Roadway Departure Safety Implementation Plan

Safe Roads for a Safer Future

Investment in roadway safety saves lives

U.S. Department of Transportation
Federal Highway Administration

Oregon Roadway Departure Safety Implementation Plan

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For additional information, contact Mary McDonough, Roadway Departure Team Leader, at mary.mcdonough@dot.gov.

Table of Contents

Executive Summary ..... **iv**

1. Background **1**

2. Oregon Data Limitations **2**

2.1 Crash Reporting 2

2.2 Crash and Roadway Data Availability 2

2.3 Degree of Curvature 2

3. The Roadway Departure Safety Goal **3**

3.1 The Approach 3

3.1.1 Data Analysis *3*

3.1.2 Additional Features *4*

3.2 Distribution of the Roadway Departure Fatality Problem 4

3.3 Summary of Roadway Departure Crash Concerns 6

3.4 Summary of Roadway Departure Countermeasure Deployments 6

4. Key First Steps **9**

5. Major Components of the Plan **10**

5.1 Systematic Deployment of Low-Cost Countermeasures 10

5.1.1 Enhanced Sign and Markings to Reduce Roadway Departures on Curves *11*

5.1.2 Centerline Rumble Strips To Reduce Head-On and Opposing-Flow Sideswipe Crashes *15*

5.1.3 Edgeline Rumble Stripes and Shoulder Rumble Strips to Reduce Roadway Departure Crashes *17*

5.1.4 Alignment Delineation *20*

5.1.5 Select Tree Removal in Rural Areas to Reduce Future Tree Crash Occurrences *21*

5.1.6 Guard Rail Upgrades *23*

5.2 Comprehensive Education, Enforcement, and Engineering (3-E) Improvements 23

5.2.1 Targeted Corridor Education and Enforcement (Minimal or No Infrastructure Improvements) *23*

5.2.2 Key Steps for Implementing Education and Enforcement Safety Corridors *26*

5.2.3 Targeted 3-E Engineering, Education, and Enforcement for Corridors *28*

5.2.4 Targeted Engineering, Education, and Enforcement for Cities *30*

5.3 Deployment of Traditional Roadway Departure Countermeasures 32

5.3.1 Roadway Departure Countermeasures on Local Roads *33*

5.4 Incorporation of Low-Cost, Cost-Effective Countermeasures at Crash Locations within the Limits of Work for Programmed Projects 33

5.4.1 Key Implementation Steps *34*

5.5 Deployment and Evaluation of New Roadway Departure Countermeasures.....35

6. Performance Measures.....38

6.1 Production Performance Measures.....38

6.2 Effectiveness Performance Measures– Program Effectiveness in Reducing Targeted Crashes 40

7. Summary 41

List of Tables

Table 1: State Roadway Departure Fatalities 3

Table 2: Roadway Departure Crashes and Fatalities by Locality – 2002-2008 4

Table 3: Summary of Roadway Departure Fatalities, Crashes, and Fatalities per 100 Crashes – 2002-2008 5

Table 4: Enforcement and Education-Related Roadway Departure Crashes by Human Factor and Locality – 2002-2008 5

Table 5: Roadway Departure Crashes by Crash Type, Number of Crashes, and Number of Fatalities (top 4 types) - 2002-2008 6

Table 6: Strategy Matrix - Summary of Countermeasure Deployment Levels and Estimated Safety Impacts 7

Table 7. Summary of Curve Crashes (2002-2008) 11

Table 8: Enhanced Signs and Markings for Curves – Curve Roadway Departure Crashes – State Rural Roads (2002-2008) 11

Table 9: Enhanced Signs and Markings for Curves Plus Flashing Beacons – Curve Roadway Departure Crashes – State Rural Roads (2002-2008) 12

Table 10: Enhanced Signs and Markings for Curves – Curve Roadway Departure Crashes – State Urban Roads (2002-2008) 12

Table 11: Basic and Enhanced Sign and Marking Improvements – State Curve Roadway Departures (2002-2008) 13

Table 12: Enhanced Signs and Markings for Curves – Curve Roadway Departure Crashes – Local Roads 14

Table 13: Centerline Rumble Stripes – Head-On and Sideswipe-Meeting – State Rural Roads ≥ 20 Feet Road Width (2002-2008) 16

Table 14: Centerline Rumble Stripes – Head-On and Sideswipe-Meeting Crashes – Local Roads 17

Table 15: Summary of Edge Rumble stripes and Shoulder Rumble Strip Deployments – State Rural Roads (2002-2008) 18

Table 16: Edge Line Rumble Strips – Single Vehicle Roadway Departure Crashes – Local Roads 19

Table 17: Alignment Delineation – Roadway Departure Crashes – Dark – State Rural Roads 20

Table 18: Alignment Delineation – Roadway Departure Crashes – Dark – Local Roads 21

Table 19: Tree Removal/Safety Enhancements – Tree Crashes (1st, 2nd, or 3rd Crash Event) – State Rural Roads (2002-2008) 22

Table 20: Tree Removal/Safety Enhancements – Tree Crashes (1st, 2nd, or 3rd Crash Event) – Local Roads 22

Table 21: Enhanced Corridor Enforcement – Roadway Departure Crashes – Speed-Related or Unbelted Driver – State Roads - Not Interstates (2002-2008) 24

Table 22: Enhanced Corridor Enforcement – Roadway Departure Crashes – Speed-Related or Unbelted Driver – Local Roads (2002-2008) 24

Table 23: Enhanced Corridor Enforcement – Roadway Departure Crashes – Alcohol-Related (2002-2008) 25

Table 24: Key Implementation Steps for Roadway Departure Education and Enforcement Strategies 27

Table 25: Summary of Roadway Departure Crashes (2002-2008) on Candidate Corridors for 3-E (Engineering, Education, Enforcement) Initiatives 28

Table 26: Key Implementation Steps for 3-E Corridor Enhancements 30

Table 27: Summary of Roadway Departure Crashes by Major City (2002-2008) 30

Table 28: Key Implementation Steps for Roadway Departure City-Wide 3E Improvements 31

Table 29: Four to Three Lane Conversions – Roadway Departure Crashes –4 Lanes, < 18,000 AADT, Undivided – State Roads (2002-2008) 32

Table 30: Key Steps to Four to Three Lane Conversions on State Rural Highways 32

Table 31: Key Implementation Steps for Considering the Inclusion of Low-Cost, Cost-Effective Countermeasures in Other Programmed Projects 34

Table 32: Infrastructure Traffic Calming Measures to Reduce Speeding-Related Crashes – State and Local Roads (2002-2008) 36

Table 33: Key Steps to Evaluate New Roadway Departure Countermeasures 36

Table 34: Production Performance Measures 38

Table 35: Performance Measures 40

Executive Summary

The Oregon Transportation Safety Action Plan (TSAP) – analogous to the Strategic Highway Safety Plan – has a safety goal of reducing the number of annual highway fatalities within the State to no more than 334 by the end of 2015.[1] With an average of 462 annual fatalities in Oregon from 2002-2008, this is an aggressive reduction of nearly 28 percent.

Roadway departure fatalities account for approximately 66 percent of all fatalities in Oregon. The TSAP recognizes the importance of the roadway departure issue, including a requirement to "develop a plan to address roadway departure crashes on the State and local system."

A data analysis package and a set of roadway departure countermeasures was merged to identify a set of cost-effective countermeasures, deployment levels, and funding needed to achieve an approximate 20 percent reduction in roadway departure fatalities on Oregon roadways from the 2002-2008 annual average of 307. This reduction will result in the prevention of 65 fatalities each year.[2]

Since roadway departure severe crashes are such a high percentage of the traffic safety problem in Oregon, a significant impact on this crash type will make a big difference in the overall number of fatalities and incapacitating injuries in the State.

The data analysis indicates that the roadway departure goal can be achieved with the following enhancements to the safety program:

- The traditional approach of relying primarily on pursuing major improvements at high-crash roadway departure locations must be complemented with two additional approaches:
    1. A systematic approach that involves deploying large numbers of relatively low-cost, cost-effective countermeasures at many targeted segments of roadway with a history of roadway departure crashes, and
    2. A comprehensive approach that coordinates an engineering, education, and enforcement (3E) initiative on corridors and in urban areas with high numbers of severe roadway departure crashes.
- The systematic improvement categories to be deployed include the following: sign and marking enhancements on curves, centerline rumble strips on rural two-lane highways, edge line rumble stripes and shoulder rumble strips, alignment delineation, and selective rural tree removal.
- The systematic and comprehensive approaches will generate a higher number of roadway departure improvements statewide, and Region personnel will require training as they are asked to take a more active role in identifying the appropriateness of systematic improvements within their Regions.
- Low-cost, cost-effective countermeasures should be considered on other types of projects as appropriate. (e.g., resurfacing, surface transportation projects) when a crash history exists

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[1] 2004 *Oregon Transportation Safety Action Plan Performance Measures*, http://www.oregon.gov/ODOT/TS/docs/TSAP_PerformanceMeasureTable.pdf, accessed April 2010.

[2] An average of 307 RD fatalities occurred annually in Oregon from 2002-2008. Saving 65 lives each year will be a 21.1 percent reduction.

within the area of the work and the countermeasure can reduce future crash potential. In these cases, safety-specific funding can be used to supplement the project funds when necessary.

- The safety program must encompass cost-effective treatments on local roads, as a significant portion of the statewide roadway departure crash problem occurs off the State system.
- Additional countermeasures rarely or never used in the State need to be carefully and judiciously deployed on highway sections that have specific crash problems that these countermeasures can address. These countermeasures include fluorescent yellow warning signs; inlaid pavement markings in advance of curves; high friction surfaces; traffic calming; and installation of edge line and shoulder rumble stripes/strips on narrow pavements.
- To achieve the roadway departure safety goal, it will take an investment of the following:
    - **Infrastructure Improvements**: Approximately $36 million over a 5-year period ($7.2 million per year).
    - **Enforcement & Education Initiatives**: Approximately $15.8 million over a 5-year period ($3.2 million per year) for highly visible active enforcement campaigns and education initiatives focused on roadway departure crashes.
- In addition, a substantial 3-E pilot program should be initiated to combine engineering, enforcement, and education solutions to enhance safety on selected corridors and cities with significant numbers of severe roadway departure crashes. If successful in reducing severe crashes, these programs should be applied to other corridors and cities that have similar crash histories.

This plan provides specific information on how these additions to the current safety program can be effectively implemented.

The bottom line for a successful plan implementation is that, once fully implemented over a 10-year period, approximately 10,600 reported roadway departure crashes and more than 1,200 disabling injury crashes will be prevented, and approximately 650 lives will be saved.

1. Background

The Oregon Transportation Safety Action Plan has an overall goal of reducing the number of roadway fatalities to no more than 334 annually by the end of 2015. One of the emphasis areas identified in the plan is to improve roadway departure safety. Roadway departure fatalities within the State account for approximately 66 percent of all fatalities. The Oregon Transportation Safety Action Plan provides insight on broad initiatives in the roadway departure safety area to support achieving the overall goal, but it lacks detail regarding countermeasures, actions, deployment characteristics, costs, impacts, and key steps that must be taken to improve roadway departure safety significantly. The objective of this effort is to achieve a 20 percent reduction in roadway departure fatalities on Oregon roads. The purpose of this Implementation Plan is to provide the specific details on countermeasures, actions, key steps, schedules, and investments needed to meet that objective to save 65 lives annually in Oregon.

2. Oregon Data Limitations

2.1 Crash Reporting

It is important to note that Oregon, unlike many other states, collects non-injury crash reports predominantly from citizens. Due to this practice in the state, the overall number of reported roadway departure crashes is lower than would be expected in a State with similar population, vehicles miles traveled (VMT), and severe roadway departure crashes.

This issue affects the "Fatalities per 100 crashes" and "Incapacitating injuries per 100 crashes" values, as the real values are "Fatalities (or incapacitating injuries) per 100 reported crashes."

2.2 Crash and Roadway Data Availability

On State-maintained routes in Oregon, the data analysts were able to determine the location of each roadway departure crash in relation to a linear referencing system on the road. Additionally, this referencing system provided analysts the ability to conduct segmentation analyses for normalization of the data.

