined as higher speed roads with grass ditches and/or medians. *Suburban* roads were also identified as containing a hybrid of urban and rural characteristics. The speed categories are defined in Section 1 above. TABLE 1 lists all thirty-three measures by applicable context.

One-page guidelines were then prepared for each of the *Highly Effective Measures*. These guidelines act as 'quick references' for application guidance, costs and likely benefits. They also provide references to the best current industry application and implementation guidance. Note that of the seven objective areas; only Vehicle-Wildlife Collisions did not have any measures to be classified as highly effective, due to the low rate and severity of injuries to humans. The one-page guidelines for the eight Priority 1 measures are provided in FIGURE 1 to FIGURE 8.

## 4. Detailed Application Guidelines

Of the 33 *Highly Effective* Measures, a benefit-cost analysis was undertaken and determined the top eight measures to be the most effective (Priority 1) due to their high cost-effectiveness and high overall effectiveness in reducing collisions. These measures are as follows:

- Gateway Treatments;
- Variable Speed Limits;
- Conversion of Stop-controlled Intersections to Roundabouts;
- Positive Offset Left-turn Lanes;
- Protected-only Left-turn Phasing;
- High-Tension Cable Barrier Systems;
- Removal of Fixed Objects; and,
- Pedestrian Countdown Signals.

The eight Priority 1 measures were then described in detail, with the following sub-sections:

Background and Definitions;Current Status in Alberta;Example Applications;Benefits and Costs;Existing Application Guidance (Provincial, National and International);Recommended Application Guidance;Applicability (Land Use and Speed

Context);Recommended Procedures and Implementation Considerations;Human Factors; and,Maintenance Considerations.

## 5. Benefit-Cost Evaluation

The benefits (expected collision reduction ranges for Alberta) and life-cycle costs of each of the *Highly Effective Measures* were derived, then a range of Benefit Cost Ratio (BCR) values were calculated and compared to produce an implementation strategy. The highest and lowest BCRs for each of the 33 countermeasures were determined as follows:

$BCR_{Low}$=Lowest Expected Benefit / Highest Expected Cost
$BCR_{High}$=Highest Expected Benefit / Lowest Expected Cost

The BCR range for each of the thirty-three countermeasures is provided in TABLE 2 by objective area.

## 6. Implementation Strategy

An implementation strategy was developed to facilitate the timely and optimal implementation of the highly effective measures identified in this study. Implementability depends on numerous factors, and was presented for the consideration of each agency and for discussion between agencies. Three time frames were identified at the outset of the study (Immediate, 1-7 years, and 7-20 years). Ten countermeasures were identified as "quick-wins" and are recommended to be implemented immediately. Eighteen countermeasures were recommended during the 1-7 year time frame, while five were identified for the 7-20 year horizon. The recommended time frames for the top 33 countermeasures are presented in TABLE 3. The success of several of the measures will depend on the level of public education delivered and the extent of enforcement conducted. Legislative changes may also be required to enforce some of the recommended countermeasures.
The success of any collision reduction initiative can only be assessed if a clear and effective monitoring and evaluation plan is put into place. It is suggested that *fatal and injury collisions* be used as the primary source of data, to measure the success of implementing the measures identified in this study. While activities should be monitored on an ongoing basis, it is recommended that the effectiveness of the enhancements be formally evaluated at pre-determined intervals:

*-Quick wins:* after one year and subsequently every three years thereafter;
*-1-7 Year Strategies:* within three years, and then within seven years of implementation; and,
*-7-20 Year Strategies:* formal evaluations should be conducted every three years.

## 7. Next Step and Possible Further Work

To maximize the value of this study, TRANS and the Engineering Committee can consider the following follow-up actions:

- Circulate study deliverables to road agencies;
- Provide training to industry and stakeholders in Alberta;
- Incorporate measures into existing processes and budgets;
- Adapt guidelines to current policies and standards; and,
- Set up evaluation and monitoring program.

Subsequent to (or in parallel with) the above "next steps", TRANS and the Engineering Committee may consider the following work items:

- Conduct another agency survey to prioritize the need for detailed guidance for other 25 Highly Effective Measures;
- Develop application guidance for other Highly Effective Measures;
- Initiate the development of national guidance;
- Provide updates as important new guidance gets released;
- Prepare supporting implementation guidance;
- Incorporate new HSM information and new Canadian CMFs;
- Prepare Alberta-specific collision prediction models; and,
- Conduct another comprehensive MORCOAR study in 5 years (2015), to capture new national and provincial priorities and 2020 targets.

