Oregon Intersection Safety Implementation Plan
June 2012

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Executive Summary

Intersection fatalities within Oregon have averaged 72 annually over the 2005-2010 time period. However, intersection deaths have been gradually declining over this period, with 60 occurring in 2010. The Oregon DOT is pursuing the identification and implementation of strategies and countermeasures in the intersection area that will continue the reduction of intersection fatalities within the state.

Oregon's Transportation Safety Action Plan (TSAP) includes an overall goal of reducing fatality rate to less than 9.25 per 100,000 population in 2020.

The TSAP lists Intersection Crashes as a "Priority 2 Emphasis Area," focusing on the following objectives:

- Focusing on key infrastructure safety emphasis areas.
- Investigating the usefulness of advanced signing, roundabouts, access management techniques, advanced technology and features, and improvements to signal timing.
- Implement effective solutions.

The following TSAP actions also have connections to this Intersection Safety Implementation Plan:

- Action 1. Statewide Safe Communities
- Action 3. Tribal/local TSAP implementation
- Action 4. Bike/Ped engineering solutions
- Action 7. Safety need prioritization
- Action 9. Access management
- Action 12. Vegetation management
- Action 13. Safety research
- Action 88. Emerging ITS systems

A workshop composed of Oregon Department of Transportation (ODOT) safety personnel, Region traffic engineering and maintenance personnel, local transportation partners, and other stakeholders representatives was held April 19, 2012, to identify safety initiatives in the intersection emphasis area that could help achieve the reduction of statewide intersection fatalities within Oregon. Approximately 10 additional lives can be saved annually after full implementation — meaning that more than a 13 percent reduction in intersection fatalities can be achieved if a series of strategies and countermeasures are deployed including the following provisions:

- The traditional approach of relying primarily on pursuing major improvements at high-crash intersections must be complemented with a) a expansion of the systematic approach that involves deploying large numbers of relatively low-cost, cost-effective countermeasures at many targeted high-crash intersections and b) a comprehensive approach that coordinates an engineering, education, and enforcement (3E) initiative on corridors with high numbers of severe intersection crashes.

- The expanded systematic and comprehensive approaches will generate a much larger number of intersection improvements statewide, and Region traffic and safety personnel will need to take a more active role in identifying the appropriateness of systematic improvements within their regions.

- To achieve the intersection safety goal, it will take an investment of approximately $33 million beyond currently programmed intersection safety projects over the 5-year period (for State and local improvements, both infrastructure and education/enforcement), or approximately $6.5 million annually to achieve the goal.
    - A sizeable portion of the infrastructure funding (approximately $12 million) is recommended to be spend on the local road system.

To increase the opportunity for success, the ODOT Highway Leadership Team and Highway Engineering Safety Committee within Oregon DOT should provide support and guidance to the Traffic Roadway Section, ODOT Regions, ODOT Local Programs, and local highway agencies during the implementation phase. The bottom line of a successful implementation of this plan is that - once fully implemented - over a 10-year period more than 24,000 intersection crashes and 800 disabling injuries will be prevented along with 100 lives saved.

Using a value of life of $5.8 million, an incapacitating injury (Injury A) value of $402,000, a cost average of $4,000 for minor injury (Injury B, C) and property damage-only crashes, and an average expected countermeasure life of 10 years, the overall benefit cost ratio for this set of initiatives exceeds 29:1.

Background

Oregon's 2012 TSAP has an overall goal to reduce the number of fatalities in Oregon to less than 306 by 2030 (compared to an average of 391 from 2007 to 2010). One of the emphasis areas identified in the SHSP is to reduce intersection crashes. Intersection fatalities within the State have averaged 72 annually over the 2005-2010 time period. The TSAP provides insight on broad initiatives in the intersection safety area to support achieving the overall goal, but it lacks detail regarding countermeasures, actions, deployment characteristics, costs, impacts, and key steps that have to be taken to significantly improve intersection safety. This plan provides that detail and, if fully implemented, is projected to prevent at least 10 intersection fatalities annually, which is approximately a 13 percent reduction in fatalities. The purpose of this plan is to provide the specifics on countermeasure implementation actions, key steps, schedules, and investments needed to achieve that goal.

The Intersection Safety Goal

Over the past several years, the number of intersection fatalities within Oregon has gradually decreased as indicated in Table 1.

Table 1. Oregon Intersection Fatalities

	2005	2006	2007	2008	2009	2010	Avg
Number of Intersection Fatalities	80	63	80	78	68	60	72

Each of the sets of intersections that are candidates for these countermeasures are defined by the following definitions generated by Oregon DOT:

- **Intersectional crash** – a crash which occurs within the limits of the intersection of two or more roads; or, crashes which occur outside these limits but are a direct result from some maneuver at or because of the intersection.
- **Intersection-related crash** – crashes that occur outside the limits of an intersection that are indirectly related to a maneuver or circumstance at a nearby intersection.

The Intersection Safety Implementation Plan is designed to use low-cost solutions to reduce Statewide intersection crashes and resulting injuries and fatalities by approximately 10-15 percent.

The Approach

In the past, traditional intersection safety program efforts have been based upon identifying and analyzing individual high-crash intersections from the crash data system, defining crash patterns, determining appropriate countermeasures, and then implementing those countermeasures. While these are important approaches and need to continue, they need to be supplemented to continue the reduction of statewide levels of intersection fatalities.

To help further lower statewide intersection fatalities, two additional initiatives are recommended to be undertaken as follows:

- Systematic application of large numbers of cost-effective, low-cost countermeasures.
- Comprehensive application of low-cost infrastructure improvements coupled with targeted education and enforcement initiatives on a corridor basis.

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 a high number of moderate- to high-crash intersections where the countermeasure can be cost-effectively deployed. Estimates of the impacts of the deployments can be made in terms of projected statewide cost-effective deployment levels, annual lives saved, and deployment costs. The application of the systemic approach could also apply to areas where "crash associated factors" are also present (e.g., small curve radius, narrow roadway), even if a crash pattern does not exist. These sections can still be considered "high risk", and addressing them proactively can prevent future crashes. This approach is being successfully implemented in Oregon to address roadway departure crashes.

The comprehensive approach combines sets of cost-effective, low-cost infrastructure countermeasures with a coordinated set of education and enforcement initiatives targeted at improving intersection safety. The comprehensive approach is normally applied on a highway

corridor or city-wide basis and employs countermeasures and strategies that can result in a measurable corridor- or city-wide reduction of severe intersection crashes.

Distribution of the State Intersection Fatality Problem

The Oregon intersection crash data were analyzed to gain insight on the distribution and characteristics of the intersection crash problem. Key information derived from the intersection data analysis is shown in Tables 2-4.

Table 2. Oregon Intersection Crashes and Fatalities, 2005-2010

	State Roads		Local Roads		Total	
	Crashes	Fatalities	Crashes	Fatalities	Crashes	Fatalities
2005	6,084	35	12,056	45	18,140	80
2006	6,301	31	12,157	32	18,458	63
2007	6,529	30	12,159	50	18,688	80
2008	6,263	38	12,532	40	18,795	78
2009	6,576	40	12,310	28	18,886	68
2010	7,205	35	13,670	25	20,875	60
Total	38,958	209	74,884	220	113,842	429

Table 3. Oregon Intersection Crashes, Fatalities, and Incapacitating Injuries for State Intersections – 2005-2010

	State Rural Stop-Controlled	State Urban Stop-Controlled	State Rural Signalized	State Urban Signalized
Total Crashes				
Crashes	5,694	9,681	1,348	21,478
Fatalities	85	40	12	67
Serious Injuries	430	312	59	555
Fatalities per 100 Crashes	1.49	0.41	0.89	0.31
Serious Injuries per 100 Crashes	7.55	3.22	4.38	2.58
Divided Road Crashes				
Crashes	597	2,323	123	6,980
Fatalities	1	7	-	25
Serious Injuries	16	57	2	163
Fatalities per 100 Crashes	0.17	0.30	0.00	0.36
Serious Injuries per 100 Crashes	2.68	2.45	1.63	2.34
Angle Crashes				
Crashes	822	1,316	253	3,739
Fatalities	22	8	4	18
Serious Injuries	98	67	26	131
Fatalities per 100 Crashes	2.68	0.61	1.58	0.48
Serious Injuries per 100 Crashes	11.92	5.09	10.28	3.50
Angle Crashes on Divided Roads				
Crashes	52	143	10	915
Fatalities	1	1	-	5

Serious Injuries	2	4	1	38
Fatalities per 100 Crashes	1.92	0.70	0.00	0.55
Serious Injuries per 100 Crashes	3.85	2.80	10.00	4.15
Left Turn (2 or More Vehicles) Crashes				
Crashes	1,941	2,690	425	4,692
Fatalities	33	12	6	9
Serious Injuries	179	111	18	156
Fatalities per 100 Crashes	1.70	0.45	1.41	0.19
Serious Injuries per 100 Crashes	9.22	4.13	4.24	3.32
Pedestrian Crashes				
Crashes	30	161	19	387
Fatalities	2	14	1	17
Serious Injuries	5	33	2	65
Fatalities per 100 Crashes	6.67	8.70	5.26	4.39
Serious Injuries per 100 Crashes	16.67	20.50	10.53	16.80
Dark Crashes				
Crashes	922	1,537	192	4,346
Fatalities	22	16	1	37
Serious Injuries	73	77	8	168
Fatalities per 100 Crashes	2.39	1.04	0.52	0.85
Serious Injuries per 100 Crashes	7.92	5.01	4.17	3.87
Wet Pavement Crashes (Posted Speed 45 MPH or Greater)				
Crashes	615	366	146	530
Fatalities	7	4	2	6
Serious Injuries	61	17	5	12
Fatalities per 100 Crashes	1.14	1.09	1.37	1.13
Serious Injuries per 100 Crashes	9.92	4.64	3.42	2.26
Wet Pavement Crashes				
Crashes	1,154	2,049	339	4,940
Fatalities	8	10	2	17
Serious Injuries	79	70	12	131
Fatalities per 100 Crashes	0.69	0.49	0.59	0.34
Serious Injuries per 100 Crashes	6.85	3.42	3.54	2.65
Speeding-Related Crashes				
Crashes	943	799	138	1,633
Fatalities	21	12	2	22
Serious Injuries	67	37	5	63
Fatalities per 100 Crashes	2.23	1.50	1.45	1.35
Serious Injuries per 100 Crashes	7.10	4.63	3.62	3.86

Table 4. Intersection Crashes, Fatalities, and Serious Injuries for Local Intersections – 2005-2010

	Local Rural Stop-Controlled	Local Urban Stop-Controlled	Local Rural Signalized	Local Urban Signalized
Total Crashes				
Crashes	5,053	35,961	246	32,504
Fatalities	62	91	1	65
Serious Injuries	350	960	14	824
Fatalities per 100 Crashes	1.23	0.25	0.41	0.20
Serious Injuries per 100 Crashes	6.93	2.67	5.69	2.54
Divided Road Crashes				
Crashes	N/A	N/A	N/A	N/A
Fatalities	N/A	N/A	N/A	N/A
Serious Injuries	N/A	N/A	N/A	N/A
Fatalities per 100 Crashes	N/A	N/A	N/A	N/A
Serious Injuries per 100 Crashes	N/A	N/A	N/A	N/A
Angle Crashes				
Crashes	1,160	11,206	45	6,195
Fatalities	15	18	-	21
Serious Injuries	85	293	3	251
Fatalities per 100 Crashes	1.29	0.16	0.00	0.34
Serious Injuries per 100 Crashes	7.33	2.61	6.67	4.05
Angle Crashes on Divided Roads				
Crashes	N/A	N/A	N/A	N/A
Fatalities	N/A	N/A	N/A	N/A
Serious Injuries	N/A	N/A	N/A	N/A
Fatalities per 100 Crashes	N/A	N/A	N/A	N/A
Serious Injuries per 100 Crashes	N/A	N/A	N/A	N/A
Left Turn (2 or More Vehicles) Crashes				
Crashes	1,396	8,985	76	7,553
Fatalities	20	9	-	10
Serious Injuries	109	228	7	214
Fatalities per 100 Crashes	1.43	0.10	0.00	0.13
Serious Injuries per 100 Crashes	7.81	2.54	9.21	2.83
Pedestrian Crashes				
Crashes	23	699	2	827
Fatalities	1	25	-	22
Serious Injuries	2	108	-	101
Fatalities per 100 Crashes	4.35	3.58	0.00	2.66
Serious Injuries per 100 Crashes	8.70	15.45	0.00	12.21
Dark Crashes				
Crashes	968	5,907	45	6,731
Fatalities	16	40	-	35
Serious Injuries	97	244	2	245
Fatalities per 100 Crashes	1.65	0.68	0.00	0.52
Serious Injuries per 100 Crashes	10.02	4.13	4.44	3.64