On the local system of roadways, however, the linear referencing system was not available for analysis. Crashes could be "landed" on a county and named route, but not at a specific location on that route. An additional limitation was the lack of overall local road lengths available to the researchers. Due to this limitation, all local road analysis was conducted by route with no recognition of that route's length. This information must be taken into account to avoid erroneous conclusions when analyzing the data. This also necessitated additional assumptions when developing countermeasure costs on local roads.

2.3 Degree of Curvature

The data analysts were unable to determine the degree of curvature (i.e., relative "sharpness") for curves on either State or local roadways in Oregon. If this data becomes available, additional analysis could be performed to refine the systematic implementation of curve treatments.

3. The Roadway Departure Safety Goal

Oregon has had continued reductions in roadway departure fatalities since 2006 as indicated in Table 1.

Table 1: State Roadway Departure Fatalities

	2002	2003	2004	2005	2006	2007	2008	Total
Number of Roadway Departure Fatalities	290	347	296	318	330	299	266	2,146

The roadway departure goal in this implementation plan is to reduce the 7-year average (2002-2008) of 307 roadway departure fatalities by approximately 20 percent by 2016. Achieving this goal will prevent approximately 65 roadway departure deaths from occurring each year.

3.1 The Approach

The Highway Safety Improvement Program (HSIP) has been based upon a traditional approach directed towards improving roadway safety at specific high-crash locations by identifying and analyzing individual crashes at the locations, defining crash patterns, determining appropriate countermeasures to reduce future crash potential, and then implementing those countermeasures. While this is an important approach and needs to continue, it has limited impact in terms of reducing statewide numbers of roadway departure fatalities.

To help lower statewide roadway departure fatalities, two additional approaches are recommended to complement the traditional approach:

- **Systematic application** of large numbers of low-cost, cost-effective, countermeasures at locations with specific, moderate crash types above a specified crash frequency level.
- **Comprehensive application** of low-cost infrastructure improvements coupled with targeted education and enforcement initiatives on corridors and in municipalities that exhibit a very high severe roadway departure crash history.

The systematic approach is the reverse of the traditional approach in that low-cost, effective countermeasures are first identified and then the crash data system is searched to identify highway sections that have targeted crashes at or above a crash threshold that would insure cost-effective deployment of these countermeasures. Estimates of the impacts of the deployments can be made in terms of projected statewide roadway departure crashes prevented, annual lives saved, and overall deployment costs.

The comprehensive approach combines sets of cost-effective, low-cost infrastructure countermeasures with a coordinated set of education and highly visible enforcement initiatives targeted to reduce severe roadway departure crashes on corridors and within municipalities that have a severe roadway departure crash history.

3.1.1 Data Analysis

Roadway departure crash data drive both approaches in the following manner.

1. The systematic approach identifies crash types that specific countermeasures are designed to impact and selects clusters of locations with targeted crashes at or above a designated threshold level. All crash severities are used to identify these clusters.

2. The total targeted crashes in these clusters are multiplied by a predicted Crash Reduction Factor to estimate the total number of targeted crashes that could be reduced should the countermeasure be implemented at each of the clusters.
3. In order to refocus on severe crashes, the overall crash reduction is multiplied by the observed severity history of that crash type to estimate the severe crash reduction across the system.[3]
   - Incapacitating injuries per 100 crashes
   - Fatalities per 100 crashes

3.1.2 Additional Features

Three other features should be added to the plan to better improve the ability to achieve the safety improvement goal:

1. Low-cost, cost-effective countermeasures should be considered on other types of projects as appropriate (e.g., resurfacing, surface transportation projects) when a crash history exists within the area of the work and the countermeasure can reduce future crash potential. In these cases, safety-specific funding can be used to supplement the project funds when necessary.
2. The safety program must encompass cost-effective treatments on local roads since a sizeable portion of the statewide roadway departure crash problem occurs on the non-State system.
3. Additional countermeasures rarely or never used in the State should be carefully and judiciously deployed on highway sections with specific crash problems that these countermeasures can address.

3.2 Distribution of the Roadway Departure Fatality Problem

The roadway departure crash and fatality data for Oregon were analyzed to gain insight on the distribution and characteristics of the roadway departure crash problem. Key information derived from the roadway departure data analysis is shown in Tables 2 through 5.

Table 2: Roadway Departure Crashes and Fatalities by Locality – 2002-2008

Locality	Crashes		Fatalities	
	Total	Percentage	Total	Percentage
State	**27,911**	**50.63%**	**1,234**	**57.50%**
Rural	21,827	39.59%	1,078	50.23%
Urban	6,084	11.04%	156	7.27%
Local	**27,218**	**49.37%**	**912**	**42.50%**
Rural	15,677	28.44%	726	33.83%
Urban	11,541	20.93%	186	8.67%
Grand Total	**55,129**	**100.00%**	**2,146**	**100.00%**

[3] Using statewide ratios for these two multipliers provides a more reliable estimate of severity impact than analyzing the crash severity history at each site.

Table 3: Summary of Roadway Departure Fatalities, Crashes, and Fatalities per 100 Crashes – 2002-2008

Locality	State Rural	State Urban	Local Rural	Local Urban
All RD Crashes				
Fatalities	1,078	156	726	186
Crashes	21,827	6,084	15,677	11,541
Fat/100 crashes	4.94	2.56	4.63	1.61
Interstate RD Crashes				
Fatalities	134	50	-	-
Crashes	4,655	2,439	-	-
Fat/100 crashes	2.88	2.05	-	-
OR State Route Type RD Crashes				
Fatalities	490	67	-	-
Crashes	9,496	1,884	-	-
Fat/100 crashes	5.16	3.56	-	-
US Route Type RD Crashes				
Fatalities	436	34	-	-
Crashes	6,670	1,297	-	-
Fat/100 crashes	6.54	2.62	-	-
Other Route Type RD State Crashes				
Fatalities	18	5	-	-
Crashes	1,006	464	-	-
Fat/100 crashes	1.79	1.08	-	-

Table 4: Enforcement and Education-Related Roadway Departure Crashes by Human Factor and Locality – 2002-2008

Locality	State Rural	State Urban	Local Rural	Local Urban	State Rural Interstate Only	State Urban Interstate Only	State Rural Non-Interstate	State Urban Non-Interstate	Local Rural	Local Urban
Human Factor	Alcohol	Alcohol	Alcohol	Alcohol	Speeding or Unbelted	Speeding or Unbelted	Speeding or Unbelted	Speeding or Unbelted	Speeding or Unbelted	Speeding or Unbelted
Enforcement and Education-Related RD Crashes										
Fatalities	307	78	374	106	83	31	566	63	545	147
Incapacitating Injuries	315	94	340	144	246	77	1,266	139	1,141	385
Total Crashes	1,141	508	1,381	1,404	3,552	1,525	11,765	2,231	10,525	6,466
Incap. Injuries / 100 crashes	27.61	18.50	24.62	10.26	6.93	5.05	10.76	6.23	10.84	5.95
Fat/100 crashes	26.91	15.35	27.08	7.55	2.34	2.03	4.81	2.82	5.18	2.27

Table 4: Enforcement and Education-Related Roadway Departure Crashes by Human Factor and Locality – 2002-2008 (continued)

Locality	State Rural Non-Interstate	State Urban Non-Interstate	Local Rural	Local Urban	State Rural	State Urban	Local Rural	Local Urban
Human Factor	**Speeding**	**Speeding**	**Speeding**	**Speeding**	**Unbelted**	**Unbelted**	**Unbelted**	**Unbelted**
Enforcement and Education-Related RD Crashes								
Fatalities	529	59	523	146	97	11	89	16
Incapacitating Injuries	1,229	136	1,124	377	115	115	88	23
Total Crashes	11,664	2,210	10,419	6,424	291	291	318	123
Incap. Injuries / 100 crashes	10.54	6.15	10.79	5.87	39.52	39.52	27.67	18.70
Fat/100 crashes	4.54	2.67	5.02	2.27	33.33	3.78	27.99	13.01

Table 5: Roadway Departure Crashes by Crash Type, Number of Crashes, and Number of Fatalities (top 4 types) - 2002-2008

Crash Type	Number of Crashes	Number of Fatalities
Fixed Object	40,133	1,190
Head On and Sideswipe Meeting	8,376	766
Non-Collision	3,573	162
Rear end	2,454	19

3.3 Summary of Roadway Departure Crash Concerns

- Crashes predominantly occur in rural areas; crashes tend to be more severe in rural areas than urban areas.
- The number of roadway departure crashes is split nearly equally between state-maintained roads (51 percent) and local roads (49 percent). Since State highways represent approximately 13 percent of the total public roadway mileage, the density of crashes is greater on this portion of the system.
- Driving violations (speeding, alcohol, and unbelted driving) are major factors in roadway departure crashes. Many of these crashes involve multiple driving violation factors.
- A large portion of roadway departure fatalities (1,190 of 2,146 – 55 percent) include the vehicle hitting a fixed object.

3.4 Summary of Roadway Departure Countermeasure Deployments

A summary of the countermeasures, deployment levels, costs, and estimated lives saved using these three approaches is provided in Table 6.

Table 6: Strategy Matrix - Summary of Countermeasure Deployment Levels and Estimated Safety Impacts

Countermeasure	Approach	Number of Sections	Construction Cost ($ Million)	Enforcement, Education and EMS Costs (Annual $ Million)	Estimated Annual Crashes Reduced	Estimated Annual Incapacitating Injuries Reduced	Estimated Annual Fatalities Reduced	$ (million) required to save one annual life
State Roads								
Enhanced Signs and Markings for Curves – State Rural Roads	Systematic	740	3.70	-	112	14.71	7.56	0.49
Enhanced Signs and Markings for Curves Plus Flashing Beacons – State Rural Roads	Systematic	20	0.14	-	6	0.78	0.41	0.34
Enhanced Signs and Markings for Curves – State Urban Roads	Systematic	19	0.09	-	8	0.66	0.34	0.26
Centerline Rumble Stripes – ≥ 20 Feet Road Width – State Rural Roads	Systematic	273	4.09	-	81	24.21	15.87	0.26
Edge Line Rumble Strips – 2 Lane– State Rural Roads	Systematic	683	2.05	-	89	9.80	3.14	0.65
Shoulder Rumble Strips – 2 Lane – State Rural Roads	Systematic	1,378	4.41		189	15.22	5.68	0.78
Alignment Delineation – State Rural Roads	Systematic	126	0.63	-	16	1.66	0.76	0.83
Tree Removal/Safety Enhancements – State Rural Roads	Systematic	54	1.34	-	13	2.22	1.41	0.95
Traffic Calming to Reduce Speeding-related Crashes - State Roads	Systematic	51	1.28	-	94	9.42	4.22	0.30
Enhanced Corridor Enforcement – Speeding-Related or Unbelted Driver – State Roads – Not Interstates	Education and Enforcement	10	-	0.35	11	0.89	0.40	4.38
Enhanced Corridor Enforcement – Alcohol-Related – State Roads	Education and Enforcement	36	-	1.30	5	1.11	1.04	6.25
Corridor 3E Improvements – State Roads – Not Interstates	Comprehensive	3	1.50	0.3	53	6.32	3.75	
Area-Wide 3E Improvements – Cities – State Roads	Comprehensive	2	2.00	0.2	72	4.16	1.70	
Four to Three Lane Conversions –4 Lanes, < 18,000 AADT, Undivided – State Roads	Traditional	7	0.66	-	4	0.55	0.31	2.13
Local Roads								
Enhanced Signs and Markings for Curves – Local Roads	Systematic	442	4.42	-	143	15.29	7.39	0.60
Centerline Rumble Strips - Local Rural Roads	Systematic	88	3.52	-	28	1.39	3.17	1.11
Edge Line Rumble Strips - Local Rural Roads	Systematic	38	2.30	-	46	4.63	2.12	1.08
Alignment Delineation – Local Roads (Rural and Urban)	Systematic	71	1.78	-	17	1.62	0.77	2.31

Countermeasure	Approach	Estimated Number of Improvements	Construction Cost ($ Million)	Enforcement, Education and EMS Costs (Annual $ Million)	Estimated Annual Reported Crashes Reduced	Estimated Annual Incapacitating Injuries Reduced	Estimated Annual Fatalities Reduced	$ (million) required to save one annual life
Local Roads (continued)								
Tree Removal/Safety Enhancements – Local Roads (Rural and Urban)	Systematic	54	1.36	-	13	2.01	1.14	1.19
Traffic Calming to Reduce Speeding-related Crashes - Local Roads	Systematic	46	1.04		52	5.05	2.29	0.45
Enhanced Corridor Enforcement – Speeding-Related or Unbelted Driver – Local Rural Roads	Education and Enforcement	10	-	0.29	9	0.93	0.43	3.37
Enhanced Corridor Enforcement – Alcohol-Related – Local Roads	Education and Enforcement	30		0.73	4	0.93	0.84	4.35
Total Cost and Benefit (State and Local)								
Total Cost (Million)			**36.31**	**15.85**	-	-	-	-
Annual Cost (Million) for 5 years ; Annual Benefit			**7.26**	**3.17**	**1,065**	**124**	**65**	

This matrix reflects the final set of countermeasures, deployment levels, costs, and safety impacts to meet Oregon's roadway departure safety goals. An expanded explanation of the strategy matrix and associated analyses are available in Appendix A.