TABLES and FIGURES

## TABLE 1 33 HIGHLY EFFECTIVE MEASURES BY LAND USE AND SPEED CONTEXT

| COLLISION REDUCTION MEASURE | URBAN SPEED LIMIT (km/h) | | | | RURAL SPEED LIMIT (km/h) | | | |
|---|---|---|---|---|---|---|---|---|
| | ≤50 | 60-70 | 80-90 | ≥100 | ≤50 | 60-70 | 80-90 | ≥100 |
| ***Speed Management*** | | | | | | | | |
| 1. Consistent speed limits | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 2. Gateway treatments | | | | | | ✓ | ✓ | ✓ |
| 3. Transverse pavement markings | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | |
| 4. Variable speed limits | | | ✓ | ✓ | | | ✓ | ✓ |
| ***Unsignalized Intersections*** | | | | | | | | |
| 5. Advance warning on major road | | | | | | | ✓ | ✓ |
| 6. Conversion to roundabout | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 7. Flashing beacon on stop sign | | | | | | | ✓ | ✓ |
| 8. Left-turn lanes on major road | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| 9. Removal of obstructions | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 10. Transverse rumble strips | | | | | | | ✓ | ✓ |
| ***Signalized Intersections*** | | | | | | | | |
| 11. Advance warning flashers | | ✓ | | | | | ✓ | |
| 12. Conversion to roundabout | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | |
| 13. Dedicated left-turn lane / phasing | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | |
| 14. Positive offset left-turn lanes | ✓ | ✓ | ✓ | | | | | |
| 15. Protected only left-turn phases | | ✓ | ✓ | | | ✓ | ✓ | |
| 16. Removal of unwarranted signals | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | |
| 17. Signal back plates | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | |
| 18. Smart right-turn channel | ✓ | ✓ | | | | | | |
| ***Off-Road Movements*** | | | | | | | | |
| 19. Advance curve warning signs | | | | ✓ | | ✓ | ✓ | ✓ |
| 20. High-tension cable barrier systems | | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| 21. Horizontal and vertical realignments | | | | ✓ | | | ✓ | ✓ |
| 22. Impact attenuators | | | | | | | ✓ | ✓ |
| 23. Removal of fixed objects | | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| 24. Rumble strips (shoulder/centreline) | | | | | | ✓ | ✓ | ✓ |
| ***Roadways (Links)*** | | | | | | | | |
| 25. Delineator posts | | | | | | ✓ | ✓ | ✓ |
| 26. Edgelines and centrelines | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 27. High-visibility pavement markings | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 28. Increased sign retroreflectivity | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 29. Linear delineation systems | | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| 30. Wider pavement markings | | | ✓ | ✓ | | | ✓ | ✓ |
| ***Vulnerable Road Users*** | | | | | | | | |
| 31. New/upgraded intersection lighting | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 32. Pedestrian countdown signals | ✓ | ✓ | | | | | | |
| 33. Wider sidewalk / paved shoulder | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| TOTAL NUMBER OF MEASURES | 19 | 23 | 17 | 15 | 14 | 16 | 27 | 22 |

## TABLE 2 BENEFITS AND COSTS OF COUNTERMEASURES

| Countermeasure | Benefit Range* | Annual Life Cycle Cost Range | BCR Range |
|---|---|---|---|
| ***Speed Management*** | | | |
| Consistent Speed Limits | 10% - 16% of all injury collisions | $1,050 - $1,100 | 9.1 – 15.2 |
| Gateway Treatments | 25%-50% of serious injury/fatal collisions | $2,700 - $52,500 | 0.5 – 18.5 |
| Transverse Pavement Markings | 20% - 44% of all fatal and injury collisions | $4,000 - $7,000 | 2.9 – 11.0 |
| Variable Speed Limits | 10% - 16% of all injury collisions | $2,600 - $32,500 | 0.3 – 6.2 |
| ***Unsignalized Intersections*** | | | |
| Advance Intersection Warning on Major Road | 15% - 30% of all injury collisions | $1,030 - $1,160 | 12.9 – 29.1 |
| Conversion of Stop Controlled Intersections to Roundabouts | 57.6% - 69.6% of all fatal and injury collisions | $15,500 - $28,000 | 2.1 – 4.5 |
| Dedicated Left Turn Lanes on Major Road Approaches | 29% - 35% of all fatal and injury collisions | $3,000 - $7,500 | 3.9 – 11.7 |
| Flashing Beacon on Stop Sign | 15% - 30% of all injury collisions | $1,550 - $1,700 | 8.8 – 19.4 |
| Removal of Obstructions Within Sight Triangle | 20% - 37% of all injury collisions | $2,516 – 19,166 | >50 |
| Transverse Rumble Strips | 10% - 22% of all injury collisions | $2,900 - $3,700 | 2.7 – 7.6 |
| ***Signalized Intersections*** | | | |
| Advance Intersection Warning Flashers | 20% - 44% of all injury collisions | $3,100 - $3,700 | 5.4 – 14.2 |
| Conversion of Signalized Intersections to Roundabouts | 30% - 62.4% of all fatal and injury collisions | $16,750 - $28,000 | 1.1 – 3.7 |
| Dedicated Left-turn Lanes With Phasing | 30% - 58% of all injury collisions | $3,250 - $8,000 | 3.8 – 17.8 |
| Positive Offset Left-turn Lanes | 20% - 40% of injury collisions | $3,500 - $8,000 | 2.5 – 11.4 |
| Protected Only Left-turn Phase | 8% - 16% of injury collisions | $2,515 - $2,560 | 3.1 – 6.4 |
| Removal of Unwarranted Traffic Signals | 25% - 53% of all injury collisions | $1,066 - $1,216 | 20.5 – 49.7 |
| Signal Back Plates | 15% - 32% of all injury collisions | $1,550 - $2,700 | 5.6 – 20.6 |
| Smart Right-turn Channel | 65% - 80% of all injury collisions | $3,250 - $5,000 | 13.0 – 24.6 |

