Oregon Department of Transportation

ODOT All Roads Transportation Safety (ARTS) Program - Hot Spot

Prepared by

DKS

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Acknowledgements

The ODOT All Road Transportation Safety (ARTS) Hot Spot Program was developed through a collaborative effort among various public agencies. Input and assistance by the following people helped make this plan possible:

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Region 1

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Hillsboro
Troutdale
Clackamas County
Multnomah County
Washington County

Region 2

Salem
Albany
Keizer
Eugene
Corvallis
Springfield
Lane County
Marion County
Polk County
Tillamook County

Region 3

Grants Pass
Central Point
Medford
Roseburg
Jackson County
Josephine County

Region 4

Bend
Klamath Falls
The Dalles
Deschutes County

Region 5

Grant County
La Grande
Umatilla County

For additional information about the ARTS Program, please visit the ARTS website at:

http://www.oregon.gov/ODOT/HWY/TRAFFIC-ROADWAY/Pages/ARTS.aspx

Contents

1. Introduction

Fatal and serious injury crashes impact the lives of Oregonians every year. Reducing the most severe crashes will bring the most benefits for safety and the economy.

The Oregon Department of Transportation (ODOT) has received federal transportation funding for decades that have helped ODOT build the transportation infrastructure that exists today. In 2005, the Highway Safety Improvement Program (HSIP) was created to focus on reducing traffic fatalities and serious injuries on all roadways. Historically, federal funding provided to ODOT has been applied almost exclusively to ODOT facilities.

However, roughly half of the fatalities and serious injuries occur on other public roadways (see Figure 1 on the next page), including non-state owned roadways and roads on tribal lands, so ODOT is expanding the HSIP to include all public roads in Oregon. The extended HSIP coverage was funded, in part, by federal legislation associated with Moving Ahead for Progress in the 21st Century (MAP-21) .

ODOT met with the League of Oregon Cities (LOC) and the Association of Oregon Counties (AOC) to establish the framework for what the new program should look like. A Memorandum of Understanding was agreed upon and the All Roads Transportation Safety (ARTS) Program was formed. Because HSIP funding was already assigned to projects on ODOT roads through 2016, a transition process was used to apply additional funding to safety projects on local roadways until the full ARTS system could be implemented.

The goals of the ARTS program include:

- Reduce fatal and serious injury crashes
- Address safety on all public roads
- Utilize a data driven process that is blind to jurisdiction

By following the goals of the program, ODOT intends to increase awareness of safety on local roads, promote best practices for infrastructure safety, complement behavioral safety efforts, and focus limited resources on the areas most likely to reduce fatal and serious injury crashes in the state of Oregon. The following themes form the backbone of the ARTS Program.

Fatal and Serious Injury Crashes

While ODOT's safety program is intended to reduce all crashes, it is focused on fatal and serious injury

ODOT All Roads Transportation Safety (ARTS) Program - Hot Spot

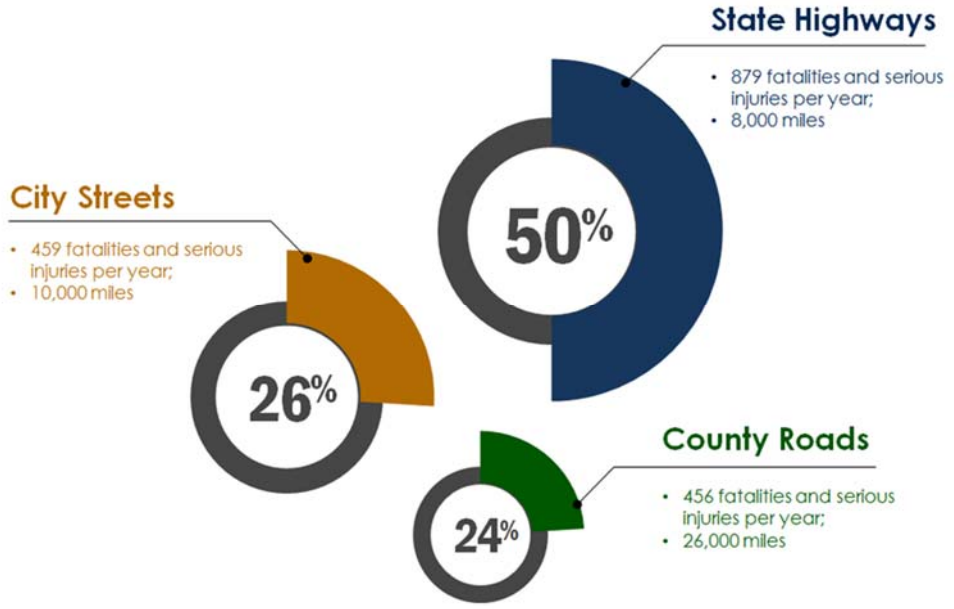


Figure 1: Statewide Crash Trends: In Oregon, approximately 50% of fatalities and serious injury crashes occur on state highways, with the remaining 50% split fairly evenly between city and county roadways.