Appendix B provides information of the locations of each site above thresholds for the countermeasures that should be considered for improvement.

A draft strategy matrix was developed for the March 2010 Oregon workshop that included additional countermeasures that were removed during the workshop discussions. To avoid confusion, only the modified strategy matrix (Table 6) is included in this Implementation Plan document.

4. Key First Steps

There are several key first steps that need to be taken before actual countermeasure implementation activities begin.

1. Present the draft implementation plan to the Regions and other affected Headquarters divisions/sections to share, review, provide input, and understand the conceptual enhancements to the safety program.
2. Develop initial preparatory materials (e.g., policies, guidance documents) for systematic countermeasures and vet with affected Oregon DOT divisions/sections. These countermeasures include sign and marking enhancements for curves, centerline rumble strips on rural non-freeway highways, edge and shoulder rumble strips, and tree removal in rural areas.
3. Establish processes and provide training to begin implementation of the low-cost countermeasures being considered for systematic deployment.
4. Meet with appropriate Maintenance, Design, Planning, and Local Programs personnel to further explore and define the processes and responsibilities that need to be developed to consider the incorporation of low-cost, cost-effective countermeasures into other program categories such as the resurfacing program and the statewide transportation improvement program (STIP). The primary low-cost countermeasures to consider for inclusion in other project types at targeted high-crash sections are as follows: sign and marking enhancements for horizontal curves, centerline rumble strips in rural areas, edge and shoulder rumble strips, tree removal in rural areas, and potential use of the Safety Edge.
5. Meet with the Governor's Highway Safety Representative and appropriate law enforcement personnel to review the crash data that identifies highway sections with concentrations of speeding, unbelted, and alcohol-related crash histories. Targeted enforcement and education initiatives should be developed and considered for implementation at many of these locations to reduce the potential for future similar crashes.
6. Analyze data and share with regional and section personnel along with the Governor's Highway Safety Representative to identify candidate corridors and cities for the 3-E comprehensive initiatives.
7. Develop a Roadway Departure Safety Committee under the appropriate Strategic Highway Safety Plan (or similar) coalition. This committee should provide guidance and address issues and problems that arise during the implementation of the program. The committee should meet on a planned quarterly basis throughout the implementation phase.
8. Develop and deploy a tracking system to monitor the implementation of the various types of countermeasures being deployed. This system should include collection of roadway departure crashes, forms designed to secure "before" and "after" targeted crash histories, dates of countermeasure implementation, linkages to roadway departure improvements being implemented under other programs, and other information deemed pertinent by the Roadway Departure Safety Committee.

5. Major Components of the Plan

The remaining sections of this plan provides a detailed description of key implementation steps for each of the major efforts needed to achieve a 20 percent reduction in roadway departure fatalities. The efforts are categorized as follows:

- Systematic deployment of low-cost, cost-effective countermeasures.
- Incorporation of low-cost, cost-effective countermeasures into other programmed projects.
- Local road improvements
- Comprehensive 3-E improvements.
- Traditional improvements.
- Implementation of new countermeasures.

5.1 Systematic Deployment of Low-Cost Countermeasures

This initiative involves the installation of several sets of low-cost, cost-effective countermeasures at locations with high crash histories to decrease the potential of future crashes significantly. Five types of low-cost countermeasures have been identified for extensive systematic deployment as follows:

1. Enhanced sign and marking improvements for curves with crash histories.
2. Centerline rumble strips to reduce head-on and opposing-flow sideswipe crashes.
3. Edge and shoulder rumble strips to reduce single vehicle roadway departure crashes.
4. Traffic calming measures to reduce speed-related roadway departure crashes.
5. Selected tree removal to reduce fixed object crashes with trees.

In addition to the above countermeasures, one other countermeasure may be deployed either systematically or as part of the traditional approach: surface friction enhancements to reduce the potential of future wet weather crashes.

The methodology to identify sections of highway which have crashes at or above the threshold steps down a roadway in uniform, discrete section lengths and identifies sections with a number of targeted crash types that equal or exceed the defined threshold. Once the initial analysis is completed, the output from this process needs refinement based upon field conditions and overall route characteristics. As an example, a single curve could have crashes initially analyzed in two adjoining sections. Thus curve crashes on either side of a section identified as a high-crash curve section need to be reviewed to determine if there are any additional curve crashes that occurred on the same curve but in the adjoining section. As another example, a rural highway may be 10 miles in length and 75 percent of the sections on the route meet the crash threshold for edge/shoulder rumble strips. For routes with numerous sections that meet the crash threshold, the application of edge rumble strips on the entire route rather than just those sections that meet the threshold needs to be considered. This may be determined by field review or GIS mapping.

Oregon DOT has been provided the list of sections of highway that exceed the crash thresholds for each countermeasure.

5.1.1 Enhanced Sign and Markings to Reduce Roadway Departures on Curves

Table 7. Summary of Curve Crashes (2002-2008)

Locality	State Rural				State Urban				Local	Local
ADT Interval	<1,000	1,001 - 3,000	3,001 - 5,000	>5,000	<1,000	1,001 - 3,000	3,001 - 5,000	>5,000	Rural	Urban
Curve RD Crashes										
Fatalities	80	126	95	121	5	-	-	34	428	85
Incapacitating Crashes	201	221	185	243	13	1	1	66	862	200
Total Crashes	1,652	1,726	1,225	2,017	106	5	23	806	7,447	2,518
Incapacitating Crashes/100 Crashes	12.17	12.80	15.10	12.05	12.26	20.00	4.35	8.19	11.58	7.94
Fatalities/100 Crashes	4.84	7.30	7.76	6.00	4.72	-	-	4.22	5.75	3.38

5.1.1.1 State Route Implementation

Curves on rural State highways with the number of crashes at or above threshold levels and considered for sign and marking enhancements are summarized in Table 8.

Table 8: Enhanced Signs and Markings for Curves – Curve Roadway Departure Crashes – State Rural Roads (2002-2008)

AADT	Threshold Crash Level	Number of Curves	Number of Targeted 5 Year Crashes on Curves	Estimated Number of Improvements [1]	Construction Costs ($ Million) [2]	Fatalities per 100 Crashes	Incapacitating Crashes per 100 Crashes	Annual Targeted Crash Reduction [3]	Annual Estimated Incapacitating Injury Crash Reduction	Annual Estimated Fatality Reduction
<1,000	2	194	493	136	0.68	4.84	12.17	15	1.80	0.72
1,000-3,000	2	369	1,236	258	1.29	7.30	12.80	37	4.75	2.71
3,001 - 5,000	2	266	947	186	0.93	7.76	15.10	28	4.29	2.20
>5000	3	228	1,071	160	0.80	6.00	12.05	32	3.87	1.93
Total		-	-	740	3.70		-	112	14.71	7.56

[1] Assumes 70% of curves can be improved.

[2] Assumes an average cost of $5,000 per curve.

[3] A CRF of 0.30 is used (oversized, left, and right fluorescent yellow, advance warning signs; chevrons; slow and XX mph pavement markings; center and edge lines).

Within the set of curves identified in Table 8, some curves exceeding higher crash thresholds would likely benefit from the addition of flashing beacons on the advanced curve warning signs. This set of curves is shown in Table 9.

Table 9: Enhanced Signs and Markings for Curves Plus Flashing Beacons – Curve Roadway Departure Crashes – State Rural Roads (2002-2008)

AADT	Threshold Crash Level	Number of Sections	Number of Targeted Crashes on Sections	Estimated Number of Improvements [1]	Construction Costs ($ Million) [2]	Fatalities per 100 Crashes	Incapacitating Crashes per 100 Crashes	Annual Targeted Crash Reduction [3]	Annual Estimated Incapacitating Injury Crash Reduction	Annual Estimated Fatality Reduction
<1,000	10	-	-	-	-	-	-	-	-	-
1,000-3,000	10	8	104	6	0.04	7.30	12.80	1.56	0.21	0.11
3,001 - 5,000	10	11	146	8	0.05	7.76	15.10	2.19	0.29	0.15
>5000	10	9	142	6	0.04	6.00	12.05	2.13	0.28	0.15
Total	-	-	392	20	0.14	-	-	5.88	0.78	0.41

[1] Assumes 70% of curves can be improved.

[2] Assumes an average cost of $7,000 per curve for the flashing beacon.

[3] An incremental increase of 0.15 above the enhanced signs and markings for curves CRF (i.e., increasing overall CRF from 0.30 to 0.45) is used.

Table 10 summarizes curves on urban State highways with crashes at or above crash thresholds. These sections should be considered for sign and marking enhancements.

Table 10: Enhanced Signs and Markings for Curves – Curve Roadway Departure Crashes – State Urban Roads (2002-2008)

AADT	Threshold Crash Level	Number of Sections	Number of Targeted Crashes on Sections	Estimated Number of Improvements [1]	Construction Costs ($ Million) [2]	Fatalities per 100 Crashes	Incapacitating Crashes per 100 Crashes	Annual Targeted Crash Reduction [3]	Annual Estimated Incapacitating Injury Crash Reduction	Annual Estimated Fatality Reduction
<1,000	5	-	-	-	-	-	-	-	-	-
1,000-3,000	5	-	-	-	-	-	-	-	-	-
3,001 - 5,000	5	-	-	-	-	-	-	-	-	-
>5000	5	27	270	19	0.09	4.22	8.19	8.1	0.66	0.34
Total		-	270	19	0.09	-	-	8.10	0.66	0.34

[1] Assumes 70% of curves can be improved.

[2] Assumes an average cost of $5,000 per curve.

[3] A CRF of 0.30 is used (oversized, left, and right fluorescent yellow, advance warning signs; chevrons; slow and XX mph pavement markings; center and edge lines).

The proposed signing and marking treatments for these curves is as follows:

- Oversize advanced fluorescent yellow curve warning signs, both left and right.
- Chevrons with spacing in accordance with the 2009 MUTCD.
- Advisory speed plates beneath the advanced warning sign using a standardized approach to determine the appropriate advisory speed. Oregon's research project *Safety Evaluation of Curve Warning Advisory Speed Signs* will be considered when setting the approach.
- "SLOW" and curve symbol pavement markings in advance of the curve.[4] Additional pavement marking strategies to reduce high-end approach speeds (e.g., advisory speeds, peripheral transverse pavement markings) should also be considered.
- Vegetation-covered signs tend to be a significant issue in Oregon. This concern should also be addressed as part of the treatment.

A summary of these enhancements including an estimated number of State route deployments, costs, and annual crashes, incapacitating injury crashes, and fatalities prevented is provided in Table 11.

Table 11: Basic and Enhanced Sign and Marking Improvements – State Curve Roadway Departures (2002-2008)

Category	Approach	Number of Sections	Construction Cost ($ Million)	Estimated Annual Crashes Reduced	Estimated Annual Disabling Injuries Reduced	Estimated Annual Fatalities Reduced
Enhanced Signs and Markings for Curves – State Rural Roads	Systematic	740	3.70	112	14.71	7.56
Enhanced Signs and Markings for Curves Plus Flashing Beacons – State Rural Roads	Systematic	20	0.14	5.88	0.78	0.41
Enhanced Signs and Markings for Curves – State Urban Roads	Systematic	19	0.09	8.10	0.66	0.34
Total	**-**	**779**	**3.93**	**126**	**16.15**	**8.31**

[4] The curve pavement marking treatments must receive FHWA approval.