| Countermeasure | Benefit Range* | Annual Life Cycle Cost Range | BCR Range |
|---|---|---|---|
| ***Off-Road Movements*** | | | |
| Advance Curve Warning Signs | 5% - 13% of all injury collisions | $1,090 - $1,240 | 4.0 – 11.9 |
| Cable Barriers | 15% - 35.2% reduction of run-off-road injury collisions (roadside)<br><br>36% - 72% reduction of head-on injury collisions (median) | $4,700 - $7,500 | 2.0 – 7.5 (roadside)<br><br>4.8 – 15.3 (median) |
| Horizontal and Vertical Realignments | 50% - 73% of all injury collisions | $3,500 - $34,333 | 1.5 – 20.9 |
| Impact Attenuators | 35% - 75% of injury collisions | $5,500 - $8,500 | 4.1 – 13.6 |
| Removal of Fixed Objects | 15% - 30% of all injury collisions | $2,003 - $52,000 | 0.3 – 15.0 |
| Shoulder Rumble Strips | 10% - 18% of all injury collisions | $2,530 - $2,560 | 3.9 – 7.1 |
| ***Roadways (Links)*** | | | |
| Delineator Posts | 5% - 11% of all injury collisions | $1,150 - $1,200 | 4.2 – 9.6<br>(assume 10 posts) |
| Edgelines and Centrelines | 10% - 19% of all injury collisions | $1,584 - $1,758 | 5.7 – 12.0 |
| High-visibility Pavement Markings | 10% - 19% of injury collisions | $1,600 - $1,800 | 5.6 – 11.9 |
| Increased Sign Retroreflectivity | 25% - 42% of all injury collisions | $1,100 - $1,320 | 18.9 – 38.2 |
| Linear Delineation Systems | - | $1,800 - $81,500 | - |
| Wider Pavement Markings | 10% - 16% of all injury collisions | $1,600 - $1,800 | 5.6 – 10.0 |
| ***Vulnerable Road Users*** | | | |
| New or Upgraded Intersection Lighting | 39% - 78% of all injury collisions | $2,600 - $3,500 | 11.1 – 30.0 |
| Pedestrian Countdown Signals | 15% - 25% of all pedestrian collisions | $2,080 - $2,200 | 6.8 – 12.0 |
| Wider Sidewalk or Paved Shoulder | 65% -89% of all pedestrian collisions | $13,000 - $52,000 | 1.3 – 6.8<br>(assume 1km length) |

*Note: "all" (in terms of collision type) is assumed to refer to the preventable collisions, or collisions within the affected area only. This was not explicitly stated in the sourced material, but by making this assumption it will not result in a non-conservative estimate; e.g. gateway treatments are only effective in the vicinity of the gateway treatment, and the reductions associated positive offset left-turn lanes refer only to left-turn collisions in the direction of application.

