

ATTACHMENT D

White Paper: Comprehensive RDG

NCHRP 20-07(360)

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CHAPTER 3

COMPREHENSIVE ROADSIDE DESIGN GUIDE

This chapter provides a white paper which is a stand-alone document in support of mission statement 1: *to develop, implement, and maintain policies which reduce fatal and serious-injury lane departure crashes*. This white paper offers a mini-plan under the TCRS strategic plan framework to achieve a Roadside Design Guide (RDG) with specific design objectives and which can be easily updated as new data analysis becomes available. Accompanying research needs statements (RNS) are provided in Appendix A.

A major update of the RDG is warranted and outlined herein. A comprehensive roadside safety approach is proposed for inclusion in the 2020 (i.e., not the immediately pending revision) of the RDG. This comprehensive approach embraces explicit design objectives for the roadside, medians, bridges, and work zones and provide planners, designers, construction and maintenance personnel with tools for assessing and achieving the stated objectives.

The proposed outline of the 2020 RDG is structured to provide user access to all assumptions and research relied upon in the creation of the guidelines contained within the RDG. This overt display of steps necessary has many benefits including education of the user community and allowing for each step to be individually updated as new research or data analysis becomes available. Currently when new research is conducted, updates of entire chapters are often necessary because research assumptions and data are buried within charts or graphs. For example, research on the effect of curves and grades on roadside crashes is currently underway to update research conducted in 1976.[Carrigan15; Wright76] This new research will change all barrier, length-of-need, and slope warrants, justifying updating many chapters. The approach proposed displays the curve and grade assumptions discretely from the warrants, as discussed below, allowing for easily updating the charts on curve and grade in this case, rather than many warrants in many locations.

Finally, this approach will improve the knowledge base of all highway practitioners, providing familiarity with the roadside safety principles which can be implemented at various stages of the highway life-cycle, from planning through construction and maintenance. This approach provides the design community with improved tools for understanding the desired outcome, designing situations outside of the scope of the guide, and will remove some of the “engineering judgment” currently employed.

BACKGROUND

The TCRS vision, mission, and objectives, as outlined in the 2015 TCRS strategic plan are provided here for reference. This section also summarizes policy needs identified by the TRB AFB20, the National Transportation Safety Board (NTSB), and the TCRS. Policy gaps covered by recently completed research

TCRS Strategic Plan

Vision: Lead roadside policy development, support safety innovations, and be an information resource to promote a decline in lane departure related deaths and serious injuries.

Mission In support of the AASHTO SCOH and SCOD Strategic Plans, (1) develop, implement, and maintain policies which reduce fatal and serious-injury lane departure crashes, (2) develop

evaluation standards to support roadside safety innovation and decision making, and (3) monitor the effectiveness of implemented policies and testing standards to assess the progress being made and implement changes as needed to continue moving toward zero roadside fatal and serious-injury lane departure crashes.

Objectives proposed in support of the TCRS vision and three mission statements:

- A. Critique and improve the underlying assumptions within the RDG and MASH through the analysis of field performance and assessment of available data.
- B. Identify standards that are outdated, lacking, or not supported by current data analysis within the current RDG and MASH that should be addressed in upcoming revisions and conduct research to satisfy those needs.
- C. Keeping up with the dynamic changes in roadside policy can be costly (i.e., budget and schedule); make changes to the RDG and MASH when the change is likely to result in measurable gains.
- D. Provide tools which support making design and policy decisions.
- E. Determine the most effective means to communicate the MASH standards and RDG guidance to promote consistency in interpretation and implementation in the field.
- F. Develop and publish a RDG and MASH which are based on quantifiable performance measures and specific design goals.
- G. Identify and implement methods which will foster innovation in hardware development.

IDENTIFIED POLICY NEEDS OR GAPS

Needs, knowledge gaps, and gaps in available guidance for roadside policy specific to the information which would be presented in the RDG have been summarized here. Research Needs Statements (RNS) identified by the TRB AFB20 committee, recommendations made by the National Transportation Safety Board (NTSB), needs identified through this effort and through outreach to the community are discussed below. These needs are separated into groups, including:

- Work recently completed, but not implemented;
- Work recently initiated;
- No current plans to satisfy the need; and
- Gaps which could be satisfied by reorganizing existing knowledge.

POLICY GAPS COVERED BY RECENTLY COMPLETED RESEARCH

The following are policy gaps which have been identified by the community where research has been recently completed or is substantially complete to satisfy the identified policy gap.

NCHRP 22-12(03) developed tables for the selection of MASH test level two through five bridge rails based on traffic volumes, vehicle mix, and highway characteristics. Implementation of these selection guidelines would address the knowledge gaps identified by the NTSB recommendations for bridge rails, including:

- 09-25: Work with FHWA to establish performance and selection guidelines for bridge owners to use to develop objective warrants for high-performance TL-4, 5, and 6 bridge railings applicable to new construction and rehabilitation projects where railing replacement is determined to be appropriate, and include the guidelines in the LRFD Bridge Design Specifications.

- 09-26: Revise Section 13 of the LRFD Bridge Design Specifications to state that bridge owners shall develop objective warrants for the selection and use of high-performance TL-4, 5, and 6 bridge railings applicable to new construction and rehabilitation projects where railing replacement is determined to be appropriate.

NCHRP Report 638, “Guidelines for Guardrail Implementation” by Dean L. Sicking, Karla A. Lechtenberg, and Scott Peterson

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_638.pdf

NCHRP Report 711, “Guidance for the Selection, Use, and Maintenance of Cable Barrier Systems” by Dhafer Marzougui, Umashankar Mahadevaiah, Fadi Tahan, Cing Dao (Steve) Kan, Richard McGinnis, and Richard Powers

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_711.pdf

NCHRP Project Number 22-27, the Roadside Safety Analysis Program (RSAPv3) update, by Malcolm Ray, Christine Carrigan, Chuck Plaxico, and Olaf Johnson

<http://rsap.roadsafellc.com/RSAPv3EngineersManual.pdf> .