The basic steps and schedule to implement this initiative are as follows:

1. Gain management acceptance of the Roadway Departure Safety Implementation Plan.
2. Traffic-Roadway Section develops guidelines and a standard template treatment for curves that are at or above the threshold in the above tables. The guidelines will be issued to the Region personnel for implementation. Note that the guidance will provide a process to consider treatment and funding alternatives for similar sharp curves on the same route.

   Schedule: Guidelines issued within 6 months of acceptance of the Plan
3. Region personnel will use guidelines and template(s) to field review each identified curve with crashes and determine appropriate sign and marking improvements. Region personnel will assemble Region wide or county wide contract plans to implement the improvements.

   Schedule: Curve sign and marking recommendations completed within 12 months of acceptance of the Plan
4. Signing and marking improvements will be implemented

   Schedule: Sign and marking enhancements for all curves completed within 24 months of acceptance of the Plan

5.1.1.2 Local Road Implementation

Due to the high number of roadway departure crashes on local road curves in Oregon, it is imperative to address the local needs in this area as well. Table 12 provides the recommended deployment level and benefits for installing sign and marking upgrades on local roads. Note that the analysis of local road crashes and the recommendations for deployment apply to the entire route (due to crash and roadway data limitations). The locations of the 552 local roads to be reviewed are provided in Appendix B.

Table 12: Enhanced Signs and Markings for Curves – Curve Roadway Departure Crashes – Local Roads

Locality	Threshold Crash Level (7 Years)	Number of Local Roads	Number of Local Road Crashes in 7 Years (02-08)	Estimated Number of Improvements [1]	Construction Costs ($ Million) [2]	Fatalities per 100 Crashes	Incapacitating Injuries per 100 Crashes	Annual Targeted Crash Reduction [3]	Annual Estimated Incapacitating Injury Reduction	Annual Estimated Fatality Reduction
Local Rural	5	351	3,121	281	2.81	11.58	5.75	107.01	12.39	6.15
Local Urban	3	201	1,064	161	1.61	7.94	3.38	36.48	2.90	1.23
Total	-	552	-	442	4.42	-	-	143.49	15.29	7.39

[1] Assumes 80% of curves can be improved.

[2] Assumes an average cost of $10,000 per local road (multiple curves on each local road to be improved)

[3] Assumes 80% of curve crashes occur on curves to be improved by sign and markings. A CRF of 0.30 is used.

For local roads, it will be necessary for ODOT to work with its local partners to determine how signing and pavement marking projects can be implemented on the non-State system. Due to the limitations in local road data regarding roadway widths, conditions of pavement, etc., it will be necessary to complete a

field check of each local road to determine its potential for signing and pavement marking implementation. It is assumed that approximately 80 percent of the local roads reviewed will be viable for these countermeasures.

5.1.2 Centerline Rumble Strips To Reduce Head-On and Opposing-Flow Sideswipe Crashes

According to the Spring 2010 Rumble Strip Proposal developed by ODOT's Traffic-Roadway Section, there is great interest in increasing the application of rumble strips (both centerline and edgeline/shoulder) on Oregon roads. Calculations from the proposal report that, even if only fatal and incapacitating injuries reductions are used for the benefit, rumble strips provide a 90:1 benefit/cost (B/C) ratio. This B/C is far above most other safety countermeasures and represents an excellent return on investment.

The ODOT Rumble Strip Proposal recommended installation of centerline rumble strips on approximately 4,000 miles of State rural roads. Similarly, the analysis completed in the development of the Implementation Plan discovered approximately 4,600 miles of State rural roads that should be addressed for maximum benefit.

5.1.2.1 State Route Implementation

Center line rumble strips will be implemented as follows

Systematic deployment of centerline rumble strips on two-lane and multi-lane undivided rural highways with a pavement width of at least 20 ft. and a crash threshold of 3 or more head-on and sideswipe-meeting crashes in a 15,000 ft. section of rural highway occurring in the past 7 years.

1. Each roadway with one or more sections of highway meeting this threshold will be evaluated to determine if the centerline rumble strip application should be expanded to the entire route or a major portion of the route for continuity. Criteria will include roadway features and traffic volumes. Strong consideration should be given to providing route continuity.[5]

The summary of high-crash, head-on, and sideswipe-meeting sections where centerline rumble strips are to be considered for installation on State rural highways at least 20 ft. in width is shown in Table 13. The locations of these sections are provided in Appendix B.

[5] Note that the costs and benefits of potential additional miles are not included in the 4,600 miles analyzed.

Table 13: Centerline Rumble Stripes – Head-On and Sideswipe-Meeting – State Rural Roads ≥ 20 Feet Road Width (2002-2008)

Roadway Width	Threshold Crash Level	Number of Sections	Number of Targeted Crashes in the Sections	Estimated Number of Improvements [1]	Construction Costs ($ Million) [2]	Fatalities per 100 Crashes	Disabling Injuries per 100 Crashes	Annual Targeted Crash Reduction [3]	Annual Estimated Disabling Injury Reduction	Annual Estimated Fatality Reduction
≥22 ft.	3	340	1,604	272	4.08	19.66	29.98	80.66	24.18	15.86
≥20 ft and <22 ft.	3	1	3	0.8	0.01	9.09	18.18	0.15	0.03	0.01
Total			1,607	273	4.09	-	-	80.81	24.21	15.87

[1] Assumes 80% of locations can be improved.
[2] Assumes an average cost of $15,000 per section.
[3] A CRF of 0.21 is used.

The basic steps and schedule to implement this initiative are as follows:

1. Gain management acceptance of the Roadway Departure Safety Implementation Plan.
2. Traffic–Roadway Section will develop guidelines and a standard template treatment for centerline rumble strips to be installed at locations meeting the threshold in the above table. The guidelines will be issued to Region personnel for implementation. Note that the guidance will provide a process to consider the treatment and funding alternatives for providing centerline rumble strips on the entire or major portion of the route.
    a. The guidelines will also address pavement condition: if the pavement is old and deteriorated (within 3 years of replacement) or showing signs of visible distress, the application of centerline rumble strips may be deferred and incorporated into the next overlay of the section.

    Schedule: Guidelines issued within 6 months of acceptance of the Plan.
3. Region personnel will use the guidelines and template(s) to field review each identified highway section with crashes and determine the appropriateness of installing centerline rumble strips now or deferring until the next overlay. Region personnel will assemble a Region-wide or county-wide contract plans to implement the improvements.

    Schedule: Centerline rumble strip locations within the Region on rural State highways 20 ft. or wider are finalized within 12 months of acceptance of the Plan.
4. Contracts will be let and improvements will be implemented.

    Schedule: Centerline rumble strips in place within 30 months of acceptance of the Plan.

5.1.2.2 Local Road Implementation

Due to the high number of head-on and sideswipe-meeting crashes on local roads in Oregon, it is imperative to address the local needs in this area as well. Table 14 provides the recommended deployment level and benefits for installing centerline rumble strips on local roads. Note that the analysis of local road

crashes and the recommendations for deployment apply to the entire route (due to crash and roadway data limitations). The locations of these 88 local roads to be reviewed are provided in Appendix B.

Table 14: Centerline Rumble Stripes – Head-On and Sideswipe-Meeting Crashes – Local Roads

Locality	Threshold Crash Level (7 Years)	Number of Local Roads	Number of Local Road Crashes in 7 Years (02-08)	Estimated Number of Improvements [1]	Construction Costs ($ Million) [2]	Fatalities per 100 Crashes	Incapacitating Injuries per 100 Crashes	Annual Targeted Crash Reduction [3]	Annual Estimated Incapacitating Injury Reduction	Annual Estimated Fatality Reduction
Local Rural	4	88	548	70	3.52	5.05	11.51	27.56	1.39	3.17

[1] Assumes 80% of locations can be improved.

[2] Assumes an average cost of $50,000 per rural road for center line rumble strips.

[3] A CRF of 0.44 is used for center line rumble strips.

For local roads, it will be necessary for ODOT to work with its local partners to determine how centerline rumble strips can be implemented on the non-state system. Suggested implementation is as follows:

1. Systematic deployment of centerline rumble strips on two-lane and multi-lane undivided rural local roads with a pavement width of at least 20 ft. and a crash threshold of 4 or more head-on and sideswipe-meeting crashes on the entirety of the local road's length occurring in the past 7 years.
2. Due to the limitations in local road data regarding roadway widths, conditions of pavement, etc., it will be necessary to complete a field check of each local road to determine its potential for centerline rumble strip implementation. It is assumed that approximately 80 percent of the local roads reviewed will be viable for centerline rumble strip implementation.

5.1.3 Edgeline Rumble Stripes and Shoulder Rumble Strips to Reduce Roadway Departure Crashes

Edge and shoulder rumble strips will be implemented similarly to centerline rumble strips:

The 2010 ODOT Rumble Strip Proposal recommended installation of edgeline or shoulder rumble strips on approximately 4,000 miles of State rural roads. The Implementation Plan recommends a smaller initial deployment of 1,150 miles of State rural roads for edgeline and shoulder rumble strips (not accounting for the continuity issues described below).

5.1.3.1 State Route Implementation

Edgeline and shoulder rumble strips will be implemented as follows

1. Systematic deployment of shoulder rumble strips on two-lane and multi-lane undivided rural highways with a paved shoulder width of 4 ft. or greater, an acceptable recovery area, and a crash threshold of 2 or more single vehicle roadway departure crashes in a 3,000 ft. section of rural highway occurring in the past 7 years.
2. Systematic deployment of edgeline rumble strips on two-lane and multi-lane undivided rural highways with a paved shoulder width of less than 4 ft., an acceptable recovery area, and a crash

threshold of two or more single vehicle roadway departure crashes in a 3,000 ft. section of rural highway occurring in the past 7 years.

3. Each roadway with one or more sections of highway meeting this threshold will be evaluated to determine if the rumble strip application should be expanded to the entire route or a major portion of the route for continuity. Criteria will include roadway features and traffic volumes. Strong consideration should be given to providing route continuity.

The summary of high-crash single vehicle roadway departure crash sections where shoulder and edgeline rumble strips are to be considered for installation on State rural highways is shown in Table 15. The exact locations of these sections are provided in Appendix B.

Table 15: Summary of Edge Rumble stripes and Shoulder Rumble Strip Deployments – State Rural Roads (2002-2008)

Number of Lanes, Shoulder Width (Countermeasure)	Threshold Crash Level (7 Years)	Number of 3,000 ft. Sections	Number of Section Crashes in 7 Years (02-08)	Estimated Number of Improvements [1]	Construction Costs ($ Million) [2]	Fatalities per 100 Crashes	Incapacitating Injuries per 100 Crashes	Annual Targeted Crash Reduction [3]	Annual Estimated Incapacitating Injury Reduction	Annual Estimated Fatality Reduction
2 lanes, < 4 foot shoulder (Edge Line Rumble Strips)	2	1,139	3,594	683	4.10	3.52	10.97	89.34	9.80	3.14
2 lanes, ≥ 4 foot shoulder (Shoulder Rumble Strips)	2	1,723	5,690	1,378	8.27	3.01	8.07	189	15.22	5.68
Total	**-**	**-**	**9,284**	**2,062**	**12.37**	**-**	**-**	**278**	**25.02**	**8.82**

[1] For edge line rumble strips, assumes 60% of locations can be improved. For shoulder rumble strips, assumes 80% of locations can be improved.

[2] Assumes an average cost of $3,000 per section.

[3] A CRF of 0.29 is used.