**TABLE 3 RECOMMENDED COUNTERMEASURE IMPLEMENTATION TIMELINES**

| Implementation Time Frame | Objective Area | Collision Reduction Measures |
|---|---|---|
| Immediate ("quick-wins")<br><br>(10 Collision Reduction Measures) | Speed Management | • Consistent Speed Limits |
| | Unsignalized Intersections | • Removal of Sight Obstructions<br>• Advance Intersection Warning on Major Road<br>• Flashing Beacon on Stop Sign |
| | Signalized Intersections | • Removal of Unwarranted Traffic Signals<br>• Smart Right-Turn Channels |
| | Roadways (Links) | • Edgelines and Centrelines |
| | Run-Off-Road | • Cable Barriers |
| | Vulnerable Road Users | • New or Upgraded Intersection Lighting<br>• Pedestrian Countdown Signals |
| | | |
| 1 – 7 Years<br><br>(18 Collision Reduction Measures) | Speed Management | • Gateway Treatments<br>• Transverse Pavement Markings<br>• Variable Speed Limits |
| | Unsignalized Intersections | • Dedicated Left-Turn Lanes<br>• Transverse Rumble Strips<br>• Conversion to a Roundabout |
| | Signalized Intersections | • Signal Back Plates<br>• Advance Warning Flashers<br>• Dedicated Left-Turn Lane and Phasing<br>• Positive Offset Left-Turn Lanes<br>• Protected-Only Left-Turn Phasing |
| | Roadways (Links) | • Increased Sign Retro-reflectivity<br>• High Visibility Pavement Markings<br>• Wider Pavement Markings |
| | Run-Off-Road | • Impact Attenuators<br>• Curve Warning Signs<br>• Rumble Strips (shoulder/centreline) |
| | Vulnerable Road Users | • Wider Sidewalks or Paved Shoulders |
| | | |
| 7 – 20 Years<br><br>(5 Collision Reduction Measures) | Speed Management | • None |
| | Unsignalized Intersections | • None |
| | Signalized Intersections | • Conversion to Roundabouts |
| | Roadways (Links) | • Linear Delineation Systems<br>• Delineator Posts |
| | Run-Off-Road | • Horizontal and Vertical Realignments<br>• Removal of Fixed Objects |
| | Vulnerable Road Users | • None |

# Gateway Treatments

## Land Use

| | |
|---|---|
| Urban | |
| Suburban | √ |
| Rural | √ |


## Posted Speeds


| | |
|---|---|
| ≤50 km/h | |
| 60-70 km/h | √ |
| 80-90 km/h | √ |
| ≥100 km/h | √ |

## Application Guidance

***Objective:*** **to define and emphasize the transition between a higher-speed and lower-speed environment.**

Gateway Treatments are more common outside of Canada, and there is no specific guidance for their application within Canada. Detailed guidelines have been prepared in the document *Application Guidelines for Gateway Treatments* as part of the study on *Methods of Reducing Collisions on Alberta Roads (Section 3.1)*. Gateway treatments are encouraged:

- Where there is a transition in the land use (rural to suburban, or suburban to urban;
- Where the speed limit changes by 20 km/h or more;
- Where collisions are concentrated near this transition (including collisions involving vulnerable road users);

The detailed application guidelines provide guidance on the various types of gateway treatments for each land-use and speed limit category. In general, the effectiveness of a gateway treatment is maximized when it contains a combination of both horizontal and vertical features. They also contain a number of implementation details, including instructions for the placement of gateway treatments.

## Alberta Status

| | *N* | *L* | *C* | *P* |
|---|---|---|---|---|
| Large Municipalities | | √ | | |
| Small Municipalities | √ | | | |
| Highways | √ | | | |

N=None; L=Limited; C=Common; P=Proven

## Documented Benefit

25% of all injury collisions[1]

50% of all fatal and serious injury collisions[1]

*25%-50% of serious injury/fatal collisions*

## Typical Installation Cost

| | Unit | Cost Range* | |
|---|---|---|---|
| | | Low | High |
| Retrofit | each | $2000 | $500,000 |
| New | each | $2000 | $500,000 |

*Large cost ranges due to variability of treatment types.

## Further Guidance

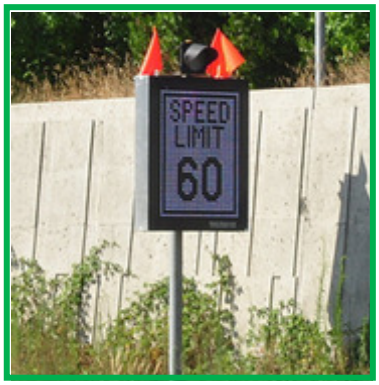
FHWA *Determining Effective Roadway Design Treatments for Transitioning from Rural Areas to Urban Areas on State Highways* (2008)

LTSA *Guidelines for Urban-Rural Speed Thresholds RTS 15* (2002)

## Other Effective Strategies and Enhancements

- New or upgraded intersection lighting
- Advance intersection warning on major road
- Transverse pavement markings
- Wider Sidewalk or Paved Shoulder
- Conversion of Signalized Intersection to a Roundabout
- Conversion of Unsignalized Intersection to a Roundabout

# Variable Speed Limits




## Land Use

| | |
|---|---|
| Urban | √ |
| Suburban | √ |
| Rural | √ |


## Posted Speeds


| | |
|---|---|
| ≤50 km/h | |
| 60-70 km/h | |
| 80-90 km/h | √ |
| ≥100 km/h | √ |

## Application Guidance

***Objective:*** **to provide safer and more appropriate speed limits that reflect real-time traffic, road surface and weather conditions.**

Variable speed limits (VSLs) have been successfully applied in Europe and other parts of the world. However, legislation does not currently permit these signs to be enforceable in Alberta or other provinces. Due to their significant safety benefits, VSLs are now gaining more attention. The document *Safety Benefits of Variable Speed Limits* has been prepared as part of the study on *Methods of Reducing Collisions on Alberta Roads (Section 3.2)*, to synthesize these benefits, and to identify the barriers towards implementing VSL on Alberta's roadways.