Other ongoing research nearing completion which could be considered for implementation in the pending 2017 RDG update:

- 1.1 Guidelines for Cost-effective Safety Treatment of Roadside Ditches under NCHRP 16-05, completion Q3, 2015.
- 1.2 Development of Clear Recovery Area Guidelines under NCHRP 17-11(02), completion Q2, 2015.
- 1.3 Design Guidelines for TL3 through TL5 Roadside Barrier Systems Placed on Mechanically Stabilized Earth (MSE) Retaining Walls, under NCHRP 22-20(02), completion Q2, 2015.
- 1.4 Identification of Factors Related to Serious Injury and Fatal Motorcycle Crashes into Traffic Barriers, under NCHRP 22-26, completion Q4, 2014.
- 1.5 Criteria for the Restoration of Longitudinal Barriers, Phase II, under NCHRP 22-28, completion Q4, 2014.

Action: *Implement the findings from completed research projects into the pending 2017 RDG.*

Policy gaps covered by recently initiated research

The following are policy gaps that have been identified by the community (i.e., TCRS, AFB20, etc.) and research is just starting. These efforts will not be complete or substantially complete until after the revision of the RDG planned for 2017 but could be incorporated into the following revision (maybe 2020?).

Objective guidelines for the selection and placement of different test level median barriers has been a long recognized policy gap. The TCRS, AFB20, and AFB10 collaborated to recently submit for funding research needs statements (RNS) related to median barrier selection and placement. The NTSB recommendations for median barrier include:

- 06-13: Work with FHWA to establish evaluative criteria for determining when to install median barriers on high-volume, high-speed roadways, regardless of access type.
- 11-31: Work with the FHWA to establish warrants and implementation criteria for the selection and installation of TL-4 and TL-5 median barriers on the National Highway System, and publish those warrants and criteria in the Roadside Design Guide.

- 11-32: Work with the FHWA to identify cross-median crash rates that call for special consideration when median barriers, and publish the rates in the Roadside Design Guide
- 11-33: Work with the FHWA to define the criteria for median barrier selection, including heavy vehicle traffic volume, and publish the criteria in the Roadside Design Guide

Recently, NCHRP advertised and selected a contractor for NCHRP 22-31, Median barrier selection and placement guidelines. This research will develop objective guidelines for the selection and placement of test level two through five median barriers. While this contract has not been initiated, it is anticipated these guidelines will use a similar research approach as was used in NCHRP 22-12(03), the selection of bridge rails and is currently being used in NCHRP 12-90, pier protection guidelines. It is also reasonable to assume that the basic selection process for bridge rails, pier protection, and median barriers will be similar. These projects should be kept in mind when conceptualizing the 2020 RDG (update after the pending 2017 RDG).

Finally, Guidelines for Slope Traversability under NCHRP 17-55 may impact recently completed work on the placement of roadside barriers and/or may generate separate guidelines.

Action: *Coordinate with the research teams responsible for these efforts consistently throughout the course of the research to ensure the final product meets the identified policy gap and can be implemented directly by the TCRS into the RDG.*

Action: *Communicate implementation needs to the research contractors to ensure these ongoing projects can be easily implemented into the RDG.*

Policy gaps with no currently planned research

Some policy gaps have been identified by the community and no research is pending to address these gaps. The NTSB has made these recommendations pertaining to accommodating different vehicle types in the guidelines, including:

- 12-26: Evaluate the adequacy of barrier systems currently approved through NCHRP Report 350 or the MASH for safely redirecting commercial passenger vehicles and, if warranted, develop new barrier designs incorporating appropriate height and deflection characteristics capable of safely redirecting commercial passenger vehicles.

TRB AFB20 has submitted the following unfunded research needs statements (RNS) from 2009 through 2013 which would contribute to roadside policy advancement.

- Development of plan/guidelines to improve roadway and roadsides for motorcyclists (2010)
- Risk-Based Criteria and Selection Guidelines for Positive Protection in Work Zones (2013); and Warrants for anchoring portable barriers in work zones (2010)
- Guidelines for Design of Roadway and Roadside Features to Accommodate Automated Vehicles (2013)
- Classification of Crash Cushions (2013)

Action: *Develop RNS which address the identified needs, specify which policy gaps will be filled, and where the research results will be implemented.*

Policy gaps which could be satisfied with existing or pending work and reorganization of the RDG

Some policy gaps have been identified by the community and no research is pending to address these gaps, however, existing or pending work may satisfy these gaps if the RDG is reorganized to unveil the components of the pending research, buried in single charts which are traditionally used to display warrants. Restated, many of these gaps are only perceived gaps. The NTSB has made these recommendations pertaining to accommodating different vehicle types in the guidelines, including:

- 05-31: Establish warrants in the Roadside Design Guide (RDG) regarding the selection and use of high-performance barriers, including 42- and 50-inch-high concrete barriers that are capable of redirecting heavy trucks.
- 09-08: Work with FHWA to develop and implement criteria based on traffic patterns, passenger volume, and bus types that can be used to assess the risks of rural travel by large buses.
- 12-25: Work with the FHWA to establish performance and selection guidelines for state transportation agencies to use in developing objective warrants for high-performance barriers applicable to new construction and rehabilitation projects where barrier replacement has been determined to be appropriate.
- 12-27: Once barrier testing has been completed and selection guidelines have been developed, revise chapter 5 of the Roadside Design Guide to incorporate guidance for the selection of high-performance barriers in new construction and rehabilitation projects; this guidance should specifically address the unique considerations of shielding commercial passenger vehicles from point hazards.
- 05-32: Upon completion of Federal Highway Administration testing of standard and high-performance portable concrete median barriers on unpaved surfaces, provide clear guidance in the Roadside Design Guide on the placement of portable concrete median barriers on unpaved surfaces.

Breakout sessions and various communications of this research effort have identified these policy gaps which would contribute to advancing the stated mission.