Wet Pavement Crashes (Posted Speed 45 MPH or Greater)				
Crashes	213	148	11	186
Fatalities	9	3	-	2
Serious Injuries	35	8	-	9
Fatalities per 100 Crashes	4.23	2.03	0.00	1.08
Serious Injuries per 100 Crashes	16.43	5.41	0.00	4.84
Wet Pavement Crashes				
Crashes	1,001	7,627	54	7,289
Fatalities	13	15	-	14
Serious Injuries	70	211	5	206
Fatalities per 100 Crashes	1.30	0.20	0.00	0.19
Serious Injuries per 100 Crashes	6.99	2.77	9.26	2.83
Speeding-Related Crashes				
Crashes	1,092	2,990	32	2,150
Fatalities	23	37	-	17
Serious Injuries	96	136	4	69
Fatalities per 100 Crashes	2.11	1.24	0.00	0.79
Serious Injuries per 100 Crashes	8.79	4.55	12.50	3.21

- Approximately 51 percent of intersection fatalities occur on the local road system.
- For those crashes in which the traffic control device is known, the majority of fatalities occur at stop-controlled intersections.
- Angle crashes at State rural stop-controlled intersections have one of the highest rates of fatalities per 100 crashes. Pedestrian and dark crashes are also very severe, relative to other types analyzed.

Summary of Countermeasures

A summary of the countermeasures, deployment levels, costs, and estimated lives saved using these three approaches is provided in Table 5.

Table 5. Summary of Intersection Countermeasures, Costs, and Benefits

Countermeasure	Intersection Type	TCD	Crash Type	Approach	Estimated Number of Improvements (Intersections)	Construction Costs ($ Million)	Educ / Enf Costs (Annual $ Million	Estimated Annual Crashes Prevented	Estimated Annual Serious Injuries Prevented	Estimated Annual Fatalities Prevented	$ Million Expended Per Annual Life Saved
State Roads											
Basic Set of Sign and Marking Improvements	State Rural and Urban	Stop-Controlled	Total	Systematic	567	3.88	0.00	264.15	13.10	2.24	1.74
Enhanced Signing Treatments (Median Stop Sign, Warning and/or Stop Beacon)	State Rural and Urban	Stop-Controlled	Total	Systematic	43	0.85	0.00	14.88	0.76	0.13	6.53
J-Turn Modifications on High-Speed Divided Arterials	State Rural and Urban	Stop-Controlled	Angle Crashes on Divided Roadways	Systematic	2	0.48	0.00	4.32	0.13	0.05	10.52
Basic Set of Signal and Sign Improvements	State Rural and Urban	Signalized	Total	Systematic	329	2.63	0.00	327.78	8.92	1.17	2.26
Change of Permitted and Protected Left-Turn Phase to Protected Only (or Flashing Yellow Arrow)	State Rural and Urban	Signalized	Left Turn with 2 or More Vehicles	Systematic	131	1.96	0.00	106.45	3.64	0.34	5.70
Enforcement Assisted Lights	State Rural and Urban	Signalized	Angle	Systematic	34	0.03	0.00	11.78	0.48	0.07	0.51
Pedestrian Improvements	State Rural and Urban	Stop-Controlled and Signalized	Pedestrian	Systematic	19	0.22	0.00	4.53	0.77	0.22	1.03
New or Upgraded Lighting	State Rural and Urban	Stop-Controlled and Signalized	Dark, Dark/Total ≥ 0.22 (Rural)/0.24 (Urban)	Systematic	47	0.70	0.00	34.46	1.63	0.39	1.79
High Friction Surface	State Rural and Urban	Stop-Controlled and Signalized	Wet, Wet/Total ≥ 0.26	Systematic	51	1.28	0.00	21.71	1.06	0.17	7.41
Traffic Calming Improvements	State Rural and Urban	Stop-Controlled	Speeding-Related Crashes	Systematic	18	0.28	0.00	4.60	0.28	0.09	3.07

Hot Spot Improvements	State Rural and Urban	Stop-Controlled and Signalized	Total	Traditional	8	3.16	0.00	51.75	1.93	0.30	10.61
Local Roads											
Basic Set of Sign and Marking Improvements	Local Rural and Urban	Stop-Controlled	Total	Systematic	359	2.47	0.00	216.23	8.11	1.08	2.29
Enhanced Signing Treatments (Median Stop Sign, Warning and/or Stop Beacon)	Local Rural and Urban	Stop-Controlled	Total	Systematic	31	0.62	0.00	12.54	0.44	0.05	11.25
Basic Set of Signal and Sign Improvements	Local Rural and Urban	Signalized	Total	Systematic	326	2.61	0.00	350.83	8.99	0.71	3.69
Change of Permitted and Protected Left-Turn Phase to Protected Only (or Flashing Yellow Arrow)	Local Rural and Urban	Signalized	Left Turn with 2 or More Vehicles	Systematic	171	2.56	0.00	145.27	4.21	0.19	13.46
Enforcement Assisted Lights	Local Rural and Urban	Signalized	Angle	Systematic	47	0.05	0.00	15.18	0.62	0.05	0.91
Pedestrian Improvements	Local Rural and Urban	Stop-Controlled and Signalized	Pedestrian	Systematic	38	0.49	0.00	8.80	1.11	0.25	1.99
New or Upgraded Lighting	Local Rural and Urban	Stop-Controlled and Signalized	Dark, Dark/Total ≥ 0.22 (Rural)/0.24 (Urban)	Systematic	50	0.75	0.00	39.92	1.75	0.26	2.87
Traffic Calming Improvements	Local Rural and Urban	Stop-Controlled	Speeding-Related Crashes	Systematic	9	0.13	0.00	2.68	0.18	0.04	2.98
Hot Spot Improvements	Local Rural and Urban	Stop-Controlled and Signalized	Total	Traditional	6	2.52	0.00	50.28	1.47	0.15	16.89
Corridors and Cities											
Corridor Improvements				Comprehensive	3 corridors	3.00	0.30	174.00	5.13	1.00	3.30
City-Wide 3E Improvements				Comprehensive	2 cities	3.00	0.30	592.00	16.28	1.52	2.17

Totals											
State Roads					1,250	15.49	0.00	846.39	32.70	5.16	3.00
Local Roads					1,036	12.20	0.00	841.73	26.87	2.79	4.38
Corridors and Cities						6.00	0.60	766.00	21.41	2.52	2.38
Grand Total					2,286	33.69	0.60	2,454.12	80.98	10.47	3.22

Key First Steps

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

1. The draft implementation plan should be presented to the Regions, Highway Leadership Team, Highway Engineering Safety Committee, and other affected Headquarters organizations to share, review, and provide input before finalization.
2. A financial assessment of available safety monies should be completed to insure that adequate funds are available to finance this initiative (approximately $32 million for safety infrastructure over 5 years and $600,000 annually in funding for enforcement and education efforts).

It is projected that these items can be accomplished within 3 months after the plan is accepted, and implementation activities can then commence. The Traffic-Roadway Section will lead the completion of these steps.

Implementation

The successful implementation of the multiple strategies in the plan will require constant and broad management support. It is expected that as the effort is implemented, unforeseen problems will arise, new opportunities will develop, and changes in direction and emphasis will be needed to take advantage of changing conditions. As such, the following actions should be taken to ensure success.

- A Highway Safety Engineering Committee comprised of the following members 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.
  - Traffic-Roadway Section Lead
  - Administrator, Office of Traffic
  - Governors Highway Safety Representative
  - Federal Highway Administration (FHWA) Safety Representative
  - Region Safety Coordinator Representatives
- The Traffic-Roadway Section should develop and deploy a tracking system to monitor the implementation of the various types of countermeasures being deployed. This system should include forms designed to secure before and after targeted crash histories, dates of implementation, linkages to other improvements implemented at the intersection, and other information deemed pertinent by the Highway Safety Engineering Committee.

The remainder of this section provides a detailed description of and key implementation steps for each countermeasure to be implemented. A tabulation of the countermeasures and type of approach is shown in Table 6.

Table 6. Intersection Safety Countermeasures by Approach Type

Number	Countermeasure	Approach
1	Sign and Marking Improvements – State Stop-Controlled Intersections ➢ Basic Set of Sign and Marking Improvements ➢ Flashing LED Beacons on Advance Intersection Warning Signs and STOP Signs or Actuated Flashing Overhead Intersection Beacons ➢ Optional Signing and Marking Improvements Based on the Characteristics of the Intersection	Systematic
2	J-Turn Modifications on High-Speed Divided Arterials – State Stop-Controlled Intersections	Systematic
3	Basic Set of Sign and Marking Improvements – Local Stop-Controlled Intersections	Systematic
4	Signal and Sign Improvements – State and Local Signalized Intersections ➢ Basic Set of Signal and Sign Improvements ➢ Optional Signal and Sign Improvements Based on the Characteristics of the Intersection ➢ Change of Permitted and Protected Left-Turn Phase to Protected Only or conversion to Flashing Yellow Arrow ➢ Enforcement-assisted Lights	Systematic
5	New or Upgraded Lighting – State and Local Rural Intersections	Systematic
6	High Friction Surfaces at Intersection Approaches – State Intersections	Systematic
7	Pedestrian Safety Enhancements	Systematic
8	Traffic Calming Improvements – State and Local Intersections	Systematic
9	Corridor 3E Improvements on High-Speed Arterials with Very High Frequencies of Severe Intersection Crashes	Comprehensive
10	City-wide Pilot Improvements (Flashing Yellow Arrow, Clearance Intervals, Enforcement-Assisted Lights)	Systematic / Comprehensive
11	Spot Location Improvements / Roundabouts	Traditional

1. Sign and Marking Improvements – State Stop-Controlled Intersections

Basic Set of Signing and Marking Improvements

This initiative involves the installation of a set of basic signing and marking improvements that are collectively low-cost, designed to lower the potential of future crashes significantly, and are to be applied predominantly on single through-lane, high-crash, stop-controlled State intersections in both rural and urban areas. They may also be applied on dual through-lane, high-crash, stop-controlled intersections with lower traffic volumes (less than about 25,000 average annual daily traffic (AADT)) where the use of J-treatments is not appropriate and the frequency of acceptable gaps for entering traffic is such that long waiting and higher risk taking are not present at the intersection.