The above document also provides some basic guidance on appropriate applications for VSLs. They are typically provided on freeways, where movement is free-flow outside of peak traffic periods and not influenced by traffic control devices such as traffic signals. They would be most commonly provided for congestion relief in more urbanized areas, for weather/road conditions in more rural areas, and where road incidents could result in major disruptions to the traffic and secondary incidents.

Once legislation is in place, extensive review of individual locations would need to be undertaken to determine the safe and appropriate speed to display.

## Alberta Status

| | *N* | L | *C* | *P* |
|---|---|---|---|---|
| Large Municipalities | √ | | | |
| Small Municipalities | √ | | | |
| Highways | √ | | | |

N=None; L=Limited; C=Common; P=Proven

## Documented Benefits

45% of all collisions[2]

20% of all injury collisions[3]

*10% - 16% of all injury collisions*

## Typical Installation Cost

| | Units | Cost Range* | |
|---|---|---|---|
| | | Low | High |
| Retrofit | each | $1200 | $300,00 |
| New | each | $1000 | $300,000 |

*Large cost ranges due to variability in sign types (side-mounted vs. overhead).
'Retrofit' slightly higher due to the removal of existing sign.

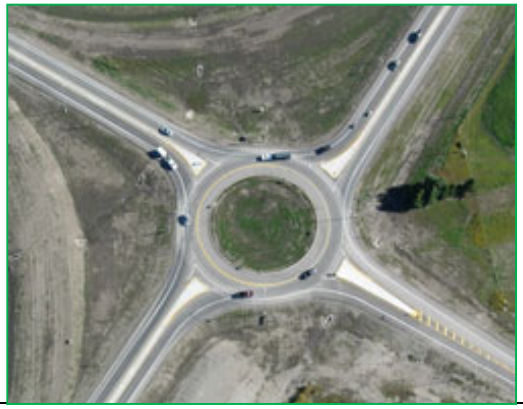
## Further Guidance

*MUTCD [Section 2B.13]*

## Other Effective Strategies and Enhancements

- Consistent speed limits
- Transverse pavement markings
- Horizontal and vertical realignments
- Gateway treatments

# Conversion of Stop-Controlled Intersections to Roundabouts



## Land Use

| | |
|---|---|
| Urban | √ |
| Suburban | √ |
| Rural | √ |


## Posted Speeds


| | |
|---|---|
| ≤50 km/h | √ |
| 60-70 km/h | √ |
| 80-90 km/h | √ |
| ≥100 km/h | √ |

## Application Guidance

***Objective:* to reduce conflicting movements and collision severity at stop-controlled intersections through horizontal deflection, reduced speeds and simple yield-control.**

A high proportion of the rural fatalities and major injuries around the province occur at stop controlled intersections, and enhancements to the stop control have resulted in only limited effectiveness. A well designed modern roundabout can improve the safety of some of these intersections by more effectively reducing speeds and eliminating conflict points.

Detailed application guidelines have been prepared as part of the *Methods of Reducing Collisions on Alberta Roads* study, and are documented in *Application Guidelines for the Conversion of Stop-Controlled Intersections to Roundabouts (Section 3.3)*.

In general, conversion to a roundabout should be considered along higher-speed non-freeway roads in all cases where:

- the need to provide a higher degree of traffic control than a "stop control" is established; and
- there is a clear economic benefit based on safety and other considerations under current traffic conditions.

Roundabouts are discouraged along existing or future freeways, national highway routes, and at other locations where through volumes are dominant and left-turning volumes are minimal.

If a roundabout is to be installed, implementation guidance (for the layout, signing and marking) is described in Roundabouts: An Informational Guide (Publication No. FHWA-RD-00-067), USDOT, FHWA.

## Alberta Status

| | *N* | *L* | *C* | *P* |
|---|---|---|---|---|
| Large Municipalities | | √ | | |
| Small Municipalities | | √ | | |
| Highways | | √ | | |

N=None; L=Limited; C=Common; P=Proven

## Documented Benefits

18% - 72% of all collisions[4]

72% - 87% of all fatal and injury collisions[4]

*57.6% - 69.6% of all fatal and injury collisions*

## Typical Installation Cost

| | Units | Cost Range | |
|---|---|---|---|
| | | Low | High |
| Retrofit | LS | $250,000 | $275,000 |
| New* | - | - | - |

*'Retrofit' is expected to be slightly more expensive than 'New' due to the added costs of removing existing signs and possible regrading.