The basic steps and schedule to implement this initiative are as follows:

1. Gain management acceptance of the Roadway Departure Safety Implementation Plan.
2. Traffic–Roadway Section will develop guidelines and a standard template treatment for edge rumble stripes and shoulder rumble strips to apply on highway sections that are at or above the threshold in the above tables and issue the guidelines and template to Region personnel for implementation. Note that the guidance will provide a process to consider the treatment and funding alternatives for considering the application of edge rumble stripes and shoulder rumble strips on the entire route rather than on just those sections of the route that are at or above the crash threshold.
    a. The guidelines will address pavement condition: if the pavement is old and deteriorated (within 3 years of replacement) or showing signs of visible distress, the application of rumble strips may be deferred and incorporated into the next overlay of the section.

b. The guidelines will consider applications in areas with concentrations of residences that are close to the highway where noise could become a significant concern.

c. The roadway's recovery area (i.e., side slopes) should be considered when determining appropriate locations

d. If the section is part of a designated bicycle route or has significant bicycle activity, edge rumble stripes and shoulder rumble strips will be further evaluated to determine the appropriateness of application. Alternatives discussed with Oregon DOT include rumble stripes on the edgeline (even if the shoulder width is greater than 4 ft.) and profile durable markings. Both of these alternative solutions provide additional shoulder for bicyclists.

Schedule: Guidelines issued within 6 months of acceptance of the Plan.

3. Region personnel will use guidelines and template(s) to field review each identified highway section with crashes and determine appropriateness of installing edge rumble stripes or shoulder rumble strips now or deferring until the next overlay. Region personnel will assemble Region-wide or county-wide contract plans to implement the improvements.

   Schedule: Sections and routes identified for edge rumble stripes or shoulder installations identified within 12 months of acceptance of the Plan.

4. Contracts will be let and improvements will be implemented.

   Schedule: All identified edge/shoulder rumble strip sections and routes implemented within 30 months of acceptance of the Plan.

5.1.3.2 Local Road Implementation

Due to the high number of roadway departure crashes on local roads in Oregon, it is imperative to address local needs. Table 16 provides the recommended deployment level and benefits for installing edgeline and shoulder rumble strips on local roads. Note that the analysis of local road crashes and the recommendations for deployment apply to the entire route (due to crash and roadway data limitations). The locations of these 64 local roads to review are provided in Appendix B.

Table 16: Edge Line Rumble Strips – Single Vehicle Roadway Departure Crashes – Local Roads

Countermeasure - Locality	Threshold Crash Level (7 Years)	Number of Local Roads	Number of Local Road Crashes in 7 Years (02-08)	Estimated Number of Improvements [1]	Construction Costs ($ Million) [2]	Fatalities per 100 Crashes	Incapacitating Injuries per 100 Crashes	Annual Targeted Crash Reduction [3]	Annual Estimated Incapacitating Injury Reduction	Annual Estimated Fatality Reduction
Edge Rumble Strips – Local Rural	20	64	1,835	38	2.30	4.65	10.15	45.60	4.63	2.12

[1] For edge line rumble strips, assumes 60% of locations can be improved.

[2] Assumes an average cost of $60,000 per local road for rumbles ($6k/mile, assumed avg. 10-mile road)

[3] A CRF of 0.29 for edge rumble strips.

For local roads, it will be necessary for ODOT to work with its local partners to determine how centerline rumble strips can be implemented on the non-state system. Suggested implementation is as follows:

1. Systematic deployment of edgeline and shoulder rumble strips on two-lane and multi-lane undivided rural local roads meeting a crash threshold of 20 or more single vehicle roadway departure crashes on the entirety of the local road's length occurring in the past 7 years.
2. Due to the limitations in local road data regarding roadway widths, existence of shoulder, conditions of pavement, etc., it will be necessary to complete a field check of each local road to determine its potential for centerline rumble strip implementation. It is assumed that only 60 percent of the local roads meeting the crash criteria will be viable options for edgeline and shoulder rumble strip implementation.

5.1.4 Alignment Delineation

Raised pavement markers (RPMs) and other methods to delineate the alignment of the roadway for night driving will be considered on those sections of highway which have high incidences and proportions of night crashes. Tables 17 and 18 below show the number of State road sections and local roads for systematic deployment of alignment delineation countermeasures.

Table 17: Alignment Delineation – Roadway Departure Crashes – Dark – State Rural Roads

Locality	Threshold Crash Level (7 Years) [1]	Number of 3,000 ft. Sections	Number of Section Crashes in 7 Years (02-08)	Estimated Number of Improvements	Construction Costs ($ Million) [2]	Fatalities per 100 Crashes	Incapacitating Injuries per 100 Crashes	Annual Targeted Crash Reduction [3]	Annual Estimated Incapacitating Injury Reduction	Annual Estimated Fatality Reduction
State Rural	5	158	962	126	0.63	4.58	10.07	16.49	1.66	0.76

[1] Also need a dark to total crash ratio of at least 0.30.

[2] Assumes 80% of locations can be improved.

[3] Assumes an average cost of $5,000 per section.

[4] A CRF of 0.15 dark crashes is used.

Table 18: Alignment Delineation – Roadway Departure Crashes – Dark – Local Roads

Locality	Threshold Crash Level (7 Years) [1]	Number of Local Roads	Number of Local Road Crashes in 7 Years (02-08)	Estimated Number of Improvements	Construction Costs ($ Million) [2]	Fatalities per 100 Crashes	Incapacitating Injuries per 100 Crashes	Annual Targeted Crash Reduction [3]	Annual Estimated Incapacitating Injury Reduction	Annual Estimated Fatality Reduction
Local Rural	10	50	732	40	1.00	5.52	10.88	12.55	1.37	0.69
Local Urban	5	39	247	31	0.78	1.71	5.94	4.23	0.25	0.07
Total	-	-	-	71	1.78	-	-	16.78	1.62	0.77

[1] Also need a dark to total crash ratio of at least 0.30.

[2] Assumes 80% of locations can be improved.

[3] Assumes an average cost of $25,000 per local road.

[4] A CRF of 0.15 dark crashes is used.

5.1.5 Select Tree Removal in Rural Areas to Reduce Future Tree Crash Occurrences

Trees are the fixed object most often associated with roadway departure fatalities. Most of these fatalities occur in rural areas. One of the challenges associated with this initiative is that tree removal alone may not be the sole low-cost countermeasure that needs to be implemented; removal or relocation of other vulnerable fixed objects also needs to be considered. In addition, many vulnerable trees may be located beyond the ditch line and/or on private property. Processes should be developed to work with the property owner to allow for removal (or replace the tree at a less vulnerable location or with more crash-impact-friendly shrubbery). In addition, some sections with high numbers of tree crashes will not be suitable for tree removal; in these cases, alternate countermeasures such as edge rumble strips or delineation may be considered to reduce the likelihood of tree collisions.

A hierarchy of questions should be asked to identify the appropriate countermeasure to reduce future tree crashes:

- Should/can the tree be removed?
- If the answer is yes, are there other improvements needed to improve the safety of the section (e.g., removing other vulnerable fixed objects, minor re-grading)?
- Also, if the tree is not on highway agency right of way, can arrangements be made with the property owner to have the tree removed?
- If the tree cannot be removed, would shielding result in a significant safety benefit? If shielding will not substantially improve safety, can other alternatives (e.g., edge rumble strips, wrapping delineation around the tree) reduce the potential for future tree crashes?

The number of sections, crash threshold, costs, and safety impact of this initiative are provided in Tables 19 and 20 for State and local roads.

Table 19: Tree Removal/Safety Enhancements – Tree Crashes (1st, 2nd, or 3rd Crash Event) – State Rural Roads (2002-2008)

Roadway	Threshold Crash Level	Number of Sections	Number of Targeted Crashes on Sections	Estimated Number of Improvements [1]	Construction Costs ($ Million) [2]	Fatalities per 100 Crashes	Incapacitating Crashes per 100 Crashes	Annual Targeted Crash Reduction [3]	Annual Estimated Incapacitating Injury Crash Reduction	Annual Estimated Fatality Reduction
State Rural Road	3	67	230	54	1.34	10.74	16.89	13.14	2.22	1.41

[1] Assumes 80% of locations can be improved by tree removal, other improvements to reduce roadway departure frequencies in the vicinity of the struck trees, or reduced speed to reduce severity. A field review will be needed to determine the appropriate countermeasure.

[2] Assumes an average cost of $25,000 per section.

[3] An average CRF of 0.50 is used as an overall average for all possible tree countermeasures.

Table 20: Tree Removal/Safety Enhancements – Tree Crashes (1st, 2nd, or 3rd Crash Event) – Local Roads

Locality	Threshold Crash Level (7 Years)	Number of Local Roads	Number of Local Road Crashes in 7 Years (02-08)	Estimated Number of Improvements [1]	Construction Costs ($ Million) [2]	Fatalities per 100 Crashes	Incapacitating Injuries per 100 Crashes	Annual Targeted Crash Reduction [3]	Annual Estimated Incapacitating Injury Reduction	Annual Estimated Fatality Reduction
Local Rural	5	64	410	51	1.28	9.38	16.19	11.71	1.90	1.10
Local Urban	10	4	42	3	0.08	3.35	9.06	1.20	0.11	0.04
Total	-	-	-	54	1.36	-	-	13	2.01	1.14

[1] Assumes 80% of locations can be improved by tree removal, other improvements to reduce roadway departure frequencies in the vicinity of the struck trees, or reduced speed to reduce severity. A field review will be needed to determine the appropriate countermeasure.

[2] Assumes an average cost of $25,000 per local road.

[3] An average CRF of 0.25 is used as an overall average for all possible tree countermeasures.

The basic steps and schedule to implement this initiative are as follows:

1. Gain management acceptance to the Roadway Departure Safety Implementation Plan.

2. Traffic–Roadway Section will develop guidelines and a standard template for tree removals/treatments and issue it to Region personnel for implementation. Guidance should provide a process to consider removal of trees both within and beyond right-of-way limits; property owner considerations; other complementary roadway departure countermeasures such as the removal of other fixed objects adjacent to the trees and minor re-grading to create a clear zone; identification and options for considering environmental and historical factors associated with the vulnerable trees; and a set of alternate countermeasures, including edge rumble strips and tree delineation, to reduce the likelihood of tree crashes should the tree not be removed.

   Schedule: *Guidelines issued within 9 months of acceptance of the Plan.*

3. Region personnel will use guidelines and template(s) to field review each identified tree section and determine appropriate countermeasures.
4. In situations where the work will be contracted, Region personnel will assemble Region wide or county wide contract plans to implement the improvements.

   Schedule: Improvement sets identified for all identified sections within 18 months of acceptance of the Plan.

5. Contracts will be let and improvements will be implemented.

   Schedule: All identified improvements implemented within 36 months of acceptance of the Plan.

6. For local roads, ODOT will work with local jurisdictions to consider a similar plan of action.

5.1.6 Guard Rail Upgrades

The data analysis of Oregon roadway departure crashes showed that 100 roadway departure fatalities from 2002-2008 included a vehicle hitting the guard rail. It is assumed that improvements to roadside hardware will not reduce the number of roadway departure crashes, but it can impact the severity of a crash when it happens.

A separate funding source has been dedicated to this effort in Oregon, demonstrating a commitment from ODOT to address this issue. Guard rail upgrades were not included in the final Strategy Matrix, but this is a potentially beneficial strategy to reduce severe roadway departure crashes.

This report recommends that during the guard rail needs identification process, ODOT should use the analysis completed as part of this Implementation Plan effort to help choose the locations most likely to benefit from this countermeasure. Approximately 2 years after the guard rail upgrade program has begun, ODOT should evaluate the program to determine if it continues to be the most effective use of safety funds.

5.2 Comprehensive Education, Enforcement, and Engineering (3-E) Improvements

This initiative involves a three-pronged approach involving the actions summarized below.

5.2.1 Targeted Corridor Education and Enforcement (Minimal or No Infrastructure Improvements)

This initiative combines education and enforcement actions on corridors with high concentrations of roadway departure crashes involving speeding, unbelted drivers, and alcohol use.

The plan identifies sections of highway with concentrations of speed or unbelted driver crashes both on and off the Interstate as well as concentrations of alcohol-related crashes. The speed and unbelted driver

crashes were combined because the enforcement tactics to impact these types of violations are complementary.

Alcohol-related crashes are concentrated in the late evening-early morning hours, and the enforcement tactics emphasize sobriety checkpoints. Therefore, the alcohol enforcement sections were separated from the other enforcement sections. Summaries of the targeted sections for education and enforcement are provided in Tables 21 through 23.