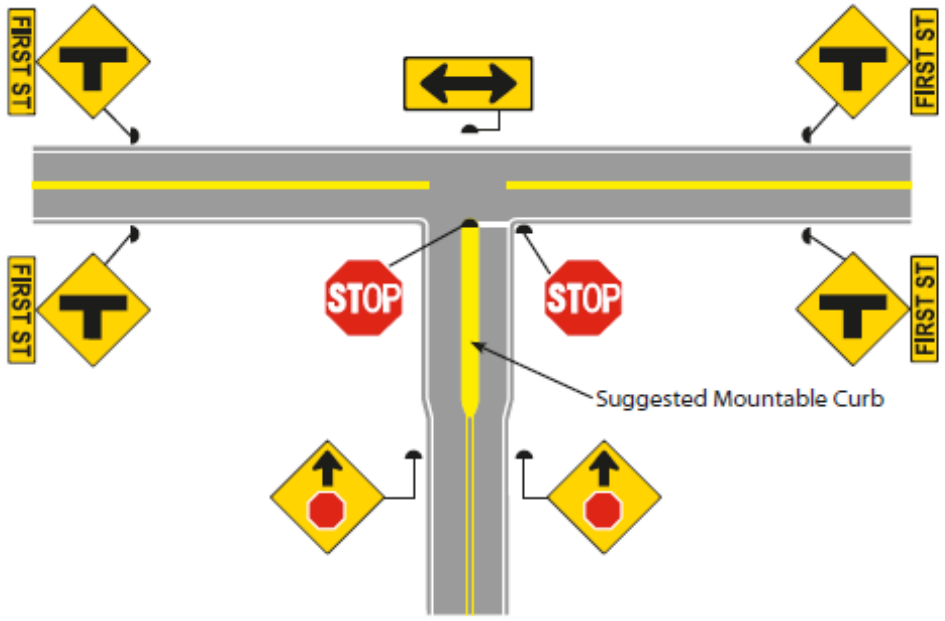

Figure 1. Examples of Basic Low-Cost Countermeasures for Stop-Controlled Intersections

Basic enhancements considered for improvement are illustrated in Figure 1 and include the following:

- Through approach:
  - Doubled up (left and right), oversize advance intersection warning signs, with street name plaques.
- Stop approach:
  - Doubled up (left and right), oversize advance "Stop Ahead" intersection warning signs;
  - "Stop Ahead" legend pavement marking;
  - Doubled up (left and right), oversize Stop signs;
  - Installation of a minimum 6 ft. wide raised splitter island on the stop approach (optional -to be considered if no pavement widening is required);
  - Properly placed stop bar;

- Removal of any foliage or parking that limits sight distance; and
- Double arrow warning sign at stem of T-intersections.

The splitter island can be considered on those approaches where no pavement widening is needed to install the island. Approach lanes may be narrowed to accommodate the island, but the island should be designed for expected routine turning truck sizes. Further information on the design characteristics of the island can be found in FHWA Report HRT 08-063 *Two Low-Cost Safety Concepts for Two-Way Stop-Controlled Intersections on High-Speed Two-Lane Two-Way Roadways.*

The high-crash intersections where the basic set of signing and marking improvements are to be considered for installation are summarized in Tables 7 and 8. The ODOT Traffic-Roadway Section has a complete listing of all intersections with numbers of crashes that meet or exceed the threshold levels in these and all remaining tables. In addition to this listing, detailed crash information for each crash that occurred at these intersections is also available.

Table 7. Basic Set of Sign and Marking Improvements – State Stop-Controlled Intersections – Total Crashes

	Threshold Crash Level (6 Years)	Number of Statewide Crash Intersections	Number of Targeted 6 Year Crashes in the Intersections	Estimated Number of Improvements[1]	Construction Costs ($ Million)[2]	Serious Injuries per 100 Crashes	Fatalities per 100 Crashes	Annual Targeted Crash Reduction[3]	Serious Injuries Reduced	Annual Estimated Fatality Reduction
State Rural (0-11,999 AADT)	3	437	2,249	306	1.84	7.55	1.49	78.72	5.94	1.18
State Rural (12,000-19,999 AADT)	4	56	419	39	0.24	7.55	1.49	14.67	1.11	0.22
State Rural (20,000+ AADT)	6	33	362	23	0.14	7.55	1.49	12.67	0.96	0.19
State Urban (0-9,999 AADT)	4	85	673	43	0.36	3.22	0.41	23.56	0.76	0.10
State Urban (10,000-24,999 AADT)	6	266	2,834	133	1.12	3.22	0.41	99.19	3.20	0.41
State Urban (25,000+ AADT)	12	47	1,010	24	0.20	3.22	0.41	35.35	1.14	0.15
[1] Assumption - Locations to be improved		70%	for Rural	50%	for Urban					
[2] Assumption - Average cost per intersection		$6,000								
[3] CRF		0.30								

Flashing LED Beacons on Advance Intersection Warning Signs and Stop Signs or Flashing Overhead Intersection Beacons

In addition to the basic sign and marking enhancements at State stop-controlled intersections, this initiative also involves the installation of supplemental warning notification for the traveling public at State stop-controlled intersections with a number of crashes that are well beyond the crash threshold for sign and marking enhancements. The enhanced warning notifications may be either LED flashing beacons placed on the oversized advance warning signs for the through approach, or they could be a combination of both presence detectors on the stop approach that recognize a stopped vehicle and activated LED flashing beacons on advance warning signs on the through approach. Flashing beacons may also be placed on the Stop signs if running Stop signs is a significant problem and transverse rumble strips are not appropriate due to noise issues.

The high-crash intersections where flashing beacons are to be considered for installation are summarized in Table 8.

Table 8. Enhanced Signing Treatments (Median Stop Sign, Warning and/or Stop Beacon) - Stop-Controlled Intersections - Total Crashes

	Threshold Crash Level (6 Years)	Number of Statewide Crash Intersections	Number of Targeted 6 Year Crashes in the Intersections	Estimated Number of Improvements[1]	Construction Costs ($ Million)[2]	Serious Injuries per 100 Crashes	Fatalities per 100 Crashes	Annual Targeted Crash Reduction[3]	Serious Injuries Reduced	Annual Estimated Fatality Reduction
State Rural	12	38	611	27	0.53	7.55	1.49	6.42	0.48	0.10
State Urban	24	23	806	16	0.32	3.22	0.41	8.46	0.27	0.03
Local Rural	12	14	225	10	0.20	6.93	1.23	2.36	0.16	0.03
Local Urban	24	30	969	21	0.42	2.67	0.25	10.17	0.27	0.03
[1] Assumption - Locations to be improved		70%								
[2] Assumption - Average cost per intersection		$20,000								
[3] CRF		0.09								

Optional Signing and Marking Improvements Based on the Characteristics of the Intersection

The optional additional improvements listed below may be beneficial if specific intersection safety concerns are present. These improvements should be considered for each stop-controlled intersection with a number of crashes that meets or exceeds the threshold. The determination to include one or more of these improvements cannot be determined from the crash data; it must be made after a field review of the intersection to identify physical, traffic, or pedestrian characteristics that merit inclusion.

- Placing reflective strips on sign posts if sign visibility due to a competing background may be a concern.
- Installing peripheral transverse markings or narrowing the approach lane width by reconfiguring the lane lines on the through approach if entry speeds are high.
- Applying rumble strips or transverse pavement markings on the stop approach if running the STOP sign is a problem and noise is not an issue.
- If the number of crashes is extremely high or if a significant sight distance problem exists that cannot be addressed, consider installing presence detectors on the stop approaches that activate flashing beacons on a warning sign for the through approach, giving through motorists additional warning that a vehicle on the stop approach is present and may enter the intersection.

Key Implementation Steps

The key steps necessary to implement this initiative and to realize the full safety benefits of the improvements, the organizations responsible for each key step, and the schedule to implement this activity fully are shown in Table 9.

Table 9. Key Implementation Steps for Sign and Marking Improvements – Stop-Controlled Intersections

Step	Organization Responsible for Step	Completion Date (Months After Implementation Plan Acceptance)
1. Develop and issue a list of candidate intersections and guidelines for Region review of stop-controlled intersections with crashes above the crash threshold including: upgraded signs and markings (using information from the workshop as a base); sight distance minor improvements (foliage obstructions and parking in urban areas); potential addition off a splitter island on the stop approaches at high-crash rural and urban stop-controlled intersections; and flashing beacons for intersections with crashes well above the crash threshold. As part of guidelines provide an optional list of additional intersections which meet a lower crash threshold for improvement consideration	Traffic-Roadway Section	1 month
2. Establish teams (Region Office Traffic Engineering Operations and/or Safety Engineer and/or consultant) to field review intersections, determine appropriate improvements, determine means to implement (department forces, new Region-wide contract) and prepare contract plans (if needed).	Traffic-Roadway Section; Region Safety Review Team	3 months
3. Train team on guidelines, field review requirements, and contract plan preparation.	Traffic-Roadway Section	6 months
4. Commence and complete field views of listed intersections, identify intersections where improvements are appropriate, identify improvements, identify which Regions will implement using Department forces, prepare statewide or Region contract plans for remaining work.	Region Safety Review Team	12 months
5. Let contracts (if applicable) and implement improvements.	Regions	24 months

2. J-Turn Modifications on High-Speed Divided Arterials – State Stop-Controlled Intersections

Description

This initiative involves the installation of minor channelization on the stop approaches to multi-lane, divided, high-speed highways to make all approaching traffic right-turn only. Left-turn and through movements from the stop approach are eliminated by minor channelization and signing. This option is feasible where vehicles can reach their intended destination by turning right at the intersection and, within a reasonable distance downstream, enter an exclusive left-turn lane to make a U-turn. Figure 2 provides an illustration.

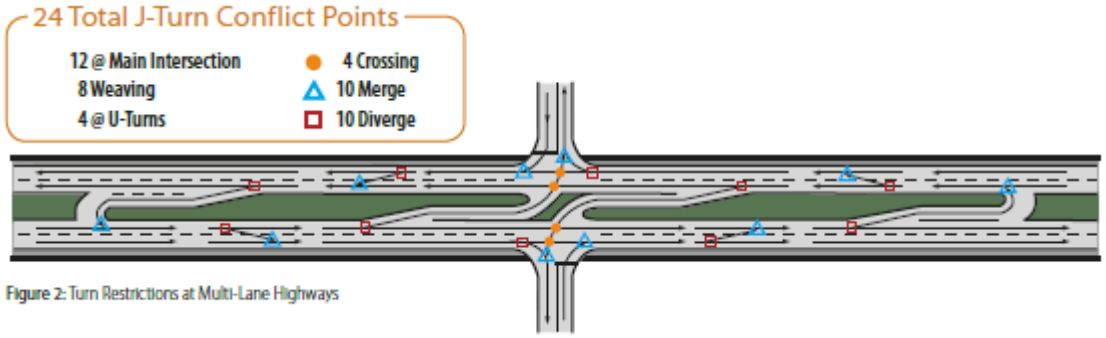

Figure 2. Turn Restrictions at Multi-Lane Highways

The J-turn treatment is considered the most effective low-cost countermeasure treatment available for reducing future angle crash potential at divided highway intersections. However, if left-turn lanes for the turnarounds are not available within a reasonable distance and the costs to install new lanes is prohibitive, or if significant controversy is involved with limiting movements at the intersection, less effective countermeasures can be considered as follows:

1. Install sign and marking improvements together with flashing beacons similar to those described in the sign and marking improvements countermeasure. Also, if intersection approach speeds are high, consider adding countermeasures to reduce intersection approach speeds on the through approaches (e.g., peripheral transverse pavement markings, lane narrowing techniques, or "SLOW" pavement marking legends).
2. Install presence detectors on the stop approaches that activate flashing beacons on a warning sign for the through approach, giving through motorists additional warning that a vehicle on the stop approach is present and may enter the intersection.
3. Consider adding a traffic signal if the intersection meets one of the *Manual on Uniform Traffic Control Devices* (MUTCD) signal warrants.

The high-crash intersections where J-treatments should be considered are summarized in Table 10.

Table 10. J-Turn Modifications on High-Speed Divided Arterials – State Rural Stop-Controlled Intersections – Angle Crashes on Divided Roadways

	Threshold Crash Level (6 Years)	Number of Statewide Crash Intersections	Number of Targeted 6 Year Crashes in the Intersections	Estimated Number of Improvements[1]	Construction Costs ($ Million)[2]	Serious Injuries per 100 Crashes	Fatalities per 100 Crashes	Annual Targeted Crash Reduction[3]	Annual Estimated Serious Injuries Reduced	Annual Estimated Fatality Reduction
State Rural	4	2	14	1	0.24	3.85	1.92	1.26	0.05	0.02
State Urban	6	2	34	1	0.24	2.80	0.70	3.06	0.09	0.02
[1] Assumption - Locations to be improved		60%								
[2] Assumption - Average cost per intersection		$200,000								
[3] CRF		0.90								

J-turn treatments also should be considered for any divided, urban, stop-controlled intersection that meet the rural crash thresholds indicated in Table 10.