## Further Guidance

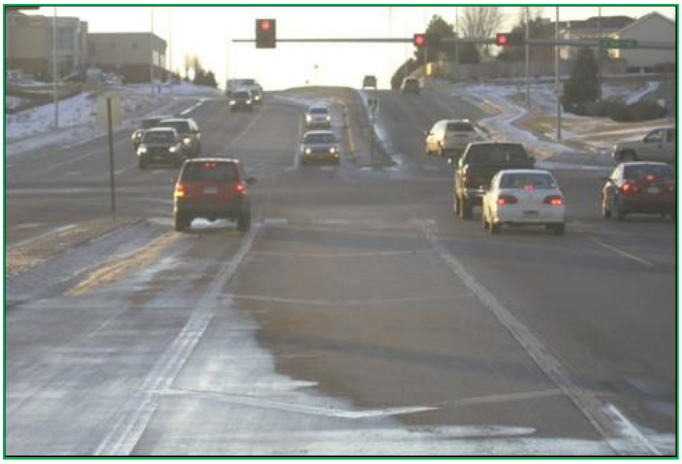
*Alberta Transportation Roundabout Design Guidelines on Provincial Highways (Design Bulletin #68/2010)*

TAC's *Synthesis of North American Roundabout Practice* (2008)

## Other Effective Strategies and Enhancements

- Transverse rumble strips
- New or upgraded intersection lighting
- Gateway treatments
- Advance intersection warning on major road
- Removal of obstructions in sight triangle

# Positive Offset Left-turn Lanes



## Land Use


| | |
|---|---|
| Urban | √ |
| Suburban | √ |
| Rural | √ |

## Posted Speeds


| | |
|---|---|
| ≤50 km/h | √ |
| 60-70 km/h | √ |
| 80-90 km/h | √ |
| ≥100 km/h | |

## Application Guidance

***Objective:* to improve sight distance for permissive left-turn movements at signalized intersections.**

Positive offset left-turn lanes (aligning opposing left-turn lanes to the left-of one another) can help provide an unobstructed view of opposing traffic, to assist drivers in successfully accepting a safe gap in traffic. This measure has been found to be extremely beneficial for older drivers.

In general, it is suggested that positive-offset left-turn lanes be provided wherever space exists and permissive left-turn movements are provided. *Guidelines for the Application of Positive Offset Left-turn Lanes* have been prepared as part of the study on *Methods of Reducing Collisions on Alberta Roads (Section 3.4)*. The key installation criteria include:

- Safety: presence of left-turn collisions
- Signal phasing: where it may not be possible to provide protected left-turn phasing
- Median width: at least 10.8 metres

The offset is much more effective with raised separation, but can also be applied using depressed island or pavement markings. The detailed guidelines referred to above include recommended positive offset distances.

## Alberta Status

| | *N* | *L* | *C* | *P* |
|---|---|---|---|---|
| Large Municipalities | | | √ | |
| Small Municipalities | | √ | | |
| Highways | | √ | | |

N=None; L=Limited; C=Common; P=Proven

## Documented Benefits*

20%-40% of left-turn across path injury/fatal collisions[5]

*Although not explicitly stated, the collision reduction is assumed to be just for the approaches that the treatment was applied.

*20% - 40% of injury collisions*

## Typical Installation Cost

| | Units | Cost Range | |
|---|---|---|---|
| | | Low | High |
| Retrofit | LS | $10k | $100k |
| New | LS | $25k | $100k |

## Further Guidance

*TAC Geometric Design Guide for Canadian Roads [Section 2.3.8.7]*

*Alberta Highway Geometric Design Guide, Urban Supplement [Section U.D.1.4]*

## Key Related Strategies and Enhancements

- Protected only left-turn phase
- New or upgraded intersection lighting
- Dedicated left-turn lane with phasing
- Traffic signal backboards

# Protected Only Left-turn Phase

## Land Use


| | |
|---|---|
| Urban | √ |
| Suburban | √ |
| Rural | √ |

## Posted Speeds


| | |
|---|---|
| ≤50 km/h | |
| 60-70 km/h | √ |
| 80-90 km/h | √ |
| ≥100 km/h | |

## Application Guidance

***Objective:*** **to provide assured gaps for left-turn vehicles at signalized intersections.**

Protected-only left-turn phasing is clearly associated with a reduction in injury and fatal collisions at signalized intersections. Current guidance from the Transportation Association of Canada covers only left-turn protection and not specifically protected-only phasing. *Application Guidelines for Protected-only Left-turn Phasing* have now been prepared as part of the study on *Methods of Reducing Collisions on Alberta Roads (Section 3.5)*. These guidelines suggest reviewing the need for protected-only left-turn phase based on 24 hour conditions in addition to peak hour conditions. Protected-only phasing is encouraged where:

- Visibility for left-turn movements does not allow for adequate gap assessment;
- Left-turns cross three (3) or more opposing through lanes, or where the speed limit along the roadway is 70 km/h or greater;
- Left-turns are permitted from two or more left-turn lanes on one approach; unless opposing through traffic volumes are very low;
- Left-turn across path collisions exceed seven (7) over a three-year period for an approach where protected/ permissive phasing is in use.