Table 21: Enhanced Corridor Enforcement – Roadway Departure Crashes – Speed-Related or Unbelted Driver – State Roads - Not Interstates (2002-2008)

Locality	Threshold Crash Level	Number of Sections	Number of Targeted Crashes on Sections	Estimated Number of Improvements [1]	Construction Costs ($ Million) [2]	Fatalities per 100 Crashes	Incapacitating Crashes per 100 Crashes	Annual Targeted Crash Reduction [3]	Annual Estimated Incapacitating Injury Crash Reduction	Annual Estimated Fatality Reduction
State Rural	30	7	266	6	0.20	4.81	10.76	4.56	0.49	0.22
State Urban	30	5	375	4	0.14	2.82	6.23	6.43	0.40	0.18
Total	-	-	-	10	0.35	-	-	10.99	0.89	0.40

[1] Assumes 80% of locations will have sufficient enforcement capabilities to implement enhanced enforcement (at least 10 hours per week of highly visible active enforcement per section).

[2] Assumes an average annual enforcement cost of $36,000 per 9,000-ft.section for State highways.

[3] A CRF of 0.15 is used as an overall average for all possible enhanced corridor enforcement countermeasures. Estimated from speed and safety belt enforcement effectiveness information in NHTSA's *Countermeasures That Work.* (http://www.nhtsa.gov/staticfiles/DOT/NHTSA/Traffic%20Injury%20Control/Articles/Associated%20Files/811081.pdf).

Table 22: Enhanced Corridor Enforcement – Roadway Departure Crashes – Speed-Related or Unbelted Driver – Local Roads (2002-2008)

Locality	Threshold Crash Level (5 Years)	Number of Sections	Number of Targeted 5 Year Crashes on Sections	Estimated Number of Improvements [1]	Construction Costs ($ Million) [2]	Fatalities per 100 Crashes	Incapacitating Crashes per 100 Crashes	Annual Targeted Crash Reduction [3]	Annual Estimated Incapacitating Injury Crash Reduction	Annual Estimated Fatality Reduction
Local Rural	30	12	445	10	0.23	5.18	10.84	7.63	0.83	0.40
Local Urban	30	3	97	2	0.06	2.27	5.95	1.66	0.10	0.04
Total	-	-	-	12	0.29	-	-	9.29	0.93	0.43

[1] Assumes 80% of locations will have sufficient enforcement capabilities to implement enhanced enforcement (at least 10 hours per week of highly visible active enforcement per section).

[2] Assumes an average annual enforcement cost of $24,000 per roadway

[3] A CRF of 0.15 is used as an overall average for all possible enhanced corridor enforcement countermeasures. Estimated from speed and safety belt enforcement effectiveness information in NHTSA's *Countermeasures That Work.* (http://www.nhtsa.gov/staticfiles/DOT/NHTSA/Traffic%20Injury%20Control/Articles/Associated%20Files/811081.pdf).

Table 23: Enhanced Corridor Enforcement – Roadway Departure Crashes – Alcohol-Related (2002-2008)

Locality	Threshold Crash Level	Number of Sections	Number of Targeted Crashes on Sections	Estimated Number of Improvements [1]	Construction Costs ($ Million) [2]	Fatalities per 100 Crashes	Incapacitating Crashes per 100 Crashes	Annual Targeted Crash Reduction [3]	Annual Estimated Incapacitating Injury Crash Reduction	Annual Estimated Fatality Reduction
State Rural	5	29	170	23	0.84	26.91	27.61	2.91	0.80	0.78
State Urban	5	16	97	13	0.46	15.35	18.50	1.66	0.31	0.26
Local Rural	5	18	106	14	0.35	26.91	27.61	1.82	0.50	0.49
Local Urban	5	20	134	16	0.38	15.35	18.50	2.30	0.42	0.35
Total State	-	-	-	36	1.30	-	-	4.58	1.11	1.04
Total Local	-	-	-	30	0.73	-	-	4.11	0.93	0.84
Total	-	83	-	66	2.03	-	-	8.69	2.04	1.88

[1] Assumes 80% of locations will have sufficient enforcement capabilities to implement enhanced alcohol enforcement (i.e., sobriety checkpoints).

[2] Assumes an average annual enforcement cost of $36,000 per 9,000 ft. State road section; $24,000 per local roadway.

[3] A CRF of 0.20 is used as an overall average for all possible enhanced corridor enforcement countermeasures. Estimated from sobriety checkpoint effectiveness information in NHTSA's *Countermeasures That Work: A Highway Safety Countermeasure Guide For State Highway Safety Offices* (http://www.nhtsa.gov/staticfiles/DOT/NHTSA/Traffic%20Injury%20Control/Articles/Associated%20Files/811081.pdf).

The crash data has identified 12 non-Interstate sections of State highway of 9,000 ft. in length with high concentrations of speed-related or unbelted injury crashes. According to the assumption that 80 percent of identified sections will be viable options for enhanced deployment, 10 segments should include enforcement and education efforts. Additionally, 12 local roads were identified to be considered.

Eighty-three sections/routes with high concentrations of alcohol-related roadway departure crashes have been identified on the State and local roadway systems, with an assumption that 66 will be viable options for deployment. This effort involves inviting representative of the police personnel responsible for enforcement along these sections to initiate a coordinated education and enforcement approach by using a combination of targeted education and highly visible enforcement strategies. In addition, police and local officials may be consulted to determine the acceptability of initiating a vigorous enforcement initiative that may result in issuing a significant number of traffic violations.

Some minor infrastructure improvements to provide roadside areas where enforcement personnel can safely pull cited drivers off the highway may also be needed.

The effort should begin with a preliminary meeting with the Governor's Highway Safety Representative to identify the number of existing enforcement grants that cover portions of these corridors and determine potential sources of revenue to finance the initiative. It is not assumed that "new money" will be found to fund this effort, but instead that a portion of existing and potential future funding sources (e.g., NHTSA 402-type, HSIP flexible) could focus on the routes identified in this analysis.

Following funding source analyses, selected corridors should be identified to pilot the concept. Meetings should be arranged with appropriate local officials and law enforcement organizations responsible for enforcement along the identified pilot sections of highway to determine interest in initiating a comprehensive education and enforcement initiative.

5.2.2 Key Steps for Implementing Education and Enforcement Safety Corridors

Phase 1 – Preparatory

1. Select pilot corridors to implement the targeted education and enforcement. (This is done by the Governor's Highway Safety representative and the Traffic–Roadway Section)
2. Perform an analysis of the crash data along the pilot corridor to identify crash patterns that can be addressed by targeted education or enforcement actions. (This is done by the Region HSIP Coordinator.)
3. Determine if existing safety grants could be used to improve safety along the pilot corridor and if adjustments to these grants should be considered to increase targeted enforcement in the corridor.

Phase II – Meet with Appropriate Police Personnel

1. Arrange a meeting with police responsible for enforcement on the corridors to share this portion of the Implementation Plan.
2. Request a written commitment to enhance enforcement on the identified corridors. Indicate that ODOT will consider placing special "targeted enforcement" signing on the corridor if a written commitment of at least 10 to 15 hours of visible and active enforcement directed at the driver violations cited in the targeted crashes is provided on the corridor.
3. Advise the meeting participants, if a written commitment for enforcement will be provided, that the data and the increased enforcement should be shared with the media in a joint press conference.
4. Collectively agree on an initial set of corridors to implement the enforcement measures, develop a coordinated strategy, announce the information to the media, and begin visible enforcement. Also, agree on an education component to apprise motorists of the increased targeted enforcement on the corridor, including the potential to install signing. Agree to a 6- to 12-month follow-up meeting to evaluate the impact of the initiative and determine whether further actions are needed and if the initiative should be expanded to remaining corridors.

Phase III – Implementation

1. Meet with magistrates or Region justices who have jurisdiction over the selected traffic corridor, explain the driver safety crash concerns on the corridor, and ask for their input and cooperation when visible enforcement begins.
2. Install the targeted enforcement corridor signs if appropriate.
3. Begin visible enforcement.
4. Hold a joint ODOT-police press event for the corridor.
5. Periodically meet with police and magistrates to monitor enforcement levels and obtain any insight from police on observed changes in driving habits as a result of the added enforcement and signing. If anything newsworthy results, provide a press release.

Phase IV – Evaluation

1. After a full year of crash data becomes available, perform a "before and after" comparison of crashes on the corridor comparing the changes in targeted crashes that the enforcement has reduced (e.g., alcohol, speeding, unbelted) in the "after" period to the crash statistics from the "before" period.
2. Potentially include a "before and after" comparison of speed distributions and a safety belt survey to determine if high-end speeding is being reduced and if more people are buckling up on the route.
3. Meet with the police, share the evaluation information, and make a determination as to whether the initiative should be expanded to the remaining corridors.

Table 24: Key Implementation Steps for Roadway Departure Education and Enforcement Strategies

Step	Organization Responsible for Step	Schedule
1. Phase 1. Review the corridors, meet with the Governor's Safety Representative, and identify potential grant opportunities for education and enforcement initiatives in the five areas. Select pilot corridors	Traffic-Roadway Section, Governor's Safety Representative	2 months
2. Determine the level of NHTSA-related funding that may be available to fund the initiative; also explore the use of other funding sources should a shortfall exist.	Traffic-Roadway Section, Governor's Safety Representative	4 months
3. Finalize funds available and select corridors to consider for heightened enforcement.	Traffic-Roadway Section, Governor's Safety Representative	6 months
2. Phase 2. Meet with State and Local Police in selected corridors, gain commitments, and finalize the initial set of corridors.	Traffic-Roadway Section, Governor's Safety Representative	6 months
3. Phase 3. Implement the education and enforcement initiative on designated corridors.	Traffic-Roadway Section, Governor's Safety Representative, State and local police	Months 9-33
4. Phase 4. Evaluate the results, take any lessons learned, and make a decision to expand, expand with modifications, or terminate education and enforcement.	Traffic-Roadway Section, Governor's Safety Representative, Highway Safety Engineering Committee	Evaluation completed by month 36
5. If decision is to expand or expand with modifications, proceed with Phase 1 through 4 for additional corridors.	Traffic-Roadway Section, Safety, Governor's Representative	Phase 1 begins at month 39

5.2.3 Targeted 3-E Engineering, Education, and Enforcement for Corridors

Table 21 identifies non-Interstate corridors with the highest concentrations of severe roadway departure crashes that are candidates for combined education, enforcement, and engineering initiatives.

Table 25: Summary of Roadway Departure Crashes (2002-2008) on Candidate Corridors for 3-E (Engineering, Education, Enforcement) Initiatives

County Name	Highway No	Highway Name	Number of Roadway Departure Fatalities	Number of Roadway Departure Incapacitating Injuries	Total Roadway Departure Crashes
Klamath	4	THE DALLES-CALIFORNIA	48	63	528
Deschutes	4	THE DALLES-CALIFORNIA	35	61	471
Linn	16	SANTIAM	22	53	473
Douglas	45	UMPQUA	22	31	248
Clackamas	26	MT. HOOD	21	39	353
Marion	162	NORTH SANTIAM	21	36	329
Josephine	25	REDWOOD	21	40	290
Wasco	53	WARM SPRINGS	19	12	137
Tillamook	9	OREGON COAST	18	28	375
Columbia	92	LOWER COLUMBIA RIVER	18	34	225
Lane	18	WILLAMETTE	16	34	422
Washington	37	WILSON RIVER	16	16	86
Washington	47	SUNSET	15	26	404
Klamath	20	KLAMATH FALLS-LAKEVIEW	15	18	197
Marion	81	PACIFIC HIGHWAY EAST	15	16	138
Jefferson	4	THE DALLES-CALIFORNIA	15	19	97
Clackamas	171	CLACKAMAS	14	28	261
Polk	30	WILLAMINA-SALEM	14	31	251
Malheur	456	I.O.N.	14	27	181
Sherman	42	SHERMAN	14	19	133

The crash data has identified 20 State route corridors that have had 14 or more roadway departure fatalities over the past 7 years. The intent of this objective is to advance a set of 3-E initiatives on three of these corridors to reduce the potential for future severe roadway departure crashes. For each of the corridors, this initiative will have as its objective a reduction in corridor roadway departure fatalities and severe injuries by a minimum of 25 percent using a combination of low-cost infrastructure improvements coupled with targeted education and enforcement initiatives. While the selection of the corridor has been based upon high frequencies of severe roadway departure crashes, the approach may be broader and encompass other corridor concerns such as intersections, mid-block pedestrian problems, and driver behavioral problems, including driving while intoxicated, lack of safety belts, and speeding.