The severity of crashes at rural stop-controlled intersections is extremely high. As such, the J-treatment should be considered at all divided rural intersections and divided urban intersections with posted speeds of 45 mph or higher that meet the crash thresholds in the table.

Key Implementation Steps

The key steps necessary to implement this initiative and realize the full safety benefits of the improvements, the organizations responsible for each key step, and the schedule for this activity are shown in Table 11.

Table 11. Key Implementation Steps for J-Turn Modifications on High-Speed Divided Arterials – State Rural Stop-Controlled Intersections

Step	Organization Responsible for Step	Completion Date (Months After Implementation Plan Acceptance)
1. Develop and issue guidelines for considering J-turn treatments and other options if J-treatments are not appropriate.	Traffic-Roadway Section	3 months
2. Establish teams (Region Office Traffic Engineering Operations and/or Safety Engineer) that will field review divided highway stop-controlled intersections, determine if improvements can be made, determine the type of improvements, and prepare contract plans.	Traffic-Roadway Section, Regions, Highway Safety Steering Committee	3 months
3. Develop a training package and train team on guidelines, field review requirements, and contract plan preparation.	Traffic-Roadway Section	6 months
5. Commence and complete field reviews of intersections that meet the threshold crash levels, identify intersections where improvements are appropriate, identify which Regions will implement improvements using Department forces.	Regions	12 months
6. For those intersections in which a J-turn treatment is proposed, secure public input per DOT's processes and, once input is received,	Regions	18 months

Step	Organization Responsible for Step	Completion Date (Months After Implementation Plan Acceptance)
determine appropriateness of implementing a J-turn treatment.		
7. Develop plans, let contract, and implement J-turn treatments.	Regions	42 months
8. For those divided intersections with optional improvements, identify improvements, identify which Regions will implement using Department forces, prepare statewide or area contract plans for these improvements.	Regions	42 months

3. Basic and Enhanced Sign and Marking Improvements – Local Stop-Controlled Intersections

Description

This initiative involves the installation of a set of signing and marking improvements that are low-cost, designed to lower the potential of future crashes significantly, and are to be applied predominantly on single through lane, high-crash, stop-controlled local intersections in both rural and urban areas. They utilize the same basic set of sign and marking improvement countermeasure treatments and the same crash threshold levels as those described for State stop-controlled intersections in Countermeasure #1.

Since the level of effort to obtain Federal funds for multiple low-cost improvements on local roads and transfer them to local governments may exceed the costs of the low-cost improvements, the State initiative will include the following:

- Distribution of information on the high-crash intersection locations to appropriate local governments and guidance on low-cost sign and marking enhancements to reduce future crash potential.
- Coordination and facilitation of local government training either by the Local Technical Assistance Program (LTAP) or the FHWA Resource Center on the application of low-cost countermeasures at the high-crash intersections.

The high-crash intersections where the basic set of signs and markings should be considered are summarized in Table 12.

Table 12. Basic Set of Sign and Marking Improvements – Local Stop-Controlled Intersections

	Threshold Crash Level (6 Years)	Number of Statewide Crash Intersections	Number of Targeted 6 Year Crashes in the Intersections	Estimated Number of Improvements[1]	Construction Costs ($ Million)[2]	Serious Injuries per 100 Crashes	Fatalities per 100 Crashes	Annual Targeted Crash Reduction[3]	Annual Estimated Serious Injuries Reduced	Annual Estimated Fatality Reduction
Local Rural	3	320	1,570	224	1.34	6.93	1.23	54.95	3.81	0.67
Local Urban	12	269	4,608	135	1.13	2.67	0.25	161.28	4.31	0.41

[1] Assumption - Locations to be improved: 70% for Rural; 50% for Urban
[2] Assumption - Average cost per intersection: $6,000
[3] CRF: 0.30

Key Implementation Steps

The key steps necessary to implement this initiative and realize the full safety benefits of the improvements, the organizations responsible for each key step, and the schedule for this activity are shown in Table 13.

Table 13. Key Implementation Steps for Basic Set of Sign and Marking Improvements – Local Stop-Controlled Intersections

Step	Organization Responsible for Step	Completion Date (Months After Implementation Plan Acceptance)
1. Using the guidelines developed for State stop-controlled intersection improvements, modify for use by local government review of stop-controlled intersections with crashes above the crash threshold, including: upgraded signs and markings (using information from the workshop as a base); sight distance minor improvements (foliage obstructions and parking in urban areas); and potential use of a splitter island on the stop approaches at high-crash rural and urban stop-controlled intersections.	Traffic-Roadway Section	1 month
2. Perform an assessment of benefits, disadvantages, complexities, and issues associated with producing signs using 100 percent Federal safety funds to provide to locals for installation at high-crash stop-controlled local intersections.	Traffic-Roadway Section	1 month (assessment completed) 2 months (decision to provide signs) 3 months (additional requirements, if any, added to guidelines).
3. Identify the number of county and city governments involved and the number of intersections per local government. Coordinate with the Regions to determine if technical assistance can be provided either by the Region Safety or Traffic Engineers or by LTAP personnel	Traffic-Roadway Section, Local Programs	6 months

Step	Organization Responsible for Step	Completion Date (Months After Implementation Plan Acceptance)
4. Provide crash data; guidelines for sign and marking improvements; information on availability of signs for designated intersections to municipalities (if appropriate); and training schedule and location for local governments.	Traffic-Roadway Section, Local Programs	6 months
5. Train or assist local team on guidelines; field review requirements; improvement determination; and sign, marking, and splitter island installation.	Traffic-Roadway Section, Local Programs	9 months
6. Establish a monitoring and tracking system to insure that improvements at local intersections are properly identified and implemented.	Traffic-Roadway Section, Local Programs	12 months

4. Signal and Sign Improvements – Signalized Intersections

Description

In Oregon the majority of traffic signals are maintained by local units of government. As such, it will be important for the Oregon DOT to work with cities and counties in the State to promote the recommended countermeasures below.

Basic Set of Signal and Sign Improvements

This initiative involves the installation of a basic set of signal, sign, and marking improvements that are low-cost, are designed to lower the potential for future crashes significantly, and are to be applied at high-crash, signalized intersections in both rural and urban areas.

The typical improvements considered for implementation include:

- Back plates for all signal heads (may be reflectorized);
- 12-inch LED lenses;
- At least one signal head per approach lane;
- Signal clearance timing in accordance with Institute of Transportation Engineers (ITE) clearance formula; and
- Elimination of flashing operation during night conditions.

Since the level of effort to obtain Federal funds for multiple low-cost improvements on local roads and transfer them to local governments may exceed the costs of the low-cost improvements, the initiative will include the following:

- An assessment of the potential for manufacturing and distributing the appropriate signs and signal materials by the State Sign Shop using 100 percent Federal funds for local use at the designated intersections.
- Distribution of information on the high-crash intersection locations to appropriate local governments and guidance on low-cost signal, sign, and marking enhancements to reduce future crash potential.

- Coordination and facilitation of local government training either by the LTAP or the FHWA Resource Center on the application of low-cost countermeasures at the high-crash intersections.

The high-crash intersections where the basic set of signal and sign improvements should be considered are summarized in Table 14.

Table 14. Basic Set of Signal and Sign Improvements – Signalized Intersections – Total Intersection Crashes

	Threshold Crash Level (6 Years)	Number of Statewide Crash Intersections	Number of Targeted 6 Year Crashes in the Intersections	Estimated Number of Improvements[1]	Construction Costs ($ Million)[2]	Serious Injuries per 100 Crashes	Fatalities per 100 Crashes	Annual Targeted Crash Reduction[3]	Annual Estimated Serious Injuries Reduced	Annual Estimated Fatality Reduction
State Rural	10	56	1,001	42	0.34	4.38	0.89	25.03	1.10	0.22
State Urban (0-9,999 AADT)	12	24	462	18	0.14	2.58	0.31	11.55	0.30	0.04
State Urban (10,000-39,999 AADT)	18	286	8,774	215	1.72	2.58	0.31	219.35	5.67	0.68
State Urban (40,000+ AADT)	24	73	2,874	55	0.44	2.58	0.31	71.85	1.86	0.22
Local Rural	5	12	118	9	0.07	5.69	0.41	2.95	0.17	0.01
Local Urban	20	423	13,915	317	2.54	2.54	0.20	347.88	8.82	0.70
[1] Assumption - Locations to be improved		75%								
[2] Assumption - Average cost per intersection		$8,000								
[3] CRF		0.20								

Optional Signal and Sign Improvements Based on the Characteristics of the Intersection

The optional additional improvements listed below may be beneficial if specific intersection safety concerns are present. These improvements should be considered for each signalized intersection that has a number of crashes meeting or exceeding the threshold. The determination to include one or more of these improvements cannot be determined from the crash data; it must be made after a field review of the intersection to identify physical, traffic, or pedestrian characteristics that merit inclusion. Optional improvements include:

- Advance traffic signal warning signs doubled up for isolated rural high-speed intersections or intersections where the signal heads are not readily visible due to alignment or sight distance obstructions;
- Advance cross-street name signs for high-speed approaches on arterial highways;
- Supplemental signal heads where normally placed signal heads may be difficult to identify due to sight distance limitations, horizontal curvature, or other obstructions; or for exceptionally wide intersections where a near-side signal is needed;
- Signal coordination improvements on high-volume, high-speed arterials with closely spaced traffic signals and frequent mainline stopping due to poor or no signal coordination;

- Pedestrian countdown signals at intersections with high pedestrian activity or multiple pedestrian crashes;
- Exclusive pedestrian phasing at intersections with multiple pedestrian-vehicle conflicts; and
- Higher visibility marked crosswalks and advance pedestrian warning signs at intersections with high pedestrian activity or multiple pedestrian crashes.

Change of Permitted and Protected Left-Turn Phase to Protected Only

One major crash pattern that needs to be addressed individually is signalized intersections with a significant number or potential for left-turn, opposing-flow crashes. At these traffic signals the potential change is to modify the signal phase from permitted and protected left-turn phases to protected-only. This can be considered for intersections with high numbers of left-turn, opposing flow crashes, three or more opposing approach lanes, or high opposing volumes with few acceptable turning gaps.

In situations where converting protected-permissive left turn phasing to protected only is not feasible, the Flashing Yellow Arrow (FYA) can provide a secondary benefit. Studies have shown the FYA indication to have higher driver recognition than the traditional green ball indicating a permissive left turn movement.

Caution: Converting existing protected-only left turns to permissive-protected or permissive-only, even if using FYA, will not improve safety. It will likely increase the number of left turn crashes. Replacing existing permissive-protected or permissive only displays with FYA will likely decrease left turn crashes and improve safety.

The high-crash intersections where the protected only left-turn phase or FYA should be considered are summarized in Table 15.

Table 15. Change of Permitted and Protected Left-Turn Phase to Protected Only (or Flashing Yellow Arrow) – Signalized Intersections – Left Turn Crashes with 2 or more Vehicles

	Threshold Crash Level (6 Years)	Number of Statewide Crash Intersections	Number of Targeted 6 Year Crashes in the Intersections	Estimated Number of Improvements[1]	Construction Costs ($ Million)[2]	Serious Injuries per 100 Crashes	Fatalities per 100 Crashes	Annual Targeted Crash Reduction[3]	Annual Estimated Serious Injuries Reduced	Annual Estimated Fatality Reduction
State Rural	6	23	246	16	0.24	4.24	1.41	11.48	0.49	0.16
State Urban	8	164	2,035	115	1.72	3.32	0.19	94.97	3.16	0.18
Local Rural	5	5	32	4	0.05	9.21	0.00	1.49	0.14	0.00
Local Urban	8	239	3,081	167	2.51	2.83	0.13	143.78	4.07	0.19

[1] Assumption - Locations to be improved 70%

[2] Assumption - Average cost per intersection $8,000

[3] CRF 0.40

Enforcement-Assisted Lights for Red Light Running Enforcement

Description

This initiative involves pursuing the use of the enforcement-assisted lights at signalized intersections to reduce angle crashes. The enforcement-assisted lights provides more efficient and effective enforcement of red light running violations and coupled with a targeted education initiative informing the public about the operation of the enforcement assisted lights can substantially reduce red light running violations and angle crashes at signalized intersections.