## Alberta Status

| | *N* | *L* | *C* | *P* |
|---|---|---|---|---|
| Large Municipalities | | | √ | √ |
| Small Municipalities | | √ | | |
| Highways | | | √ | |

N=None; L=Limited; C=Common; P=Proven

## Documented Benefits*

30% - 36% of all collisions[6]

16% of urban fatal and injury left-turn across path collisions[6]

19% of urban fatal and injury angle collisions[6]

*Above reductions are for protected/ permissive phasing. Protected-only is expected to yield greater reductions.

*8% - 16% of injury collisions*

## Typical Installation Cost

| | Units | Cost Range | |
|---|---|---|---|
| | | Low | High |
| Retrofit | each | $400 | $1200 |
| New | each | $300 | $800 |

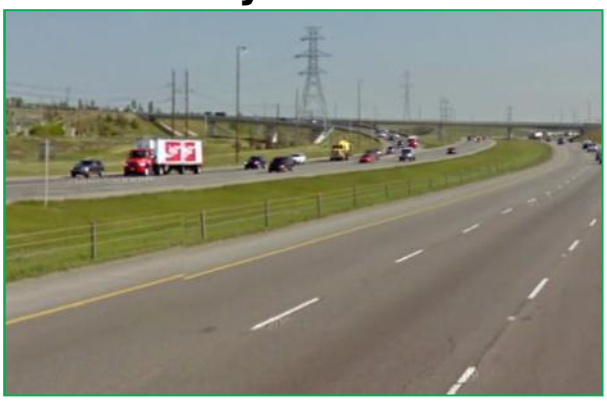
## Further Guidance

TAC *Manual of Uniform Traffic Control Devices for Canada* (1998) [Sec B4.4]
*Alberta Highway Geometric Design Guide [Sec D.4.3]*

## Other Effective Strategies and Enhancements

- Positive offset left-turn lanes
- New or upgraded intersection lighting
- Pedestrian countdown signals

# High-Tension Cable Barrier Systems



## Land Use


| | |
|---|---|
| Urban | √ |
| Suburban | √ |
| Rural | √ |

## Posted Speeds


| | |
|---|---|
| ≤50 km/h | |
| 60-70 km/h | √ |
| 80-90 km/h | √ |
| ≥100 km/h | √ |

## Application Guidance

***Objective:* to minimize the severity of median crossover collisions and run-off-road collisions.**

High tension cable barriers are intended to reduce the risk of cross-median collisions and run-off-road collisions with significant hazards. While they have recently been implemented successfully in median applications in Alberta, greater use for roadside applications is encouraged (to protect a roadside hazard such as a fixed object, steep embankment or a water body). The feasibility of removing or relocating hazards should be considered prior to providing a barrier.

Detailed application guidance is provided in *Guidelines for the Application of High Tension Cable Barrier Systems*, prepared by Opus as part of the study *Methods of Reducing Collisions on Alberta Roads (Section 3.6)*. For median applications, the need is based on a combination of traffic volume and median width. For roadside applications, factors that are to be considered include:

- Clear zones
- Presence of hazards
- Steepness of sideslopes
- Presence of obstacles and water bodies

## Alberta Status

| | *N* | *L* | *C* | *P* |
|---|---|---|---|---|
| Large Municipalities | √ | | | |
| Small Municipalities | √ | | | |
| Highways | | √ | | √ |

N=None; L=Limited; C=Common; P=Proven

## Documented Benefits

44% reduction of run-off-road fatal collisions (roadside guardrail)[7]

90% reduction of head-on injury collisions (median barrier)[8]

91% reduction of head-on fatal collisions (median barrier)[9]

*15% - 35.2% reduction of run-off-road injury collisions (roadside)*

*36% - 72% reduction of head-on injury collisions (median)*

## Typical Installation Cost

| | Units | Cost Range | |
|---|---|---|---|
| | | Low | High |
| Retrofit | m | $110 | $250 |
| New | m | $110 | $220 |

## Further Guidance

*Alberta Transportation's Roadside Design Guide (2007) [Ch H-5]*

*TAC Geometric Design Guide for Canadian Roads [Section 3]*

## Other Effective Strategies and Enhancements

- Advance curve warning signs
- Horizontal and vertical realignments
- Linear delineation systems
- Removal of fixed objects from the clear zone