- There are many instances within the RDG which indicate engineering judgment is necessary, but there is no specific guidance offered for applying the judgment. If we cannot install the ideal solution, should we quantify any improvement through a reduction in risk or should we use a benefit-cost approach to justify the design exception?
- Less specific policy gaps or items of consideration relative to policy include: low cost/low volume roadways, objective criteria for urban roadsides, and new technologies.

Action: *Discuss the benefits of reorganization to display additional information and satisfy these perceived gaps.*

PROPOSED COMPREHENSIVE APPROACH

A comprehensive roadside safety approach with stated design objective within the 2020 RDG (i.e., not the immediately pending 2017 revision) is proposed. This approach would support advancements being made in safety research and the needs of the design community who

are often asked to design situations outside of the scope of the guide. Currently, designers are left to apply “engineering judgment” with no explicit understanding of the desired objective. Consequently, scarce safety improvement funds may not be allocated to the most deserving projects. A major update of the Roadside Design Guide is proposed. This update would reorganize some existing research and provide a substantially new framework to allow for adoption of the considerable amount of ongoing research. This approach would expose the components of the roadside, median, bridge, and slope guidelines currently under development to allow for simultaneous fulfilment of other identified research needs, to better education and inform the users of the guide as to the design objective, and to allow the guide to be more easily updated as new research is released. This proposed approach, which would make explicit the design objective of the roadside, medians, bridges, and work zones and provide designers with tools for accomplishing the stated objective, is shown graphically in Figure 1 then explained in detail.

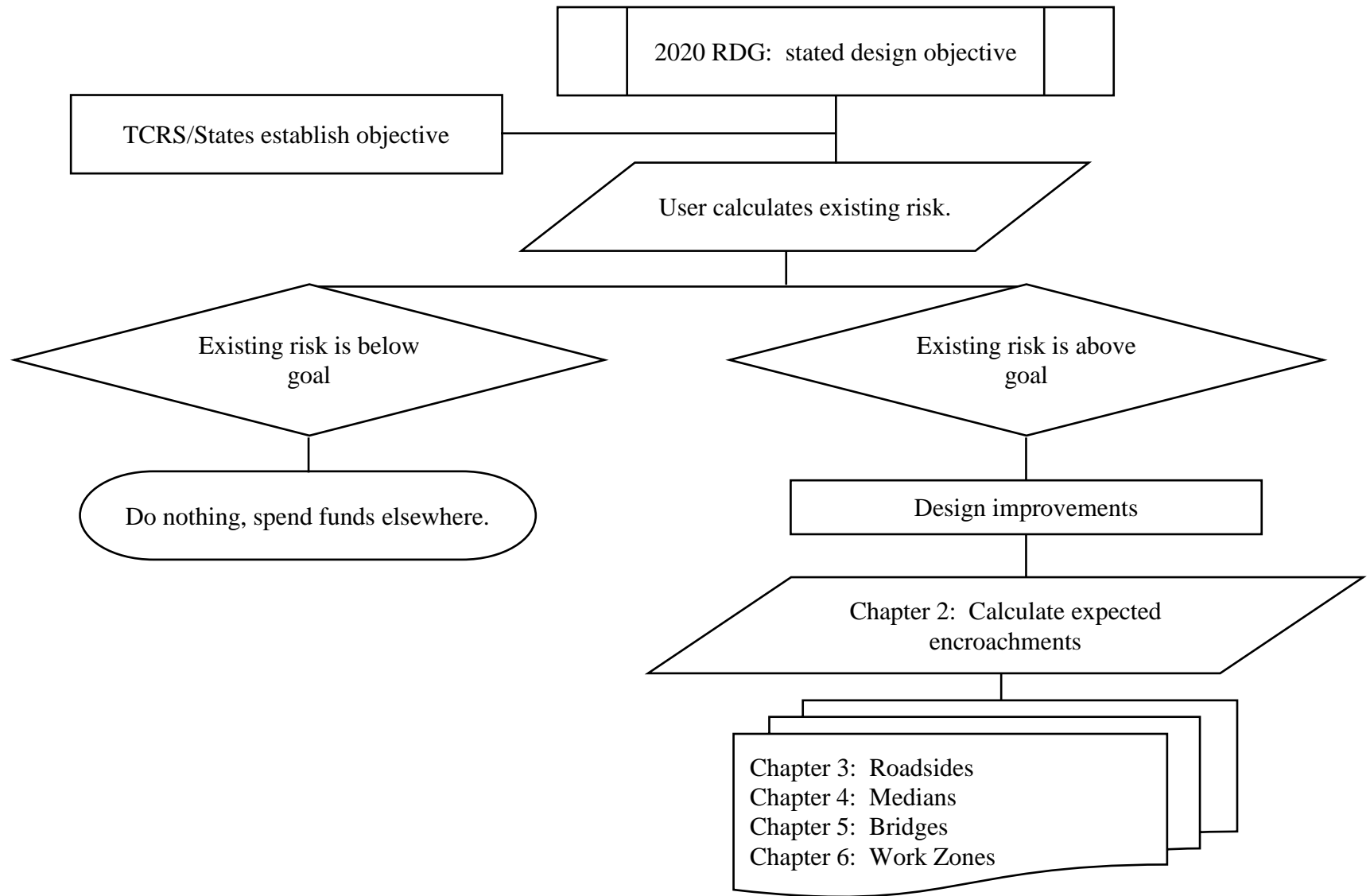


Figure 1. Flow Chart of Proposed Comprehensive Roadside Safety Approach with Stated Design Object.

RDG Chapter 1

Minor changes to the existing outline of the RDG chapter 1 are proposed. It is proposed that information including the history and benefits of roadside safety, RDG content and format, and application of the RDG are maintained, but edited as needed.

Introduce the concept of risk. Establish an acceptable level of risk for design. This target risk will be the design goal. Explain how to determine existing risk of experiencing a severe or fatal crash within the improvement limits of a specific project.