For this countermeasure, it is necessary to work in conjunction with law enforcement to request their participation and describe the potential benefits of the treatment.

Candidate intersections with significant numbers of angle crashes are listed in Table 16.

Table 16. Enforcement Assisted Lights - Signalized Intersections - Angle Crashes

	Threshold Crash Level (6 Years)	Number of Statewide Crash Intersections	Number of Targeted 6 Year Crashes in the Intersections	Estimated Number of Improvements[1]	Construction Costs ($ Million)[2]	Serious Injuries per 100 Crashes	Fatalities per 100 Crashes	Annual Targeted Crash Reduction[3]	Annual Estimated Serious Injuries Reduced	Annual Estimated Fatality Reduction
State Rural	5	16	155	4	0.00	10.28	1.58	0.97	0.10	0.02
State Urban	8	121	1,729	30	0.03	3.50	0.48	10.81	0.38	0.05
Local Rural	5	2	13	1	0.00	6.67	0.00	0.08	0.01	0.00
Local Urban	8	184	2,416	46	0.05	4.05	0.34	15.10	0.61	0.05

[1] Assumption - Locations to be improved 25%

[2] Assumption - Average cost per intersection $1,000

[3] CRF 0.15

Key Implementation Steps

The key steps necessary to implement this initiative and to realize the full safety benefits of the low-cost improvements at signalized intersections, the organizations responsible for each key step, and the schedule for these activities are shown in Table 17 and 18.

Table 17. Key Implementation Steps for Signal and Sign Improvements – Signalized Intersections

Step	Organization Responsible for Step	Completion Date (Months After Implementation Plan Acceptance)
1. Develop guidelines for upgraded signal, signs, markings (using information from the workshop as a base), optional improvements; left turn safety enhancements; and pedestrian safety State signalized intersections.	Traffic Roadway Section	1 month
2. Provide guidelines and lists of intersections with crashes above the threshold to the Regions.	Traffic Roadway Section	3 months

Step	Organization Responsible for Step	Completion Date (Months After Implementation Plan Acceptance)
4. Provide either a webinar or a workshop- meeting with Region personnel on the guidelines and intersection review process. Insure that the process includes information on a process to determine the structural integrity of the mast arm to support any signal revisions.	Traffic Roadway Section	6 months
5. Commence and complete field views of the listed signalized intersections, identify improvements, identify which Regions will implement using Department forces, prepare statewide or Region wide contract plans for remaining work.	Region Offices	18 months
6. Let contract and implement improvements	Region Offices	30 months

Table 18. Key Implementation Steps for Signal and Sign Improvements – Local Signalized Intersections

Step	Organization Responsible for Step	Completion Date (Months After Implementation Plan Acceptance)
1. Using the guidelines developed for State signalized intersection improvements, modify for use by local government.	Traffic Roadway Section	1 month
2. Identify the number of county and city governments involved and the number of intersections per local government. Coordinate with the Regions and determine if technical assistance can be provided either by the Region Safety or Traffic Engineers or by LTAP personnel.	Traffic Roadway Section, Regions, Local Programs	
3. Document a process of providing Federal safety funding to cities and counties to upgrade identified intersections with low cost safety countermeasures.	Traffic Roadway Section	
4. Provide crash data, guidelines for signal sign and marking improvements, technical assistance and training schedule, and location for local governments.	Traffic Roadway Section, Regions, Local Programs	6 months
5. Train or assist local team on guidelines; field review requirements; improvement determination; and signal, sign, and marking improvements.	Traffic Roadway Section, Regions, Local Programs	9 months
6. Implement the process with local governments	Traffic Roadway Section, Regions, Local Programs	12 months
7. Establish a monitoring and tracking system to insure that improvements at local intersections are properly identified and implemented.	Traffic Roadway Section, Regions, Local Programs	18 months

5. New or Upgraded Lighting – State and Local Intersections

Description

Crashes that occur during darkness are typically more severe than daylight crashes. Major problems associated with unlit or poorly lit intersections (e.g. only one light per intersection) include reduced driver ability to recognize that an intersection is approaching, reduced ability to navigate turning movements properly, and degradation of the ability to recognize other vehicles and pedestrians in or entering the intersection.

The low-cost countermeasure for unlit or poorly lit intersections with a high frequency and rate of night crashes is lighting. Typical example layouts for intersection lighting are shown in Figure 3. It is recommended that this layout scheme be incorporated into the design policy for intersection lighting installations.

The crash reduction factor at unlit intersections with high frequencies and rates of night crashes is 50 percent of night crashes. The crash reduction factor for improving lighting at poorly lit intersections (one existing light per intersection) is estimated by an expert safety panel as 25 percent of night crashes.

In addition, there is some assumed benefit of intersection lighting for day time crashes, as the signal poles provide additional conspicuity of a traffic signal. This benefit has not been calculated in the Implementation Plan, but it could be explored in the future.

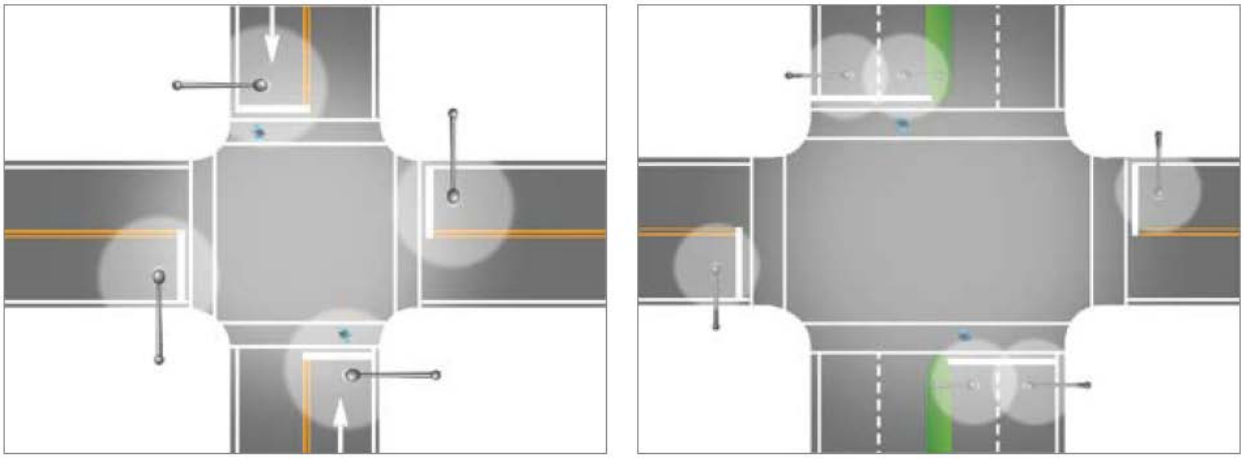

Figure 3. Potential Design for Intersection Lighting Layout (Single and Multi-Lane Approaches)[1]

The high-crash state intersections where new or upgraded lighting should be considered are summarized in Table 19 and Table 20.

[1] Federal Highway Administration, *Informational Report on Lighting Design for Midblock Crosswalks*, FHWA-HRT- 08-053 (Washington, DC: April 2008).

Table 19. New or Upgraded Lighting – Stop-Controlled Intersections – Dark Crashes

	Threshold Crash Level (6 Years)	Number of Statewide Crash Intersections	Number of Targeted 6 Year Crashes in the Intersections	Estimated Number of Improvements[1]	Construction Costs ($ Million)[2]	Serious Injuries per 100 Crashes	Fatalities per 100 Crashes	Annual Targeted Crash Reduction[3]	Annual Estimated Serious Injuries Reduced	Annual Estimated Fatality Reduction
State Rural	3	39	154	20	0.29	7.92	2.39	6.42	0.51	0.15
State Urban	6	8	64	4	0.06	5.01	1.04	2.67	0.13	0.03
Local Rural	3	26	95	13	0.20	10.02	1.65	3.96	0.40	0.07
Local Urban	6	26	188	13	0.20	4.13	0.68	7.83	0.32	0.05

[1] Dark crashes only and where the intersection dark/total ratio exceeds the statewide dark/total crash ratio of 0.22 for rural crashes and 0.24 for urban crashes.

[2] Assumption - Locations to be improved 50%

[3] Assumption - Average cost per intersection $15,000

[4] CRF 0.50

Table 20. New or Upgraded Lighting - Signalized Intersection - Dark Crashes

	Threshold Crash Level (6 Years)	Number of Statewide Crash Intersections	Number of Targeted 6 Year Crashes in the Intersections	Estimated Number of Improvements[1]	Construction Costs ($ Million)[2]	Serious Injuries per 100 Crashes	Fatalities per 100 Crashes	Annual Targeted Crash Reduction[3]	Annual Estimated Serious Injuries Reduced	Annual Estimated Fatality Reduction
State Rural	3	10	37	3	0.05	4.17	0.52	0.93	0.04	0.00
State Urban	10	68	978	20	0.31	3.87	0.85	24.45	0.95	0.21
Local Rural	3	4	16	1	0.02	4.44	0.00	0.40	0.02	0.00
Local Urban	10	77	1,109	23	0.35	3.64	0.52	27.73	1.01	0.14

[1] Dark crashes only and where the intersection dark/total ratio exceeds the statewide dark/total crash ratio of 0.22 for rural crashes and 0.24 for urban crashes.

[2] Assumption - Locations to be improved 30%

[3] Assumption - Average cost per intersection $15,000

[4] CRF 0.50

Key Implementation Steps for State Intersections

The key steps necessary to implement this initiative and realize the full safety benefits of the improvements, the organizations responsible for each key step, and the schedule for this activity are shown in Table 21.

Table 21. Key Implementation Steps for New or Upgraded Lighting – State Rural Intersections

Step	Organization Responsible for Step	Completion Date (Months After Implementation Plan Acceptance)
1. Clarify policy regarding installation, maintenance, and energizing lighting improvement responsibilities (State or local) at high night crash, State rural intersections.	Traffic-Roadway Section	1 month
2. Assuming policy allows limited expansion of lighting to high night crash, State rural, unlit intersections, develop guidelines and standard for lighting typical rural intersections with two- and four-lane approaches.	Traffic-Roadway Section	2 months
3. Establish teams (Region Office Traffic Engineering and/or Safety Engineer and/or consultant) to field review intersections, determine lighting improvements, and prepare contract plans.	Traffic-Roadway Section	3 months
4. Train team on lighting standards for intersections, field review requirements, and contract plan preparation.	Traffic-Roadway Section	6 months
5. Commence and complete field views of all listed State intersections, identify improvements, identify which regions will implement using Department forces, and prepare statewide or area contract plans for remaining work.	Regions	12 months
6. Execute necessary agreements with local municipalities for lighting responsibilities.	Regions	18 months
7. Let contract and implement improvements.	Regions	42 months

Key Implementation Steps for Local Intersections

The key steps necessary to implement this initiative and realize the full safety benefits of the improvements, the organizations responsible for each key step, and the schedule for this activity are shown in Table 22.

Table 22. Key Implementation Steps for New or Upgraded Lighting – Local Rural Intersections

Step	Organization Responsible for Step	Completion Date (Months After Implementation Plan Acceptance)
1. Using the guidelines developed for State lighting intersection improvements, modify for use by local government.	Traffic-Roadway Section, Local Programs	1 month
2. Identify the number of county and city governments involved and the number of intersections per local government. Coordinate with the Regions and determine if technical assistance can be provided either by the Region Safety or Traffic Engineers or by LTAP personnel.	Traffic-Roadway Section, Local Programs	3 months
3. Document a process of providing Federal safety funding to cities and counties to light identified intersections with low-cost safety countermeasures.	Traffic-Roadway Section, Local Programs	6 months

Step	Organization Responsible for Step	Completion Date (Months After Implementation Plan Acceptance)
4. Provide crash data, guidelines for lighting improvements, technical assistance, and training schedule and location for local governments.	Traffic-Roadway Section, Local Programs	6 months
5. Train or assist local team on guidelines, field review requirements, improvement determination, and lighting improvements.	Traffic-Roadway Section, Local Programs	9 months
6. Implement the process with local governments.	Traffic-Roadway Section, Local Programs	12 months
7. Establish a monitoring and tracking system to insure that improvements at local intersections are properly identified and implemented.	Traffic-Roadway Section, Local Programs	15 months

6. High-Friction Surfaces – State Intersections

Description

Crashes that occur when the pavement is wet on intersection approaches with posted speeds of 45 mph or higher may be associated with increased stopping distances due to low skid numbers and/or severe rutting in the wheel paths that might induce hydroplaning.