# Removal of Fixed Objects

## Land Use

| | |
|---|---|
| Urban | √ |
| Suburban | √ |
| Rural | √ |


## Posted Speeds


| | |
|---|---|
| ≤50 km/h | |
| 60-70 km/h | √ |
| 80-90 km/h | √ |
| ≥100 km/h | √ |

## Application Guidance

***Objective:* to minimize the likelihood of colliding with a fixed object once drivers leave the roadway and enter the roadside area.**

Fixed objects can result in high-severity collisions. Most road agencies have policies and/or guidelines that discourage the design and construction of fixed objects near the roadside. Policies and processes to *identify and remove* fixed objects that end up at the roadside after construction are, however, not as common. *Guidelines for the Removal of Fixed Objects* have now been prepared as part of the study on *Methods of Reducing Collisions on Alberta Roads (Section 3.7)*.

The Guidelines build on the existing definitions of fixed objects to include other hazards, such as culverts, ditches, steep slopes and water bodies. They recommend that the procedures in the *Alberta Roadside Design Guide (2007)* be followed to mitigate hazards, starting with removal. Since removal is the most effective way of dealing with hazards, the new guidelines provide more guidance to trigger the removal process. A "roadside safety assessment" is one of the tools recommended as part of the ongoing maintenance program. The document lists the types of changes in the roadway environment that would trigger such an assessment, and provides example collision thresholds for removal, protection and prevention.

## Alberta Status

| | *N* | *L* | *C* | *P* |
|---|---|---|---|---|
| Large Municipalities | | √ | | |
| Small Municipalities | √ | | | |
| Highways | | | √ | √ |

N=None; L=Limited; C=Common; P=Proven

## Documented Benefits

50% of all fatal collisions[6]

30% of all injury collisions[6]

88% of fixed object collisions[6]

*15% - 30% of all injury collisions*

## Typical Installation Cost

| | Units | Cost Range* | |
|---|---|---|---|
| | | Low | High |
| Retrofit | LS | $500 | >$1M |
| New | LS | $100 | >$1M |

*Large cost ranges due to variability of objects within clear zones. Generally lower costs for new projects.

## Further Guidance

*Alberta Transportation Roadside Design Guide (2007) [Ch H-3]*

*Alberta Highway Geometric Design Guide [Section C5]*

## Other Effective Strategies and Enhancements

- Cable barriers
- Delineator Posts
- Horizontal and vertical realignments
- Rumble strips (shoulder)

# Pedestrian Countdown Signals

## Land Use

| | |
|---|---|
| Urban | √ |
| Suburban | √ |
| Rural | |

## Posted Speeds

| | |
|---|---|
| ≤50 km/h | √ |
| 60-70 km/h | √ |
| 80-90 km/h | |
| ≥100 km/h | |

## Application Guidance

***Objective:* to providing real-time meaningful information to crossing pedestrians.**

Pedestrian Countdown Signals (PCS) provide a real-time countdown informing pedestrians how much time remains to cross at an intersection. They clear up much of the confusion that is associated with the traditional "Flashing Don't Walk" display. They have generally become very well received by the public and their implementation is becoming much more widespread. While PCS is generally encouraged at every new traffic signal, more specific guidance was prepared to assist particularly in the prioritization of retrofits, in the document titled *Guidelines for the Application of Pedestrian Countdown Signals*, as part of the study on *Methods of Reducing Collisions on Alberta Roads (Section 3.8)*.

In general, pedestrian countdown signals should be provided wherever pedestrian signal heads are provided. However, PCS should *not* be installed in rural areas, on roadways with speed limits of above 70 km/h, or where the crossing distance is very short. The priority for retrofits is as follows, using a risk-based approach:

1. History of Pedestrian Collisions/Conflicts
2. High "Vulnerable" Pedestrian Volumes
3. Locations with critical flashing do not walk intervals
4. Complex geometric or operational characteristics

## Alberta Status

| | *N* | *L* | *C* | *P* |
|---|---|---|---|---|
| Large Municipalities | | | √ | |
| Small Municipalities | | √ | | |
| Highways | | √ | | |

N=None; L=Limited; C=Common; P=Proven

## Documented Benefits

25% of all pedestrian collisions[10]

*15% - 25% of all pedestrian collisions*

## Typical Installation Cost

| | Units | Cost Range | |
|---|---|---|---|
| | | Low | High |
| Retrofit | Intersection | $4,000 | $8,000 |
| New | Signal | $400 | $900 |

## Further Guidance

TAC *An Informational Report on Pedestrian Countdown Signals (PCS)* (2008)
*Manual of Uniform Traffic Control Devices* [Sec 4E.7]

## Other Effective Strategies and Enhancements

- Wider Sidewalk or Paved Shoulder
- Smart Right-turn Channel
- New or upgraded intersection lighting
- Removal of Obstructions from Sight Triangle

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