It is proposed that the concept of risk replace the concept of cost-benefit for the development and delivery of roadside guidance.

Benefit-cost verses Risk

Is the construction cost of a higher-performance barrier offset by the reduction in crash costs of the barrier forms the underlying philosophy of the benefit-cost approach (i.e., are benefits/cost >1 ?). Benefit-cost depends on: construction costs, crash costs, comparative severity/performance of the hazard/hardware and the roadside characteristics. When considering risk, however, the question changes from “is this alternative cost-beneficial” to “is the risk of a particular crash severity over the life of the project acceptable?” For example, assume the risk of observing a severe or fatal crash on a segment of roadway is less than 1% over the 30-year life of the project. Risk depends on the comparative severity/performance of the hazard/hardware and the roadside characteristics alone. Crash costs and construction costs are removed from direct consideration. Of course, one would not consider an alternative which could not be constructed within available funds but risk allows the engineer to directly determine how much improvement can be expected by each alternative.

There are advantages and disadvantages to both approaches. The difference between the two approaches is how crash and construction costs are considered. Crash costs and construction costs vary in time and space and not always by the same proportion. As an example, say a national roadside safety guideline was developed using a benefit-cost ratio (BCR) of 2 and national average construction and crash costs. Now consider Figure 2 and Figure 3.

Figure 2 shows three bars for each state. The blue bar is each State’s crash cost relative to the national average crash cost. When a State has a value of 1, the state crash cost equals the national average crash cost. When the State has a value less than one, the State crash cost is less than the national average and when the value is greater than one the State crash cost is higher than the national average. The green bars are relative values for construction costs to the national average. The purple bar is the blue value divided by the green value, much the same way a benefit-cost ratio is calculated. In states like New York where construction costs are higher proportionally than crash costs, the ratio between the two is much lower than the national average. In states like Mississippi where both the construction and crash costs are under the national average, but the ratio is so different, it exceeds the national average. The policy would result in a project whose actual regionally adjusted BCR was $2 \cdot 0.36 = 0.72$ in New York and $2 \cdot 2.02 = 4.04$ in Mississippi. The guideline would have the unintended effect of recommending a non-cost beneficial project in New York and a very cost-beneficial project in Mississippi. The net result would be different levels of risk (or safety) in different regions of the country based only on the local economic conditions.

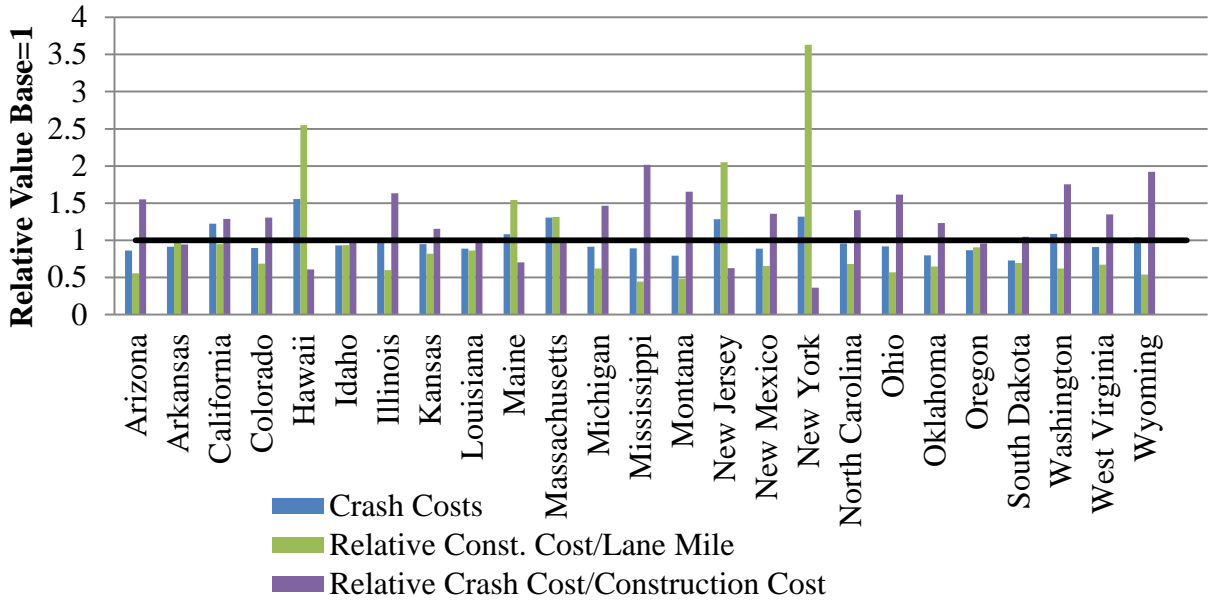


Figure 2. Relative Crash Costs, Construction Costs, and Crash to Construction Costs by State.

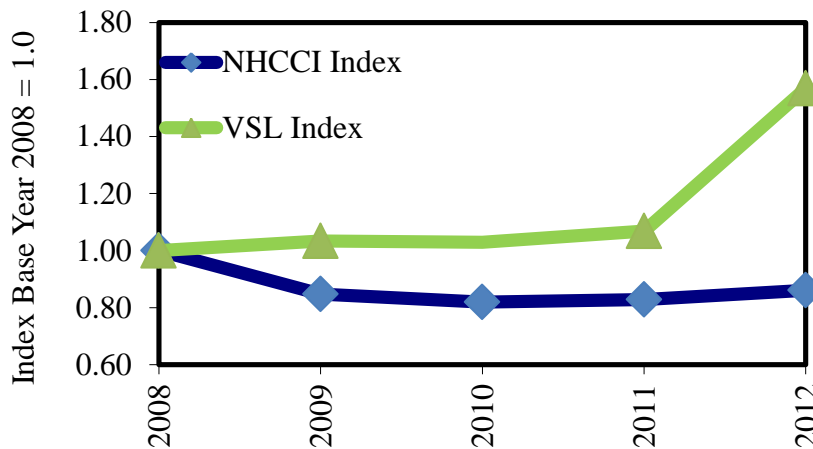


Figure 3. National Highway Construction Cost Index (NHCCI) and Value of Statistical Life (VSL).