The low-cost countermeasure for intersections with higher frequencies of wet pavement crashes and above average wet/total crash rates include increasing the friction characteristics on those intersection approaches with low skid numbers and eliminating any severe wheel path rutting.

One way transportation officials can increase pavement friction beyond what is attainable through traditional techniques is by using new high-friction surfacing systems. These systems use either a sand and asphalt micro surface material or a combination of resins and polymers (usually urethane, silicon, or epoxy) and a binder topped with a natural or synthetic hard aggregate.

The micro surface improvements are the least costly alternative and usually result in skid numbers in the high 50s range. Micro surfaces should be used for the bulk of improvements. Epoxy treatments are more costly than micro surfaces but usually produce skid numbers above 70. They are most appropriate to consider on approaches that have the most severe wet pavement crash problem.

The length of approach to apply skid resistance surfaces is variable dependent on approach speeds, sight distance, and expected queue lengths at signalized intersections. A minimum 300 feet of approach is recommended for through high-speed approaches to stop-controlled intersections. In addition, significant wheel rutting (2 inches in depth or greater) should be eliminated before applying any skid resistant surface.

Crash reduction factors for skid-resistant surfaces on high-speed (i.e., 45 mph or higher) intersection approaches with a high frequency and rate of wet pavement crashes and either (1) a ribbed tire skid

number of 30 or less, (2) wheel path rutting of at least 2 inches in depth, or (3) both is 50 percent of wet pavement crashes.[2]

The high-crash intersections where high-friction surface should be considered for state intersection approaches are summarized in Tables 23 and **24**.

Table 23. High Friction Surface - State Stop-controlled Intersections, Wet Crashes

	Threshold Crash Level (6 Years)	Number of Statewide Crash Intersections	Number of Targeted 6 Year Crashes in the Intersections	Estimated Number of Improvements[1]	Construction Costs ($ Million)[2]	Serious Injuries per 100 Crashes	Fatalities per 100 Crashes	Annual Targeted Crash Reduction[3]	Serious Injuries Reduced	Annual Estimated Fatality Reduction
State Rural	3	58	237	29	0.73	6.85	0.69	9.88	0.68	0.07
State Urban with ≥ 45 MPH Posted Speed	3	12	46	6	0.15	4.64	1.09	1.92	0.09	0.02

[1] Wet pavement crashes only and where the intersection wet/total ratio exceeds the statewide wet/total crash ratio of 0.26.

[2] Assumption - Locations that can be overlaid 50%

[3] Assumption - Average cost per intersection to remove any significant rutting and apply a thin micro-surface anti-skid surface or epoxy high friction surface. $25,000

[4] CRF 0.50

Table 24. High-Friction Surface – State Signalized Intersections, Wet Pavement Crashes

	Threshold Crash Level (6 Years)	Number of Statewide Crash Intersections	Number of Targeted 6 Year Crashes in the Intersections	Estimated Number of Improvements[1]	Construction Costs ($ Million)[2]	Serious Injuries per 100 Crashes	Fatalities per 100 Crashes	Annual Targeted Crash Reduction[3]	Serious Injuries Reduced	Annual Estimated Fatality Reduction
State Rural	5	16	131	8	0.20	3.54	0.59	5.46	0.19	0.03
State Urban with ≥ 45 MPH Posted Speed	5	16	107	8	0.20	2.26	1.13	4.46	0.10	0.05

[1] Wet pavement crashes only and where the intersection wet/total ratio exceeds the statewide wet/total crash ratio of 0.26.

[2] Assumption - Locations that can be overlaid 50%

[3] Assumption - Average cost per intersection to remove any significant rutting and apply a thin micro-surface, anti-skid surface or epoxy high friction surface. $25,000

[4] CRF 0.50

Key Implementation Steps

The key steps necessary to fully implement this initiative and realize the safety benefits of the improvements, the organizations responsible for each key step, and the schedule for this activity are shown in Table 25.

[2] Institute of Transportation Engineers, *Toolbox of Countermeasures and Their Potential Effectiveness to Make Intersections Safer,* (Washington, DC: April 2004), http://www.ite.org/library/IntersectionSafety/toolbox.pdf.

Table 25. Key Implementation Steps for High-Friction Surface – State Intersections

Step	Organization Responsible for Step	Completion Date (Months After Implementation Plan Acceptance)
1. Develop guidelines for friction courses, surface improvement approach lengths, severe wheel path rutting mitigation, and testing requirements for friction levels for intersection approaches. Determine conditions under which a micro surface skid improvement would be used and those in which a epoxy friction surface is specified.	Traffic-Roadway Section, Pavement Engineer	1 month
2. Skid test approaches on the list and determine if skid resistance needs increased.	Traffic-Roadway Section, Pavement Engineer	5 months
3. Field review intersections on the wet pavement list that have low skid numbers and determine the appropriate skid treatment.	Traffic-Roadway Section, Pavement Engineer, Regions	8 months
4. Develop plans and let contracts to apply skid treatments at designated intersections.	Regions	16 months

7. Pedestrian Safety Enhancements

Description

Multiple pedestrian crashes at the same intersection is another major concern. At these intersections proposed improvements include pedestrian countdown signals, advanced pedestrian crossing warning signs and improved marked crosswalk visibility (ladders or cross hatching). In addition, if the intersection has a large number of pedestrian crashes, modified pedestrian phasing should be considered after a capacity analysis is performed and the impact on increased congestion is ascertained. Examples include exclusive pedestrian phases, or lead pedestrian intervals (typically 3-6 seconds) to allow pedestrians to get into the center of the marked crosswalk before the adjacent motor vehicle movement is serviced.

Low-cost pedestrian intersection treatments are to be considered, including:

- Pedestrian countdown signals;
- Marked crosswalks (if none exist);
    - Marked crosswalks should be installed in conjunction with other treatments (e.g., warning signs).
- Warning signs for active pedestrian crossings;
- Potential elimination of the permissive portion of any protected/permissive turning operation phase that creates substantial conflicts with crossing pedestrians; and
- Modifications to intersection approaches to reduce high approach speeds when substantive pedestrian activity is prevalent.

Table 26. Pedestrian Improvements – Stop-Controlled Intersections – Pedestrian Crashes

	Threshold Crash Level (6 Years)	Number of Statewide Crash Intersections	Number of Targeted 6 Year Crashes in the Intersections	Estimated Number of Improvements[1]	Construction Costs ($ Million)[2]	Serious Injuries per 100 Crashes	Fatalities per 100 Crashes	Annual Targeted Crash Reduction[3]	Serious Injuries Reduced	Annual Estimated Fatality Reduction
State Rural	3	-	-	-	0.00	16.67	6.67	0.00	0.00	0.00
State Urban	3	2	7	2	0.05	20.50	8.70	0.37	0.08	0.03
Local Rural	3	-	-	-	0.00	8.70	4.35	0.00	0.00	0.00
Local Urban	3	7	23	6	0.17	15.45	3.58	1.23	0.19	0.04

[1] Assumption - Locations to be improved 80%

[2] Assumption - Average cost per intersection $30,000

[3] CRF 0.40

Table 27. Pedestrian Improvements - Signalized Intersections - Pedestrian Crashes

	Threshold Crash Level (6 Years)	Number of Statewide Crash Intersections	Number of Targeted 6 Year Crashes in the Intersections	Estimated Number of Improvements[1]	Construction Costs ($ Million)[2]	Serious Injuries per 100 Crashes	Fatalities per 100 Crashes	Annual Targeted Crash Reduction[3]	Serious Injuries Reduced	Annual Estimated Fatality Reduction
State Rural	3	1	3	1	0.01	10.53	5.26	0.16	0.02	0.01
State Urban	3	21	75	17	0.17	16.80	4.39	4.00	0.67	0.18
Local Rural	3	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00
Local Urban	3	40	142	32	0.32	12.21	2.66	7.57	0.92	0.20

[1] Assumption - Locations to be improved 80%

[2] Assumption - Average cost per intersection $10,000

[3] CRF 0.40

Key Implementation Steps

The key steps necessary to implement this initiative and to realize the full safety benefits of the low-cost improvements, the organizations responsible for each key step, and the schedule for these activities are shown in Table 28.

Table 28. Key Implementation Steps for Pedestrian Improvements

Step	Organization Responsible for Step	Completion Date (Months After Implementation Plan Acceptance)
1. Develop guidelines for upgraded pedestrian safety treatments.	Traffic-Roadway Section	1 month
2. Provide guidelines and lists of intersections with pedestrian crashes above the threshold to local partners.	Traffic-Roadway Section	3 months
3. Provide either a webinar or a workshop- meeting with local personnel on the guidelines and intersection review process.	Traffic-Roadway Section, Local Programs	6 months
4. Commence and complete field views of the listed signalized intersections, identify improvements, identify which Regions will implement using Department forces, prepare statewide or Region wide contract plans for remaining work.	Traffic-Roadway Section, Regions, Local Programs	18 months
5. Let contract and implement improvements	Traffic-Roadway Section, Regions, Local Programs	30 months

8. Corridor 3E Improvements on High-Speed Arterials with Very High Frequencies of Severe Intersection Crashes

Description

We have identified 3 State route corridors with 8 or more intersection fatalities in 6 years and a significant number of severe injury intersection crashes. The intent of this countermeasure is to advance a set of 3E initiatives on two of these corridors to reduce the potential for future severe intersection crashes. For each corridor, this initiative will have as its objective a reduction in corridor intersection fatalities and incapacitating injuries by a minimum of 25 percent using a combination of low-cost infrastructure improvements and targeted education and enforcement initiatives. While the selection of the corridors has been based upon high frequencies of severe intersection crashes, the approach may be broader and encompass other corridor concerns such as road departure, mid-block pedestrian problems, and driver behavioral problems, including driving while intoxicated, lack of safety belts, and speeding.

The effort begins with an analysis of the crash characteristics in each of the corridors to improve the understanding of the problems that need to be addressed and the concentrations of severe intersection crashes within the corridor. This analysis will also help to determine the appropriate limits of the corridor based upon displays of GIS map crash concentrations and to identify related crash patterns suitable for reduction by applying potential countermeasures. Based upon this analysis plus the level of interest exhibited by Region and local agencies encompassing each corridor, two corridors, along with the limits for each corridor, will be selected.

Safety studies will then be conducted on each of the two selected corridors using a multidisciplinary team approach.

The corridor team is normally comprised of at least the following representatives:

- Region Safety Engineer;
- Region Media Specialist;
- Governors Highway Safety Representative or designee;
- County Maintenance Manager or designee;
- Representative of State or local police responsible for enforcement on the corridor, and
- Local government representative.

Additional team members may also include the Region Traffic Engineer, 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 Safety Engineer and the Region Media Specialist should perform an analysis of the crash data along the corridor to identify appropriate limits for the corridor, and crash patterns that can be addressed by low-cost countermeasures, and education/enforcement actions. All intersection cluster lists within the corridor need to be reviewed to identify specific intersections within the corridor that appear on one or more of the cluster lists. It is anticipated that implementing a right-turn in/right-turn out limitation at stop-controlled intersections will be a significant countermeasure to consider on divided multi-lane corridors.

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 review areas of concern defined from the crash analysis and any other safety aspect identified during the field review. 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 Safety Engineer, Governors Highway Safety Representative designee, and the Region Media Specialist 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 considerations for cost-effective improvements.