The effort begins with a thorough analysis of the crash characteristics in the corridor to better understand the problems that need to be addressed and relate the patterns to potential countermeasures. A multi-disciplinary team is then formed to review the crash analysis, discuss the safety problems on the corridor, jointly field review the corridor to gain personal and group consensus of the major safety issues, and

collectively develop an overall set of 3-E countermeasures to improve safety on the corridor. After the countermeasures have been identified and approved by the agencies involved, staged and coordinated implementation of the recommendations begins. The team performs oversight and monitors the implementation activities to insure that substantive safety progress along the corridor is being made.

A pilot effort of three corridors will be initiated first. The pilot will be evaluated by the Highway Safety Engineering Committee (HSEC) and, if considered beneficial, will be expanded to the remaining corridors incorporating lessons learned from the pilot.

The goal of the corridor safety study is to reduce fatal and disabling injury crashes on designated high-volume arterials exhibiting high frequencies of severe crashes using low-cost, near-term solutions combined with highly visible enforcement, education, and emergency medical service initiatives.

Corridor safety studies are usually conducted using a team approach. The corridor team is typically comprised of at least the following representatives:

- Region Traffic and HSIP Coordinator.
- Region Press Officer.
- Region Maintenance Manager or designee.
- Representative of State or local police responsible for enforcement on the corridor.
- Local government representative.

Additional team members may also include the local Emergency Medical Services (EMS) coordinator, a Metropolitan Planning Organization (MPO) representative, and a highway design representative.

Once a corridor has been identified for a study, the Region Traffic or Region HSIP Coordinator should perform an analysis of the crash data along the corridor to identify crash patterns that can be addressed by low-cost countermeasures and education/enforcement actions. All cluster lists need to be reviewed to identify specific locations within the corridor that appear on one or more of the cluster lists.

After the crash analysis is completed, the corridor safety team is convened to review and discuss the crash analysis, findings, and safety concerns along the corridor from each member's perspective. The team then conducts a field review of the corridor, usually in one or two vehicles, to assess areas of concern defined from the crash analysis and team discussions. The team then reconvenes and reaches consensus on a set of countermeasures and initiatives that have strong potential to reduce future severe crashes.

The Region Traffic, HSIP Coordinator and the Region Press Officer take the results of the team field review meeting and prepare a cost estimate and an assessment of the probable safety impacts and cost effectiveness of implementing the recommended improvements. A brief report and tentative implementation schedule are prepared and used for programming cost-effective improvements.

Table 26: Key Implementation Steps for 3-E Corridor Enhancements

Step	Organization Responsible for Step	Schedule
1. Review 10 corridors and select three of the corridors to pilot and lead the implementation.	Traffic-Roadway Section, Governors safety rep, Region Traffic and HSIP Coordinator	3 months
2. Analyze data for the corridors selected, investigating all major crash patterns, and prepare a report of findings.	Traffic-Roadway Section, Governors safety rep, Region Traffic and HSIP Coordinator	6 months
3. Select a multidisciplinary team for each corridor to determine actions to reduce future crashes.	Region Traffic and HSIP Coordinator	8 months
4. Hold meeting of multi-disciplinary teams, complete field reviews of corridors, identify set of comprehensive 3E improvements, and prepare brief corridor reports summarizing actions and improvements proposed to reduce future fatalities. As part of the report, estimated costs and schedules are also prepared.	Multi-disciplinary Team	Reports completed in 12 months
5. Agencies approve the report, including approving their role as defined in the report.	Affected Organizations	Action on report taken in 14 months
6. Begin implementing report, including education and enforcement activities, and developing and letting contract to implement infrastructure improvements.	Affected Organizations	Improvements in place in 30 months
7. Evaluate corridor approach, take any lessons learned, and make a decision to expand, expand with modifications, or terminate corridor safety approach.	Highway Safety Executive Committee	Decision reached in 42 months
8. If decision is to expand or expand with modifications, proceed with steps 2 through 7 for additional corridors.	Traffic-Roadway Section, Governors safety rep, Region Safety Engineers	Additional corridors approved by Executive Committee started in step 2 by month 48

5.2.4 Targeted Engineering, Education, and Enforcement for Cities

Combined education, enforcement, and engineering initiatives in municipalities which have the highest frequencies of roadway departure crashes.

Table 27: Summary of Roadway Departure Crashes by Major City (2002-2008)

City Name	Number of Roadway Departure Fatalities	Number of Roadway Departure Incapacitating Crashes	Total Roadway Departure Crashes
Portland	92	240	3923
Salem	27	51	1083
Eugene	12	39	797
Bend	10	28	491
Beaverton	9	33	741
Springfield	9	18	311

The crash data has identified the four cities that have the highest number of roadway departure fatalities. An initial 3-E pilot for cities involves inviting one large and one mid-sized city to initiate an area-wide 3E approach. The objective of the effort is to reduce city roadway departure fatalities by a minimum of 10 percent using a combination of low-cost infrastructure improvements coupled with targeted education and enforcement strategies that extend beyond those that may be implemented in other systematic countermeasure deployments.

The effort should begin with a preliminary meeting with city officials to determine interest in initiating a comprehensive roadway departure safety initiative. A thorough clean-up of the crash data for roadway departure crashes on State and local roads within the urban area could be completed so clusters of crashes can be accurately combined. After the data is cleaned, a thorough analysis of the characteristics of crashes in the city should be performed with the goal of understanding the problems that need to be addressed and relating the patterns to potential countermeasures. A city-wide, multi-disciplinary team should be formed to review the crash analysis, discuss the roadway departure safety problems in the city, jointly field review the selected problem areas to gain personal and group consensus of the major safety issues, and collectively develop an overall set of 3-E countermeasures to improve safety in the city. After the countermeasures have been identified and approved by the agencies involved, staged and coordinated implementation of the recommendations should begin. The team should perform oversight and monitor the implementation activities to ensure that substantive safety progress is being made.

Table 28: Key Implementation Steps for Roadway Departure City-Wide 3E Improvements

Step	Organization Responsible for Step	Schedule
1. Review the cities and select candidate pilot cities.	Traffic–Roadway Section, Governor's Safety Representative	2 months
2. Contact cities to determine interest. If not interested, go to next candidate city. Finalize pilot cities.	Traffic–Roadway Section, Governor's Safety Representative	6 months
3. Analyze crash data for pilot cities, investigating all major roadway departure crash patterns and prepare a brief report of findings.	Traffic–Roadway Section, Governor's Safety Representative	Reports prepared in 10 months
4. Select a multi-disciplinary team in each selected city to determine actions to reduce future crashes.	Traffic–Roadway Section, Region Traffic Engineer, Region HSIP Coordinator, Governor's Safety Representative and city police, planning, and Traffic Operations representatives	Team formed in 12 months
5. Hold a meeting of the multi-disciplinary team, complete field reviews of problem and typical roadway departure locations, identify set of comprehensive 3E improvements, prepare a city set of countermeasures and improvements proposed to reduce future roadway departure fatalities by at least 10%. As part of the set of countermeasures, estimated costs and schedules are also prepared.	Multi-disciplinary Team	Set of countermeasures completed by 18 months
6. Agencies approve the set of countermeasures, including approval of their role as defined in the plan.	Affected Organizations	Action on the set of countermeasures taken by 21 months
7. Implementation of countermeasures begins, including education and enforcement activities and development and letting of contract to implement infrastructure improvements.	Affected Organizations	Improvements in place by 40 months

Step	Organization Responsible for Step	Schedule
8. Evaluate city comprehensive approach, take any lessons learned, and make a decision to expand, expand with modifications, or terminate city comprehensive safety approach.	Traffic-Roadway Section, Governor's Safety Representative	Decision reached by 44 months
9. If decision is to expand or expand with modifications, proceed with steps 2 through 9 for additional cities.	Traffic-Roadway Section, Governor's Safety Representative	Step 2 begins at month 48

5.3 Deployment of Traditional Roadway Departure Countermeasures

Currently roadway departure improvements are generated within the HSIP program by identifying and studying crash locations that have high crash rankings. One initiative will be undertaken within the traditional roadway departure program as follows:

- In addition to candidate locations generated from the existing formulae, another potential roadway departure-specific improvement type under the traditional program is the 4-lane to 3-lane conversion of a select number of 4-lane, undivided State highways with AADTs less than 18,000 per day.

A summary of the scope of these deployments and set of key steps needed to implement each of these initiatives effectively is included in Tables 29 and 30.

Table 29: Four to Three Lane Conversions – Roadway Departure Crashes –4 Lanes, < 18,000 AADT, Undivided – State Roads (2002-2008)

Locality	Threshold Crash Level (5 Years)	Number of Sections	Number of Targeted 5 Year Crashes on Sections	Estimated Number of Improvements [1]	Construction Costs ($ Million) [2]	Fatalities per 100 Crashes	Incapacitating Crashes per 100 Crashes	Annual Targeted Crash Reduction [3]	Annual Estimated Incapacitating Injury Crash Reduction	Annual Estimated Fatality Reduction
State Rural Roads	10	11	137	7	0.70	7.03	12.55	4.34	0.55	0.31

[1] Assumes 60% of locations can be improved.

[2] Assumes an average cost of $100,000 per section. A field view is needed to identify the appropriate improvements.

[3] A CRF of 0.37 for roadway departure crashes is used for roadway departure crashes.

Table 30: Key Steps to Four to Three Lane Conversions on State Rural Highways

Step	Organization Responsible for Step	Schedule
1. Review each of the identified highway sections to determine the appropriateness of converting the section from 4 lanes to 3 lanes.	Region Traffic Engineer	9 months
2. Select improvements from field reviews and program.	Region Traffic Engineer	12 months
3. Design and let contracts for construction.	Region Office	Projects let by 18 months
4. Let projects are completed and opened to traffic.	Region Office	Projects complete by 36 months.

5.3.1 Roadway Departure Countermeasures on Local Roads

In Oregon, local roads account for 49 percent of roadway departure crashes and over 42 percent of roadway departure fatalities. In order to meet the goal of reducing roadway departure fatalities by 20 percent, it will be necessary to include significant engineering, enforcement, and education efforts on local roadways.

In order to make a difference on local roads, it will be important for the Oregon DOT Local Programs Section to be involved with the Implementation Plan as it relates to local roads. Their connection to the locals is an important one, and their ability to support local road safety projects will play a large part in the success of this effort.

In addition to the local-focused discussion in the highlighted countermeasures discussed above, Oregon DOT should reach out to local highway agencies to discuss each roadway departure countermeasure, its potential deployment characteristics, and its benefits.

5.4 Incorporation of Low-Cost, Cost-Effective Countermeasures at Crash Locations within the Limits of Work for Programmed Projects

A considerable number of project types are implemented throughout Oregon. Within the contract limits of some these projects, high-crash sections exist where cost-effective, low-cost countermeasures may be considered for incorporation into the project to reduce the potential for future crashes. This initiative is to develop and implement a process to identify programmed projects that have crash histories within the geographic location of the project and determine if low-cost, cost-effective safety improvements should be incorporated into the project to reduce the potential of future crashes.

According to discussions with ODOT, overlay projects include a list of "mandatory safety items" (e.g., bridge end treatments) that must be addressed with the project. Approximately 6 percent of the project funding should be used of these safety improvements. ODOT's safety staff should consider recommending safety features from this Implementation Plan, including rumble strips, delineation, and sign upgrades.

One area of concern is a discussion in Oregon to consider new "1R" projects that will include only a surface overlay and no other treatments. Where appropriate and cost-effective, ODOT should consider using safety-focused funds to include safety elements in these "1R" projects.