Figure 3 shows the temporal variations of both the construction and crash costs. The value of statistical life (VSL) can be considered the cost of a fatal crash. Both are indexed to the same year (i.e., 2008). Notice, that despite the poor economy which drove construction costs down recently, crash costs continued to rise. For the same example discussed above, if the guideline was developed in 2008, by 2011 the construction costs would decrease by a factor of 0.82 but the crash cost would have increased by a factor of 1.07. The benefit-cost of that same alternative would really be 2.6; even better than the conditions of the original policy. On the other hand, if construction prices begin to increase dramatically in the coming years to an NHCCI of 2.6 and crash cost reaches \$12 million the same alternative will have a BCR of 1.5, below the threshold value of 2 used to develop the guideline. In this case, a different level of

risk (or safety) will result based only on the economic conditions in effect at the time of construction.

Since design alternatives generally have design lives of 20 to 30 years, it would seem highly likely that the actual BCR will change dramatically over the life of the project due to temporal and regional variations. While benefit-cost explicitly includes agency costs, the regional and temporal variations in cost lead to different solutions in different locations and at different times. Using a risk-based approach assures that the probability of a catastrophic event is consistent from region to region and over the life of the project, however, the selected alternative may not be cost-beneficial in all situations. **Recommend the Risk Approach to avoid problems with cost variations and to maintain the same design goal over time and region.**

TCRS TO DO: This lane departure definition needs to be agreed upon. I have suggested something here for a starting point. Please note I did not include side swipes.

Design Objective of Chapter 1: Determine (1) risk of serious or fatal crashes, (2) if roadside improvements are necessary or if the existing roadside meets the goal as is. [TCRS and each state would establish the goal.]

Figure 4 provides an example of a table which could be used in chapter 2 of the 2020 RDG to aid users in compiling their crash data to determine the existing risk. Figure 5 shows the table completed for tree crashes in Maine. In this case, if the goal was 0.0030, then improvements would be needed. In this example, if the goal of serious and fatal crashes were less than or equal to a risk of 0.0035, then no improvements would be needed and the funds could be used elsewhere. Let's say the goal is to cut the risk in half to 0.0015 and improvements are needed.

Figure 4. Example of RDG Table for User to Complete.

Crash definition (including lane departures): Crashes considered shall be any crash were the vehicle crosses the solid white shoulder line, solid yellow shoulder line or yellow lines separating traffic on an undivided roadways.			
Lane departure crashes (LDC) over ____ years (Y)	LDC/year	Edge miles _____ (i.e., approx. centerline *2)=EM	Risk
$X_{FATAL(K)}$	X_K/Y	$X_K/Y/EM=R_K$	Serious & Fatal = R_K+R_A
$X_{INCAPACITATING(A)}$	X_A/Y	$X_A/Y/EM=R_A$	
$X_{NON-INCAPACITATING(B)}$	X_B/Y	$X_B/Y/EM=R_B$	
$X_{POSSIBLE(C)}$	X_C/Y	$X_C/Y/EM=R_C$	
$X_{PROPERTY DAMAGE ONLY(O)}$	X_O/Y	$X_O/Y/EM=R_O$	
$X_{UNREPORTED(U)}$	X_U/Y	$X_U/Y/EM=R_U$	

Figure 5. Example of RDG Table Completed for Trees in Maine from 1989-2008.

Crash definition (including lane departures): Crashes considered shall be any crash where the vehicle crosses the solid white shoulder line, solid yellow shoulder line or yellow lines separating traffic on an undivided roadways.			
Lane departure crashes (LDC) over <u>20</u> years (Y)	LDC/year	Edge miles <u>50,000</u> (i.e., approx. centerline *2)=EM	Risk
$X_K=532$	26.60	0.0005	0.0031
$X_A=2,553$	127.65	0.0026	
$X_B=9,254$	462.70	0.0093	
$X_C=8,371$	418.55	0.0084	
$X_O=25,837$	1291.85	0.0258	
$X_U=0$	0	0	

Research Needs Statements

- Benchmark roadside risk to understand the current risk on existing highways and formulate goals for future reductions.

RDG Chapter 2: Encroachments

This chapter will be quite different from any of the existing chapters, but based entirely on existing knowledge. This chapter would be similar in some ways to the 2017 RDG chapter proposed to include information on “keeping vehicles on the road.” Determine the expected number of encroachments for a specific project. This chapter has many purposes, including educating the user about the assumptions which underlie the current guidance and increasing the knowledge base about the possible ways to improve roadside safety during the planning and early design phases of the project. Adding this chapter will also make the entire guide easier to update and maintain. It is proposed that this chapter explicitly separate the encroachment data and geometric adjustment data from all other guidelines. These data are the same for each guidelines, but generally buried deep in the early stages of the analysis with the resulting guideline summarized in a single chart. If new encroachment data or new geometric adjustments are found, it is necessary to update each guidelines within the RDG. If these data are shown separately, as proposed here, only a single chart or table will require updating. Furthermore, the identified research needs and gaps shown within the group “could be satisfied by reorganization” would be addressed mainly with this chapter.