After the countermeasures have been identified and approved by the agencies involved, plans are developed and issued, 402 safety grants are issued, and 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.

The corridors where 3E improvements should be considered are summarized in Table 29. Since the intersection corridor approach is new to the State, a pilot effort of these three corridors will be initiated. The State Safety Program Manager will evaluate the pilot. If it is considered beneficial, the pilot will be expanded to some or all of the remaining corridors, with lessons learned from the pilot being incorporated in the additional implementations.

Table 29. Corridor 3E Improvements on High-Speed Arterials with Very High Frequencies of Severe Intersection Crashes – Candidate Locations

County Name	Highway Number	Highway Name	Number of Crashes	Number of Fatalities	Number of Serious Injuries
Washington	029	Tualatin Valley Highway	2,270	8	61
Josephine	025	Redwood Highway	960	8	33
Lane	091	Pacific Highway West	946	8	29
		6-Year Total	4,176	24	123
		6-Year Average	696	4.00	20.50
		25% CRF estimates a reduction of...	174.00	1.00	5.13

Key Implementation Steps

The key steps necessary to implement this initiative and fully realize the safety benefits of the improvements, the organizations responsible for each key step, and the schedule to fully implement this activity are shown in Table 30.

Table 30. Key Implementation Steps for Corridor 3E Improvements on High-Speed Arterials with Very High Frequencies of Severe Intersection Crashes

Step	Organization Responsible for Step	Completion Date (Months After Implementation Plan Acceptance)
1. Review full corridor list and select 3 corridors to pilot and lead the implementation.	Traffic-Roadway Section	1 month
2. Analyze data for the corridors selected, investigating all major crash patterns (including intersections) and prepare a report of findings.	Traffic-Roadway Section, Regions	5 months
3. Select a multi-disciplinary team for each corridor to determine actions to reduce future crashes.	Traffic-Roadway Section, Regions, SHSP leadership	6 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, prepare estimated costs and schedules.	Traffic-Roadway Section, Regions, SHSP leadership	10 months
5. Obtain agency approval on the report, including approval of their roles as defined in the report.	Traffic-Roadway Section, Regions, SHSP leadership	12 months
6. Begin implementation, including issuing 402 grants for education and enforcement activities and development and letting of contract to implement infrastructure improvements.	Traffic-Roadway Section, Regions, SHSP leadership, Governors Highway Safety Representative	30 month

7. Evaluate corridor approach, take any lessons learned, and make a decision to expand, expand with modifications, or terminate corridor safety approach.	Traffic-Roadway Section	36 months
8. If decision is to expand or expand with modifications, proceed with steps 2 through 7 for remaining corridors.	Traffic-Roadway Section, Regions, SHSP leadership, Governors Highway Safety Representative	60 months

9. City-wide 3E Improvements

Description

Oregon DOT has identified cities with the highest number of intersection fatalities in the State. Oregon DOT hopes to identify two pilot cities to initiate a city-wide 3E approach in each city with the objective of reducing city intersection fatalities by at least percent. This goal will be accomplished by using a combination of low-cost infrastructure improvements and targeted education and enforcement strategies beyond those that may be implemented in other systematic countermeasure deployments.

The effort begins with a refined analysis of the crash data of each city, taking population and number of intersections into consideration along with anticipated Region and city interest in implementing intersection safety projects. From the refined analysis a priority list of candidate cities should be established. A preliminary meeting with city officials in each of these candidate cities should be initiated to determine interest in pursuing a comprehensive intersection safety initiative. Two cities should then be selected for the initiative.

Oregon DOT, in conjunction with each city, should perform a thorough analysis of the intersection crash characteristics in the city, with the particular goal of understanding the problems that need to be addressed to reduce future intersection fatalities within the city. A city-wide multi-disciplinary team is then formed to review the crash analysis, discuss the intersection safety problems in the city, jointly field review representative problem intersections to gain personal and group consensus of the major safety issues and probable solutions, and collectively develop an overall set of 3E countermeasures to improve intersection safety in the city. 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 is being made.

The cities where 3E improvements should be considered are summarized in Table 31. Since the city-wide 3E approach is relatively new to ODOT, the pilot program will be closely monitored by the State Safety Program Manager, and, if considered beneficial, may be expanded to additional cities.

Table 31. City-Wide 3E Improvements in Cities with High Frequencies of Severe Intersection Crashes – Candidate Cities with the Highest Intersection Fatalities, Injuries, and Crashes

City Name	Number of Crashes	Number of Fatalities	Number of Serious Injuries
Portland	30,424	72	873
Eugene	5,131	19	104
6-Year Total	35,555	91	977
6-Year Average	5,925.83	15.17	162.83
10% Crash Reduction	592.58	1.52	16.28

Key Implementation Steps

The key steps necessary to fully implement this initiative and realize the safety benefits of the improvements, the organizations responsible for each key step, and the schedule for this activity are shown in Table 32.

Table 32. Key Implementation Steps for City-wide Pilots

Step	Organization Responsible for Step	Completion Date (Months After Implementation Plan Acceptance)
1. Review the cities and tentatively select two pilot cities.	Traffic-Roadway Section, Regional Offices, Local Programs, Governor's Highway Safety, Representative	2 months
2. Contact each city selected and determine interest. If not interested go to next candidate city. Finalize two pilot cities.	Traffic-Roadway Section, Regional Offices, Local Programs, Governor's Highway Safety, Representative	5 months
3. Analyze crash data for pilot cities, investigating all major intersection crash patterns and preparing a brief report of findings.	Regional Offices	9 months
4. Select a multi-disciplinary team to determine actions to reduce future crashes for the pilot cities.	Regional Offices	10 months
5. Hold a meeting of the multi-disciplinary team, complete field views of problem and typical intersections, identify set of comprehensive 3E improvements, prepare a set of countermeasures and improvements proposed to reduce future intersection fatalities by at least 10 percent. As part of the set of countermeasures, prepare estimated costs and schedules.	Regional Offices	12 months

Step	Organization Responsible for Step	Completion Date (Months After Implementation Plan Acceptance)
6. Obtain agency approval on the set of countermeasures, including approval of their roles as defined in the plan.	Traffic-Roadway Section, Regional Offices, Local Programs, Governor's Highway Safety, Representative	14 months
7. Begin implementation, including issuing 402 grants for education and enforcement activities and development and letting of contract to implement infrastructure improvements.	Traffic-Roadway Section, Governor's Highway Safety, Representative, Regional Offices	30 months
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	36 months
9. If decision is to expand or expand with modifications, proceed with steps 2 through 7 for additional cities.	Traffic-Roadway Section	42 months and beyond

10. Hot Spot Improvements / Roundabouts

Description

Major improvements such as the construction of roundabouts require careful individual intersection analysis and are not appropriate to consider for systematic deployment. These major physical improvements have longer term benefits since their expected lives may be 30 years or longer (as compared to about 10 years for signs and traffic signals). In addition, the effectiveness of these improvements in potentially reducing the number of crashes at a location is greater than that of lower cost improvements. For example, the installation of roundabouts is expected to reduce severe intersection crashes by 90 percent. However, the high initial costs prevent roundabouts from being considered for systematic deployment. In addition, significant factors such as available right of way, environmental issues, cost differentials between alternate major improvement types, and traffic operations will have an impact on choosing them as the optimum improvement type. As a result, these improvements are best suited to consider at intersections with the highest number of severe crashes.

Roundabouts are usually the most effective countermeasures in terms of reducing future severe crash potential; however, the high cost of construction significantly reduces the attractiveness of pursuing them. The expected rate of return in terms of lives saved per dollar invested is low compared to improving large numbers of intersections with lower cost countermeasures. This is particularly the case when funding for safety is constrained and the objective is to reduce the maximum number of fatalities and incapacitating injuries possible with the available funds.

While intersections with the highest number of statewide crashes will be considered as candidates for implementing systematic low-cost countermeasures as described earlier in the plan, these same intersections will also be considered candidates for roundabout construction (where the CRF is 90% for fatalities and incapacitating injuries). Candidate intersections for roundabouts are shown in Table 33 and Table 34.

Table 33. Roundabouts – Existing Stop-Controlled Intersections – Total Crashes

	Threshold Crash Level (6 Years)	Number of Statewide Crash Intersections	Number of Targeted 6 Year Crashes in the Intersections	Estimated Number of Improvements[1]	Construction Costs ($ Million)[2]	Serious Injuries per 100 Crashes	Fatalities per 100 Crashes	Annual Targeted Crash Reduction[3]	Serious Injuries Reduced	Annual Estimated Fatality Reduction
State Rural	20	4	133	2	0.80	7.55	1.49	7.76	0.59	0.12
State Urban	40	7	347	4	1.40	3.22	0.41	20.24	0.65	0.08
Local Rural	20	3	69	2	0.60	6.93	1.23	4.03	0.28	0.05
Local Urban	40	4	237	2	0.80	2.67	0.25	13.83	0.37	0.03
[1] Assumption - Locations to be improved		50%								
[2] Assumption - Average cost per intersection		$400,000								
[3] CRF		0.70								

Table 34. Roundabouts – Existing Signalized Intersections - Total Crashes

	Threshold Crash Level (6 Years)	Number of Statewide Crash Intersections	Number of Targeted 6 Year Crashes in the Intersections	Estimated Number of Improvements[1]	Construction Costs ($ Million)[2]	Serious Injuries per 100 Crashes	Fatalities per 100 Crashes	Annual Targeted Crash Reduction[3]	Serious Injuries Reduced	Annual Estimated Fatality Reduction
State Rural	40	2	90	1	0.32	4.38	0.89	4.20	0.18	0.04
State Urban	80	4	419	2	0.64	2.58	0.31	19.55	0.51	0.06
Local Rural	40	-	-	-	0.00	5.69	0.41	0.00	0.00	0.00
Local Urban	80	7	695	3	1.12	2.54	0.20	32.43	0.82	0.06
[1] Assumption - Locations to be improved		40%								
[2] Assumption - Average cost per intersection		$400,000								
[3] CRF		0.70								

It is estimated that 16 roundabouts will be installed or under construction over the next 5 years.

Key Implementation Steps

The key steps necessary to fully implement this initiative and realize the safety benefits of the improvements, the organizations responsible for each key step, and the schedule to fully implement this activity are shown in Table 35.