There are a number of issues that should be addressed for this initiative to be successful, including:

1. **Type of project on which to consider incorporating the low-cost safety countermeasures** – Reconstruction projects will likely address most of the safety issues that low-cost countermeasures are designed to address. Specialty project types such as transportation enhancements may not be appropriate to consider for incorporating low-cost safety measures (except if the project has landscaping, tree, and shrubbery improvements). Bridge projects are usually limited to the bridge itself and may restrict the potential to incorporate these countermeasures into them. Resurfacing and 3-R projects offer the greatest opportunity for incorporation of low cost countermeasures since the primary improvement is normally limited to providing a smooth and structurally sound surface.
2. **Type of low-cost countermeasures to consider for incorporation into projects** – The predominant low-cost countermeasures that need to be considered for inclusion in programmed projects should meet the minimum crash thresholds defined for the systematic low-cost countermeasure initiative and include the following:

a. Shoulder or edge rumble strips in rural areas.

b. Centerline rumble strips in rural areas.

c. Tree removal in rural areas.

d. Use of the Safety Edge under the following conditions: at the edge of pavement if a non-paved shoulder is specified, at the outer edge of a paved shoulder, and during construction if a lift exceeding 2 inches will be open to traffic for a period of time. According to Oregon DOT, a research effort is currently underway to determine the feasibility of the Safety Edge on Oregon highways.

e. Use of an micro-texture or similar high-skid surface on sections which have 5 or more wet pavement crashes within a 3,000 foot section, a wet/total crash ratio above 22 percent, and a pavement cross section that is relatively flat, susceptible to accumulating water, and would not be corrected by the pavement overlay.

3. **Funding** – The method to finance safety improvements needs to be clarified within Oregon. There are three readily apparent funding options:

   a. Fund the safety portion as part of the existing project funding.

   b. Fund the safety portion with HSIP funding.

   c. For the local road improvements, consider High Risk Rural Roads (HRRRP) funding.

4. **Process** – The process by which low-cost, cost-effective safety countermeasures are to be considered and included in other projects needs to be developed between the Design Division, Maintenance Division, and the Traffic–Roadway Section. Some of the questions that should be addressed include the following:

   a. When in the design development stage should the consideration be given?

   b. Who should identify projects that have crash histories above the threshold? Who will perform the analyses to determine the appropriate countermeasure?

   c. Who will make the decision to include or exclude?

   d. What can be done to easily and efficiently incorporate designated low-cost improvements into the plan?

5.4.1 Key Implementation Steps

The key steps needed to effectively consider the initiative are shown in Table 31.

Table 31: Key Implementation Steps for Considering the Inclusion of Low-Cost, Cost-Effective Countermeasures in Other Programmed Projects

Step	Organization Responsible for Step	Completion Date (Months After Implementation Plan Acceptance)
1. Finalize a list of issues that need to be addressed to consider inclusion of low-cost, cost-effective countermeasures in other projects.	Traffic-Roadway Section	6 month
2. Establish a meeting between the Design, Maintenance, and Traffic-Roadway Section to further explore the inclusion of	Traffic-Roadway Section	6 months

Step	Organization Responsible for Step	Completion Date (Months After Implementation Plan Acceptance)
low-cost, cost-effective safety countermeasures into other projects, including discussing identified issues that need to be addressed.		
3. Hold a second meeting between the Sections to reach consensus on a process to identify projects where low cost countermeasures should be considered for inclusion; mechanisms to fund justified safety elements to add to the project; and revisions to existing process to consider and incorporate safety elements efficiently into projects under design.	Traffic-Roadway Section, Design, and Maintenance	9 months
4. Jointly develop an action plan to implement the results of the meeting.	Traffic-Roadway Section, Design, and Maintenance	12 months
5. Adopt the action plan and begin implementation of the action plan.	Traffic-Roadway Section, Design, and Maintenance	14 months
6. Evaluate effectiveness of Action Plan and modify as appropriate	Traffic-Roadway Section, Design, Maintenance	22 months

5.5 Deployment and Evaluation of New Roadway Departure Countermeasures

This initiative involves the limited and careful evaluation and potential deployment of new roadway departure countermeasures that offer the potential to reduce roadway departure crashes and fatalities beyond that which can be expected from existing countermeasures. One major roadway departure countermeasure has been identified that falls into this category: traffic calming to reduce high-end speeds at selected rural sites.

Oregon has minimal experience with the proposed new countermeasures. In addition, the actual effectiveness of rural traffic calming countermeasures has not been adequately validated. Nevertheless, rural traffic calming countermeasures fill gaps that the existing countermeasures cannot. ODOT should proceed cautiously with the deployment of these countermeasures to reduce risk, concentrating initial deployment on those sections with high numbers of roadway departure crashes that the countermeasure is designated to impact. A brief evaluation/implementation plan will be developed for the countermeasure that will include the limited deployment of an adequate number of improvements to identify implementation issues and any beneficial or adverse operational impacts.

Due to the prevalence of studded tires, Oregon experiences maintenance issues with pavements that may preclude the widespread use of pavement marking-based traffic calming measures. It will be important to incorporate maintenance needs when determining which countermeasures are the most cost-effective in the long term.

Any implementation issues or concerns identified from this initial deployment will be addressed and resolved before further implementation of the countermeasure is considered. Once all identified issues are resolved, sufficient additional improvements of the countermeasure will occur to improve the estimate of the effectiveness of the countermeasure in reducing targeted roadway departure crashes. When a better estimate of the effectiveness of the countermeasure is available, the countermeasure will be deployed cost effectively, depending upon the availability of funds and other priorities.

The extent to which traffic calming may be applied to Oregon highways is provided in the following table, which identifies sections of roadway with high incidences of speed-related crashes.

Table 32: Infrastructure Traffic Calming Measures to Reduce Speeding-Related Crashes – State and Local Roads (2002-2008)

Locality (Section Length)	Threshold Crash Level	Number of Sections	Number of Section Crashes	Estimated Number of Improvements [1]	Construction Costs ($ Million) [2]	Fatalities per 100 Crashes	Incapacitating Injuries per 100 Crashes	Annual Targeted Crash Reduction [3]	Annual Estimated Incapacitating Injury Reduction	Annual Estimated Fatality Reduction
State Rural (27,000 ft. section)	30	55	2,283	44	1.10	4.81	10.76	78.27	8.42	3.76
State Urban (9,000 ft. section)	20	9	467	7	0.18	2.82	6.23	16.01	1.00	0.45
Local Rural (entire roadway)	20	43	1,174	34	0.86	5.02	10.79	40.25	4.34	2.02
Local Urban (entire roadway)	20	14	351	11	0.28	2.27	5.87	12.03	0.71	0.27
State Total	-	-	-	51	1.28	-	-	94.28	9.42	4.21
Local Total	-	-	-	45	1.14	-	-	52.28	5.05	2.29
Total	-	-	-	96	2.42	-	-	146.56	14.47	6.51

[1] Assumes 80% of locations can be improved by incorporating speed reduction traffic calming measures through pavement markings. No Interstate Highways included.

[2] Assumes an average cost of $25,000 per section / roadway.

[3] An average CRF of 0.30 is used as an overall average for all possible speed reduction measures.

Types of traffic calming may be found in the FHWA report, *Traffic Calming on Main Roads through Rural Communities*.[6] In addition, the use of peripheral transverse pavement markings on a continuous section rather than for a point specific location should be considered to reduce excessive speeds throughout a section of roadway.

The key steps that need taken to consider these enhancements are as follows:

Table 33: Key Steps to Evaluate New Roadway Departure Countermeasures

Step	Organization Responsible for Step	Schedule
1. Review FHWA HRT-08-067 *Traffic Calming on Main Roads Through Rural Communities* and identify appropriate rural traffic calming measures to pilot.	Traffic-Roadway Section,	9 months

[6] FHWA Report HRT-09-067, 2008.

Step	Organization Responsible for Step	Schedule
2. Identify countermeasures, select sites for improvements, and prepare an evaluation plan for each of the selected new countermeasures.	Traffic-Roadway Section, Maintenance Section, Region Traffic	18 months
3. Install the countermeasures identified in the evaluation plans.	Region Traffic Operations	18-24 months
4. Evaluate the countermeasure and determine if use should be expanded, modified, or terminated.	Traffic-Roadway Section, Maintenance Section, Region Traffic Operations, Highway Safety Engineering Committee	24-42 months
5. If expanded, develop and provide guidance for further deployments.	Traffic-Roadway Section	48 months

6. Performance Measures

Two types of performance measures are proposed:

1. **Production** (output) performance measures that measures performance in implementing the products, processes, guidelines, and projects determined in the Plan that are needed to achieve the goal.
2. **Effectiveness** (outcome) performance measures the effectiveness of implemented countermeasures to reduce targeted crashes and compares actual to estimated effectiveness.

Specific product and effectiveness performance measures are identified in Tables 34 and 35.

6.1 Production Performance Measures

Table 34: Production Performance Measures

Countermeasure or Action	Measure	Target Completion Date	Actual Completion
Systematic Improvements			
Curve sign enhancements – State, rural, and urban –systematic	740 State sections 442 local roads	2014	Actual no. of curves
Curve sign and marking enhancements – State flashing beacons –systematic	20 sections	2014	Actual no. of curves
Centerline Rumble strips – systematic – 20 feet or greater rural roadways	273 State sections 88 local roads	2016	Actual centerline rumble strip miles
Edge/shoulder rumble strips (non-Interstate) – systematic – rural roadways	2,061 State sections 38 local roads	2015	Actual edge/shoulder rumble strip miles
Alignment Delineation – State and local roads	126 State sections 71 local roads	2016	
Tree removal – systematic	54 State sections 54 local roads	2016	Actual no. of tree crash sections treated
Incorporation of Low Cost, cost effective countermeasures at crash locations within the limits of work for programmed projects			
Action Plan to incorporate safety analysis results into other projects	Action Plan completed and implementation begins	2011	Actual Date
Implementation of Action Plan	50% of other projects with crash histories incorporating safety treatments	2013	Actual %
Comprehensive Education, Enforcement, and Engineering (3-E) Improvements			
2-E Targeted Education and Enforcement Corridors (Speed, Unbelted, Alcohol)	46 State sections 40 local roads	2013	Actual number of corridors underway by Oct. 2010
3-E Targeted Engineering, Education, and Enforcement Corridors	3 Corridor Reports completed	2013	Actual Date

Countermeasure or Action	Measure	Target Completion Date	Actual Completion
3-E Targeted Engineering, Education, and Enforcement Corridors	3 Corridors Implemented and Evaluated	2012	Actual Date
3-E Targeted Engineering, Education, and Enforcement Cities	2 City Reports completed	2012	Actual Date
3-E Targeted Engineering, Education, and Enforcement Cities	2 Cities Implemented and Evaluated	2012	Actual Date
Traditional Roadway Departure Countermeasures			
Four Lane to Three Lane Conversion – State roads	7 locations	2015	
New Roadway Departure Countermeasures			
Evaluation of rural traffic calming measures	51 State sections 45 local roads	2013	Actual number of different types under evaluation

6.2 Effectiveness Performance Measures– Program Effectiveness in Reducing Targeted Crashes

Table 35: Performance Measures

Countermeasure	Year Improvements Implemented	Year Evaluation Plan Developed	Year Evaluation Completed	Expected Crash Reduction	Actual Crash Reduction
Curve sign and marking enhancements – systematic					
Centerline Rumble strips – systematic					
Edge/shoulder rumble strips (non-Interstate) – systematic					
Tree removal – systematic					
Resurfacing Projects with safety enhancements					
2-E Targeted Education and Enforcement Corridors					
3-E Targeted Engineering, Education, and Enforcement Corridors					
3-E Targeted Engineering, Education, and Enforcement Cities					
Traffic Calming					

7. Summary

The number of roadway departure fatalities and incapacitating injuries within Oregon can measurably decline over the next several years, but it will take a number of new and special actions, increased roadway departure safety emphasis, and funding focused on the roadway departure problem to realize this benefit. The existing approach of emphasizing moderate- to high-cost improvements at high-crash roadway departure sections must be complemented with the deployment of a high number of low-cost, effective countermeasures and the use of a coordinated 3-E comprehensive approach on high-crash corridors and in municipalities with a high number of roadway departure fatalities.

The countermeasures, deployment levels, costs, and estimated lives saved needed to achieve the roadway departure safety goal are shown in Table 6. While the level and direction of effort is well beyond that currently being pursued for roadway departure safety, the expected outcome is prevention of over 1,000 crashes, 124 incapacitating injuries, and 65 fatalities annually on Oregon's highways.