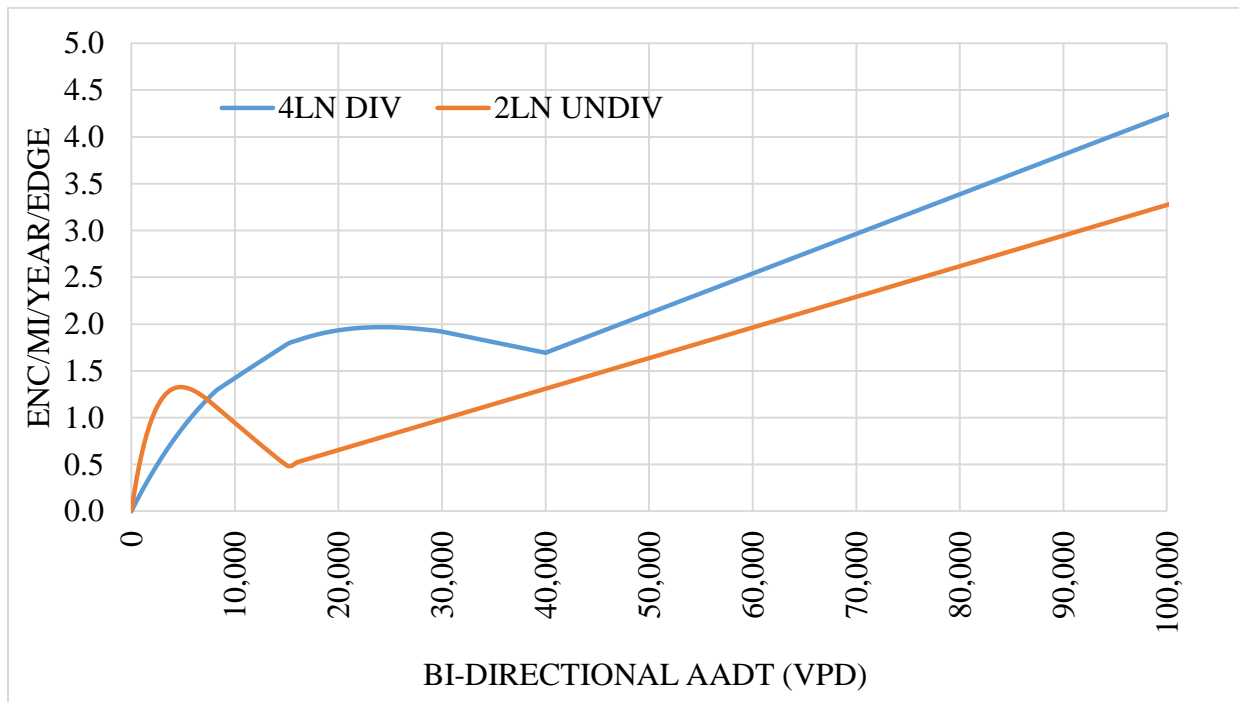
The user will be asked, through a series of figures and charts, to consider:

- Traffic volume (i.e., full range of volumes, including low- and high-volume roadways),
- Vehicle mix (i.e., percent trucks, buses, etc.),
- Roadway setting (i.e., urban, rural, transition, etc.),
- Highway geometrics, and
- Variations by edge (i.e., roadside and median edges).

Design Objective of Chapter 2: Determine if (1) early design/planning changes can be applied to reduce the expected encroachments and (2) the expected number of encroachments per edge.

Continuing with the tree example, the user knows that improvements are needed and the goal is to reduce the risk to 0.0015 serious and fatal crashes per year per edge mile. The objective of chapter 2 is to determine if (1) early design/planning changes can be applied to reduce the expected encroachments and (2) the expected number of encroachments per edge. The user would then reference a figure like that shown in Figure 6. Figure 6 shows the so-called “Cooper” data. Using the bi-directional AADT and the highway type (undivided or divided), the user can determine the encroachments/mile/year/edge. If our tree example was a four lane divided highway with 20,000 vehicles per day, then we would expect a base encroachment rate of 1.9336 encroachments/mile/year/edge.

Figure 6. Use the bi-direction AADT to determine the encroachments/mi/year/edge.



Let’s say our example is a 65 mph, four lane road with zero major access points per mile, 12’ lanes, a degree of curvature of 6 and -5% grade in the primary direction for the segment under consideration. The encroachments adjustments shown in Figure 7 would be retrieved and multiplied together for each edge of the roadway. These encroachment adjustment factors (EAFs) would then be multiplied with the previously determined encroachments/mi/year/edge to determine the number of expected encroachments adjusted for the geometric characteristics. Table 1 provides a summary of the encroachments and EAFs by edge for this example.

Figure 7. Encroachment Adjustments

Access Density			Lane Width			Horizontal Curve Radius	
Number of Access Points on Bridge or within 200 ft of either end			Avg, Lane Width (ft)			Horizontal Curve Radius at the Centerline (ft)	All Highway Types
	Undivided	Divided and Oneway		Undivided	Divided and Oneway		
0	1.00	1.00	$9 \geq$	1.50	1.25	$950 \geq R_1$	4.00
1	1.50	2.00	10	1.30	1.15	$1910 > R_1 > 950$	$(2228.2 - R_1) / 318.3$
$2 \leq$	2.20	4.00	11	1.05	1.03	$1910 \leq R_1$	1.00
			$12 \leq$	1.00	1.00	$950 \geq R_2$	2.00
						$1910 > R_2 > 950$	$(R_2 - 2864.8) / 954.9$
						$1910 \leq R_2$	1.00
						<ul style="list-style-type: none"> If road curves toward vehicle on the barrier side use R_1. If road curves away from the vehicle on the barrier side use R_2. 	
$f_{ACC} =$			$f_{LW} =$			$f_{HC} =$	
Lanes in One Direction			Posted Speed			Grade	
No. Through Lanes in One Direction			Posted Speed Limit (mi/hr)			Percent Grade	All Highway Types
	Undivided	Divided and Oneway		Undivided	Divided and Oneway		
1	1.00	1.00	< 65	1.42	1.18	$-6 \geq G$	2.00
2	0.76	1.00	≥ 65	1.00	1.00	$-6 > G > -2$	$0.5 - (G/4)$
$3 \leq$	0.76	0.91	For roads with unposted speed limits use the adjustment for < 65 mi/hr			$-2 \leq G$	1.00
$f_{LN} =$			$f_{PSL} =$			$f_G =$	
$f_{TOT} = f_{ACC} \cdot f_{LN} \cdot f_{LW} \cdot f_G \cdot f_{HC} \cdot f_{PSL} =$							

Table 1. Summary of Tree Example Problem Encroachments and Encroachment Adjustments.