Table 35. Key Implementation Steps for Roundabouts

Step	Organization Responsible for Step	Completion Date (Months After Implementation Plan Acceptance)
1. Develop and distribute guidelines for considering roundabouts.	Traffic-Roadway Section, ODOT Management	1 month
2. Analyze the high-crash intersections (perform crash analysis and field reviews) to determine if roundabouts are appropriate solutions for the intersection. Develop project packages for each intersection where roundabouts are recommended, including cost estimates for the improvement.	Traffic-Roadway Section, Regions	7 months
3. Analyze the packages and make an assessment of the viability of the improvements and the potential impact of the project in terms of utilization of existing revenues and impact on achieving the intersection fatality goal. Select a minimum of four intersections to convert to roundabouts. Advise Highway Leadership Teamof the assessment.	Traffic-Roadway Section, Regions	Within 1 month of receipt of the package
4. Develop contract plans for approved projects and let the project.	Regions	30 months
5. Implement improvements.	Regions	48 months

Performance Measures

Implementing the multiple countermeasures, deployment levels, and schedules is a complex undertaking and it is easy to lose sight of achieving the objective of the initiative, which are to reduce statewide levels of intersection fatalities and incapacitating injuries cost effectively. A set of production and performance measures is proposed for this initiative to assist in monitoring the progress in implementing the improvements and contribution of the improvements in reducing future crash potential. Production and performance measures have been set to assist implementation activities as follows:

Production Performance Measures

Table 36. Production Performance Measures

Countermeasure	Measure	Target Completion Date	Actual Completion Date
Sign and Marking Improvements – State Stop-Controlled Intersections ➢ Basic Set of Sign and Marking Improvements ➢ Flashing LED Beacons on Advance Intersection Warning Signs and STOP Signs or Flashing Overhead Intersection Beacons ➢ Optional Signing and Marking Improvements Based on the Characteristics of the Intersection	Issue guidelines and target intersections to Regions	Issued by XXXX	Date issued
	Field review each of the identified intersections and determine improvements	Intersection improvements identified by XXXX	Actual number intersections identified
	Implement improvements	Intersection improvements implemented by XXXX	Actual number improved
J-Turn Modifications on High-Speed Divided Arterials – State Stop-Controlled Intersections	Issue guidelines and target intersections to Regions	Issued by XXXX	Date issued
	Implement J-turn treatments	New J-turn treatments in place by XXXX	Actual number in place
Basic Set of Sign and Marking Improvements – Local Stop-Controlled Intersections	Issue guidelines and target intersections to locals and Regions	Issued by XXXX	Date issued
	Monitor and track system	Monitor and tracking system by XXXX	Monitor and tracking system date in place
Signal and Sign Improvements – Local Signalized Intersections ➢ Basic Set of Signal and Sign Improvements ➢ Change of Permitted and Protected Left-Turn Phase to Protected Only	Issue guidelines and target intersections to locals	Issued by XXXX	Date issued
	Monitor and track system	Monitor and tracking system by XXXX	Monitor and tracking system date in place
	Implement improvements	Intersections improved by XXXX	Number of local signals improved
New or Upgraded Lighting – Rural Intersections	Issue guidelines and locations to Regions	Issued by XXXX	Date issued

Countermeasure	Measure	Target Completion Date	Actual Completion Date
	Field review each of the identified intersections and determine improvements	Intersection improvements identified by XXXX	Actual number intersections identified
	Implement improvements	Intersections lit by XXXX	Actual number lit
High-Friction Surface – State Intersections	Issue guidelines	Issued by XXXX	Date issued
	Field review each of the identified intersections and determine improvements	Intersection improvements identified by XXXX	Actual number intersections identified by XXXX
	Implement skid approach treatments	Anti-skid material applied at approaches to intersections by XXXX	Actual number of approaches treated t by XXXX
	Implement improvements	Intersections improved by XXXX	Date implemented
Enforcement-Assisted Lights	Finalize selection of two pilot cities	XXXX	Date finalized
	Implement enforcement light demo in pilot cities	XXXX	Date implemented
Corridor 3E Improvements on High-Speed Arterials with Very High Frequencies of Severe Intersection Crashes	Finalize selection of three corridors	XXXX	Actual date
	Assemble corridor safety team, field review corridor, and identify corridor safety countermeasures	XXXX	Actual date
	Implement corridor improvements	XXXX	Actual date
City-wide Pilot Improvements	Finalize selection of candidate cities	XXXX	Actual date
	Field review each of the identified intersections and determine improvements (Flashing Yellow Arrow, Clearance Interval Timing, and/or Enforcement-Assisted Lights)	Intersection improvements identified by XXXX	Actual date
	Implement city improvements	Intersections improved by XXXX	Actual Date
Roundabouts	Finalize guidelines for roundabout consideration	Completed and issued by XXXX	Actual date issued
	Complete evaluations of targeted intersections for potential installation of roundabouts	Completed by XXXX	Date evaluations completed
	Make decision on roundabouts	XXXX	Date decisions made
	Approved roundabouts in place	In place by XXXX	Date roundabouts functional

Performance Standards – Program Effectiveness in Reducing Targeted Crashes

Table 37. Performance Measures

Countermeasure	Year Improvements Implemented	Year Evaluation Plan Developed	Year Evaluation Completed	Expected Crash Reduction	Actual Crash Reduction
Sign and Marking Improvements – State Stop-Controlled Intersections ➢ Basic Set of Sign and Marking Improvements ➢ Flashing Beacons on Advance Intersection Warning Signs and STOP Signs ➢ Optional Signing and Marking Improvements Based on the Characteristics of the Intersection					
J-Turn Modifications on High-Speed Divided Arterials – State Stop-Controlled Intersections					
Basic Set of Sign and Marking Improvements – Local Stop-Controlled Intersections					
Signal and Sign Improvements – State Signalized Intersections ➢ Basic Set of Signal and Sign Improvements ➢ Optional Signal and Sign Improvements Based on the Characteristics of the Intersection ➢ Change of Permitted and Protected Left-Turn Phase to Protected Only Advance Detection Control Systems					
Signal and Sign Improvements – Local Signalized Intersections ➢ Basic Set of Signal and Sign Improvements ➢ Change of Permitted and Protected Left-Turn Phase to Protected Only					

Countermeasure	Year Improvements Implemented	Year Evaluation Plan Developed	Year Evaluation Completed	Expected Crash Reduction	Actual Crash Reduction
New or Upgraded Lighting – State Rural Intersections					
High-Friction Surface – State Intersections					
Pedestrian Improvements					
Enforcement-Assisted Lights					
Corridor 3E Improvements on High-Speed Arterials with Very High Frequencies of Severe Intersection Crashes					
City-wide Pilot Improvements (Flashing Yellow Arrow, Clearance Interval Timing, Enforcement-Assisted Lights)					
Roundabouts					

Summary

The number of intersection 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 intersection safety emphasis, and additional intersection safety funding to realize this benefit. The existing approach of emphasizing moderate- to high-cost improvements at high-crash intersections and existing systematic approach must be complemented with an expanded systematic approach deploying a large number of low-cost, effective countermeasures and the use of coordinated 3E comprehensive solutions on high-crash corridors that have a high number of intersection fatalities.

For most of the countermeasures, key implementation steps include field reviews to determine the specific intersections at which improvements can be made. A separate set of spreadsheets has been developed to provide information that can facilitate this process – listings of candidate intersections that meet the thresholds for each of the countermeasures in the tables. The listings have identified intersections which appear on multiple countermeasure lists to assist Regions in performing more efficient the field reviews.

As a first step in implementation, a consensus-building process must be pursued to gain the broad support and funding of Regions, MPOs, cities, and the Highway Leadership Team of the implementation plan to better ensure effective implementation.

Recapping, the countermeasures, deployment levels, costs, and estimated lives saved needed to achieve the intersection safety goal are shown in Table 38. While the level and direction of effort is well beyond that currently being pursued for intersection safety, the expected outcome – preventing over 2,400 crashes, 80 incapacitating injuries, and approximately 10 fatalities at intersections each year – is worth the investment.

Table 38. Summary of Countermeasures, Deployment Levels, Costs, and Fatality Reductions

Countermeasure	Intersection Type	TCD	Crash Type	Approach	Estimated Number of Improvements (Intersections)	Construction Costs ($ Million)	Educ / Enf Costs (Annual $ Million	Estimated Annual Crashes Prevented	Estimated Annual Serious Injuries Prevented	Estimated Annual Fatalities Prevented	$ Million Expended Per Annual Life Saved
State Roads											
Basic Set of Sign and Marking Improvements	State Rural and Urban	Stop-Controlled	Total	Systematic	567	3.88	0.00	264.15	13.10	2.24	1.74
Enhanced Signing Treatments (Median Stop Sign, Warning and/or Stop Beacon)	State Rural and Urban	Stop-Controlled	Total	Systematic	43	0.85	0.00	14.88	0.76	0.13	6.53
J-Turn Modifications on High-Speed Divided Arterials	State Rural and Urban	Stop-Controlled	Angle Crashes on Divided Roadways	Systematic	2	0.48	0.00	4.32	0.13	0.05	10.52
Basic Set of Signal and Sign Improvements	State Rural and Urban	Signalized	Total	Systematic	329	2.63	0.00	327.78	8.92	1.17	2.26
Change of Permitted and Protected Left-Turn Phase to Protected Only (or Flashing Yellow Arrow)	State Rural and Urban	Signalized	Left Turn with 2 or More Vehicles	Systematic	131	1.96	0.00	106.45	3.64	0.34	5.70
Enforcement Assisted Lights	State Rural and Urban	Signalized	Angle	Systematic	34	0.03	0.00	11.78	0.48	0.07	0.51
Pedestrian Improvements	State Rural and Urban	Stop-Controlled and Signalized	Pedestrian	Systematic	19	0.22	0.00	4.53	0.77	0.22	1.03
New or Upgraded Lighting	State Rural and Urban	Stop-Controlled and Signalized	Dark, Dark/Total ≥ 0.22 (Rural)/0.24 (Urban)	Systematic	47	0.70	0.00	34.46	1.63	0.39	1.79
High Friction Surface	State Rural and Urban	Stop-Controlled and Signalized	Wet, Wet/Total ≥ 0.26	Systematic	51	1.28	0.00	21.71	1.06	0.17	7.41
Traffic Calming Improvements	State Rural and Urban	Stop-Controlled	Speeding-Related Crashes	Systematic	18	0.28	0.00	4.60	0.28	0.09	3.07

Countermeasure	Intersection Type	TCD	Crash Type	Approach	Estimated Number of Improvements (Intersections)	Construction Costs ($ Million)	Educ / Enf Costs (Annual $ Million	Estimated Annual Crashes Prevented	Estimated Annual Serious Injuries Prevented	Estimated Annual Fatalities Prevented	$ Million Expended Per Annual Life Saved
Hot Spot Improvements	State Rural and Urban	Stop-Controlled and Signalized	Total	Traditional	8	3.16	0.00	51.75	1.93	0.30	10.61
Local Roads											
Basic Set of Sign and Marking Improvements	Local Rural and Urban	Stop-Controlled	Total	Systematic	359	2.47	0.00	216.23	8.11	1.08	2.29
Enhanced Signing Treatments (Median Stop Sign, Warning and/or Stop Beacon)	Local Rural and Urban	Stop-Controlled	Total	Systematic	31	0.62	0.00	12.54	0.44	0.05	11.25
Basic Set of Signal and Sign Improvements	Local Rural and Urban	Signalized	Total	Systematic	326	2.61	0.00	350.83	8.99	0.71	3.69
Change of Permitted and Protected Left-Turn Phase to Protected Only (or Flashing Yellow Arrow)	Local Rural and Urban	Signalized	Left Turn with 2 or More Vehicles	Systematic	171	2.56	0.00	145.27	4.21	0.19	13.46
Enforcement Assisted Lights	Local Rural and Urban	Signalized	Angle	Systematic	47	0.05	0.00	15.18	0.62	0.05	0.91
Pedestrian Improvements	Local Rural and Urban	Stop-Controlled and Signalized	Pedestrian	Systematic	38	0.49	0.00	8.80	1.11	0.25	1.99
New or Upgraded Lighting	Local Rural and Urban	Stop-Controlled and Signalized	Dark, Dark/Total ≥ 0.22 (Rural)/0.24 (Urban)	Systematic	50	0.75	0.00	39.92	1.75	0.26	2.87
Traffic Calming Improvements	Local Rural and Urban	Stop-Controlled	Speeding-Related Crashes	Systematic	9	0.13	0.00	2.68	0.18	0.04	2.98
Hot Spot Improvements	Local Rural and Urban	Stop-Controlled and Signalized	Total	Traditional	6	2.52	0.00	50.28	1.47	0.15	16.89

Countermeasure	Intersection Type	TCD	Crash Type	Approach	Estimated Number of Improvements (Intersections)	Construction Costs ($ Million)	Educ / Enf Costs (Annual $ Million	Estimated Annual Crashes Prevented	Estimated Annual Serious Injuries Prevented	Estimated Annual Fatalities Prevented	$ Million Expended Per Annual Life Saved
Corridors and Cities											
Corridor Improvements				Comprehensive	3 corridors	3.00	0.30	174.00	5.13	1.00	3.30
City-Wide 3E Improvements				Comprehensive	2 cities	3.00	0.30	592.00	16.28	1.52	2.17
Totals											
State Roads					1,250	15.49	0.00	846.39	32.70	5.16	3.00
Local Roads					1,036	12.20	0.00	841.73	26.87	2.79	4.38
Corridors and Cities						6.00	0.60	766.00	21.41	2.52	2.38
Grand Total					2,286	33.69	0.60	2,454.12	80.98	10.47	3.22