Characteristic	Primary Right Edge	Opposing Right Edge
Enc/mi/year/edge	1.9336	1.9336
Access density	1.0	1.0
Lane width	1.0	1.0
DOC	1.5	1.0
Number of lanes	1.0	1.0
Posted Speed Limit	1.0	1.0
Grade	1.1	1.0
Π	3.1904	1.9336

At this time, changes to the roadway may be made to reduce the expected number of encroachments. For example, the curve or grade may be changed. If changed to the roadway are not made, proceed to the appropriate chapter for the appropriate project. In this tree example, it would be the roadside chapter (i.e., Chapter 3). Other chapters would include:

- Chapter 3: Roadsides.
- Chapter 4: Medians.
- Chapter 5: Bridge rails.
- Chapter 6: Work zones.

Research Needs Statement

Once the lane departure definition is agreed upon, research will be needed to determine centerline cross-overs and the encroachment data updated as needed to include lane departures.

- Incorporate emerging research on vehicle types into the RDG.

RDG Chapter 3: Roadsides

Using a series of figures, determine the risk of experiencing a fatal or severe injury crash on the roadside for all alternatives under consideration. Adjust for the:

- Terrain adjacent to the roadside (i.e., slope, ditches, drop off, etc.).
- Offset, density and type of fixed objects (i.e., trees, poles, etc.).
- Barrier, barrier type, end treatments, placement and test level.

Design Objective of Chapter 3: (1) Determine if changes can be made to the terrain and offset/density of fixed objects to reduce the risk of experiencing a severe or fatal crash by the goal [goal to be established]. (2) If changes cannot be made to the terrain or narrow fixed objects, determine if a barrier will reduce the risk of experiencing a severe or fatal crash by the

goal. (3) If the desired risk reduction cannot be achieved, determine and implement the alternative which will reduce the expected risk the greatest.

Continuing with the tree example, Figure 8 shows black and blue lines. The black line represents the existing risk level (i.e., 0.0030) at different offsets and the blue line represents half the risk (i.e., 0.0015). If the goal is to reduce the risk by half, the user would enter the left edge of the figure with the encroachments/mi/year/edge for both the primary right edge (PRE) and opposing right edge (ORE) and trace a line under the blue risk line is intersected then go down to determine the tree offset. Note that in this example, the tree offset would be different for the inside and outside of the curve. If clearing the tree line back 22-ft from the edge of lane on the outside of the curve is not feasible, then a guardrail should be evaluated for shielding vehicles from the trees.

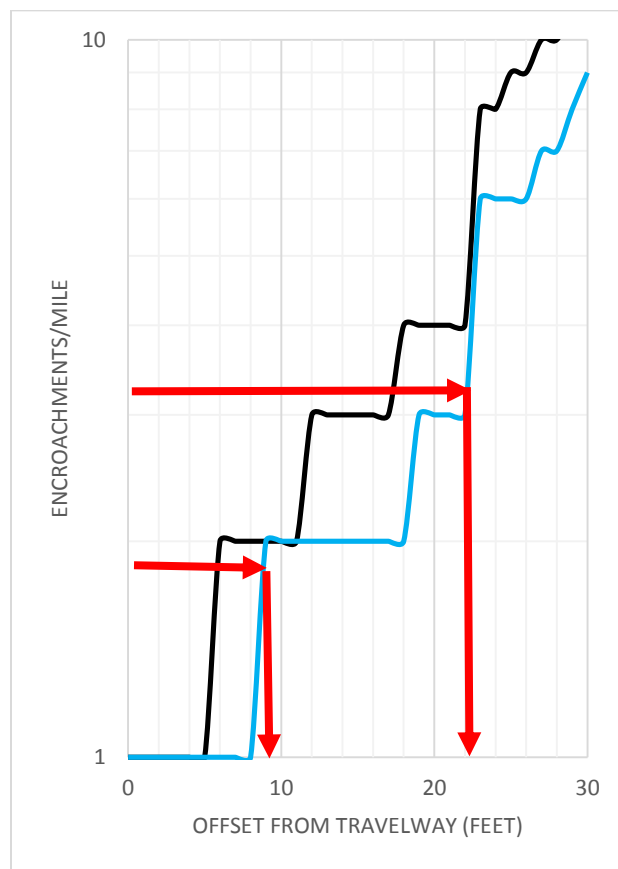


Figure 8. Example of Tree Risk by Offset.

Research Needs Statement

- Develop chapter 3 of the 2020 RDG: Reformulate NCHRP Report 638 to separate data assumptions from guidelines and prepare a draft chapter for the RDG which builds on Chapter 2. This research should develop figures for different levels of risk and recommend a risk goal for implementation.

RDG Chapter 4: Medians

Using a series of figures, determine the risk of experiencing a fatal or severe injury crash in a median-related event for all alternatives under consideration. Adjust for the:

- Median slope and width.
- Presence of fixed objects (i.e., trees, poles, bridge piers etc.) and other hazards within the median.
- Barrier, barrier type, end treatments, placement, and test level.

Design Objective of Chapter 4: (1) Determine which improvement will reduce the risk of experiencing a severe or fatal crash to or below the goal [Goal to be determined]. (2) If the desired risk reduction cannot be achieved, determine and implement the alternative which will reduce the expected risk the greatest.

Research Needs Statement

This research is underway, there are no RNS. The research team should be asked to develop a draft chapter which references chapter 2 and recommended a risk goal.

RDG Chapter 5: Bridges

Using a series of figures, determine the risk of experiencing a fatal or severe injury crash in bridge rail event for the alternatives under consideration.

Consider the hazards environment below the bridge and transitions to the roadside and median barriers.

For retrofit construction, determine which test level barrier will reduce the current risk of observing a fatal or severe injury crash to the goal [goal to be determined, research team recommended $Risk \leq 0.01$]. For new construction, determine which risk is appropriate and publish those tables within the RDG or regional guidance. The research is complete, the appendix include figures for various levels of risk.

Design Objective of Chapter 5: (1) For retrofit, determine which improvement will reduce the risk of experiencing a severe or fatal crash to the goal. (2) For new construction, select the appropriate barrier to satisfy the predetermined goal.

Research needs statements

This research is complete and ready to implement.

RDG Chapter 6: Work zones

Using a series of figures, determine the risk of experiencing a fatal or severe injury crash in a work zone event which can be prevented by positive protection.

Design Objective of Chapter 6: (1) Select and place positive protection when appropriate to reduce the risk of fatal or severe injuries to workers and drivers to the goal [goal to be determined]. (2) If the desired risk reduction cannot be achieved, determine and implement the alternative which will reduce the expected risk the greatest.

Research needs statements

- Develop Chapter 6: Conduct research and develop work zone chapter which references chapter 2. The research team shall recommended a risk goal.

Miscellaneous Changes

Miscellaneous changes to the Roadside Design Guide were also considered. For example, it was suggested that all propriety and non-propriety information on hardware be removed and full reference be made to the Task Force 13 website for identifying appropriate hardware after the user has determine hardware is needed, the appropriate material, and placement. While the Task Force 13 is developing the infrastructure to support this request, it may not be feasible at this time.

Summary

A comprehensive roadside safety approach with stated design objective within the 2020 RDG (i.e., not the immediately pending 2017 revision) is proposed to incorporate and support advancements being made in safety research and the needs of the design community. This approach will empower designers with knowledge about the underlying assumptions within each chapter through unveiling many of the data assumptions in chapter 2, improving the capability to apply “engineering judgment” with explicit statements of the desired objective to support “engineering judgement.” This update would provide a markedly new structure to allow for adoption of the considerable amount of ongoing and recently completed research. This approach will allow future research to be more easily integrated into the guide as it becomes available. For example, if new encroachment data were gathered, chapter 2 could be updated with no need to update the following chapters. Recognizing that this proposal calls for a major update of the Roadside Design Guide, it is proposed that TCRS ask NCHRP to fund implementation and training workshops. .

Research Needs Statements

- Production of a major update to the Roadside Design Guide to develop a comprehensive policy to reduce serious and fatal ROR or Lane Departure crashes
- Conduct training and implementation workshops for the 2020 RDG

CONCLUSION

The proposed vision of the TCRS is to “Lead roadside policy development, support safety innovations, and be an information resource to promote a decline in lane departure related deaths and serious injuries.” The proposed first mission of the TCRS, in support of the vision, is to “develop, implement, and maintain policies which reduce fatal and serious lane departure injuries.” The TCRS strategic plan suggests seven objectives for achieving a comprehensive RDG: (1) critique and improve the underlying assumptions within the RDG and MASH through the analysis of field performance and assessment of available data; (2) identify standards that are outdated, lacking, or not supported by current data analysis within the current RDG and MASH that should be addressed in upcoming revisions and conduct research to satisfy those needs; (3) keeping up with the dynamic changes in roadside policy can be costly (i.e., budget and schedule); make changes to the RDG and MASH when the change is likely to result in measurable gains; (4) provide tools which support making design and policy decisions; (5) determine the most effective means to communicate the MASH standards and RDG guidance to promote consistency in interpretation and implementation in the field; (6) develop and publish a RDG and MASH which are based on quantifiable performance measures and specific design

goals; (7) identify and implement methods which will foster innovation in hardware development.

A major update of the Roadside Design Guide is warranted at this time to support TCRS strategic plan. Develop the proposed comprehensive roadside safety approach with stated design object to provide an easy-to-maintain updated Roadside Design Guide which will act as a foundation for all future research. This strategy with supporting actions has been proposed as a means to advance the TCRS strategic plan. The related research needs and activities which should be programed for the continued support of the stated mission are shown in Appendix A. The resulting RDG is proposed to be maintained well into the future under the support of Mission statement 3, as explained in that paper.

APPENDIX A: RESEARCH NEEDS STATEMENTS

RNS in support of Mission 1 are suggested here.

Title: Production of a major update to the Roadside Design Guide to develop a comprehensive policy to reduce serious and fatal ROR or Lane Departure crashes.

Objective: The objective of this research is to (1) gather the recently completed objective criteria for the selection and placement of roadside and median hardware; (2) coordinate the criteria into a comprehensive document which communicates the RDG design objective to the user; (3) construct a document which can be continually updated by the TCRS based on changes to the crash testing criteria, and new research. The research should identify outdated policy for removal from the RDG. This research should propose a process for monitoring the effectiveness of each new policy.

This research should identify the most appropriate RDG delivery method to ensure maintenance of the document and implementation in the field (i.e., hard copy, e-document, living document considerations, etc.).

Title: Benchmark roadside risk to understand the current risk and formulate goals for reduction.

Objective: The objective of this research is to collect lane departure [using agreed upon lane departure definition] crashes and edge miles of road to determine the existing risk of different types of crashes and establish a goal for reduction to be included in the 2020 RDG.

Title: Develop Chapter 3 of the 2020 RDG.

Objective: Reformulate NCHRP Report 638 to separate data assumptions from guidelines and prepare a draft chapter for the RDG which builds on Chapter 2. This research should develop figures for different levels of risk and recommend a risk goal for implementation.

Title: Work Zone Risks, research for Chapter 6 of the 2020 RDG.

Objective: Conduct research to develop guidelines for positive protection in work zones and prepare a draft chapter for the RDG which builds on Chapter 2. This research should develop figures for different levels of risk and recommend a risk goal for implementation.

Title: Incorporate emerging research on vehicle types into the RDG.

Objective: the objective of this research is to assess recently completed/soon-to-be completed research on buses and motorcycles and available research on automated vehicles to determine appropriate adjustment factors for implementation in Chapter 2 of the 2020 RDG.

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