(referred to as Injury "A") crashes. The greatest economic benefit is realized from reducing the highest severity crashes. In addition, countermeasures targeting fatal and serious injury crashes are generally expected to reduce the number of less severe injury crashes.

ARTS Program Guidelines

The ARTS Program Principle Guidelines include:

- The program goal is to reduce fatal and serious injury crashes.
- The program must include all public roads.
- The program is data driven and blind to jurisdiction.
- The process will be overseen by ODOT Regions.
- Both traditional "hot spot" methodology and systemic methodology will be used.

Jurisdictionally Blind—Data Driven

In the past, ODOT has used federal funding for safety improvements primarily on state highways. A new approach was undertaken to consider safety on all roads in Oregon, regardless of jurisdiction. This new approach resulted in a program known as the All Roads Transportation Safety (ARTS) Program (formerly known as the Jurisdictionally Blind Safety Program) that focuses on the highest safety needs, wherever they are located. While ODOT still manages the safety improvement program, this jurisdictionally blind approach will address the most important safety needs in Oregon, regardless of whether it is on a state highway, a city or county road, or other public road.

The ARTS program uses a data-driven process to identify potential hot spot projects. Geocoordinates tied to crash records identify where the highest number and severity of crashes occur on the roadway network. In addition, each crash can be plotted onto a map to help evaluate hot spot locations (Figure 2).

Local Agency Outreach

It is important for each ODOT Region to engage their local jurisdictions and develop strong partnerships that support ongoing coordination to identify and construct safety improvements. Projects identified

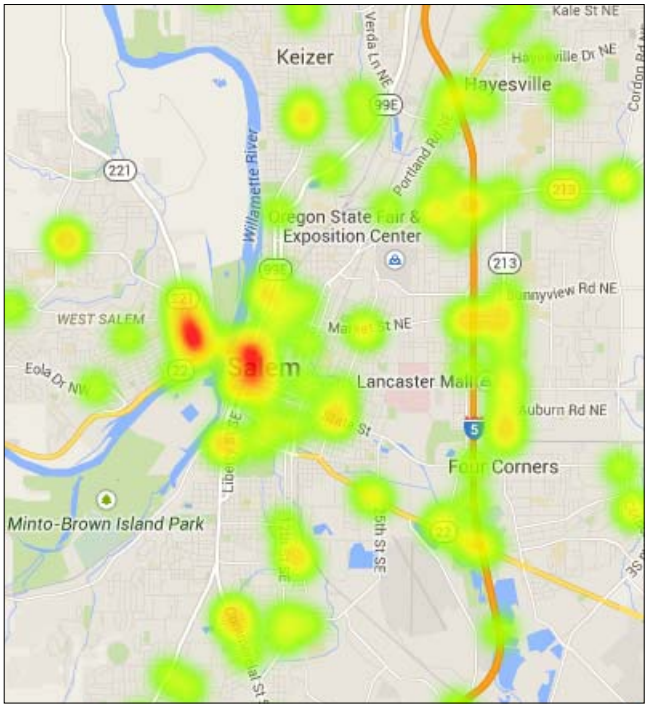


Figure 2: Mapped Crash Locations

on local agency roadways will need to be supported by local agency staff and the surrounding communities.

ODOT Responsibility for FHWA Funding

ODOT is responsible to FHWA for making the final decisions about which projects are funded and for the overall performance of the program to reduce fatal and serious injury crashes. MAP-21 requires that each State develop a Strategic Highway Safety Plan that focuses on reaching performance targets. States are required to set targets for reducing the number of serious injuries and fatalities occurring throughout the state and demonstrate progress is being made toward reaching each target.

Funds will not be given directly to local agencies to use at their discretion. Instead, the funds will be allocated based on the predetermined amounts available to each ODOT Region, based on the number of fatalities and serious injuries. ODOT Region staff are responsible for the delivery of the projects, either by ODOT the delivering the projects or coordinating with the local agencies to deliver the projects.

It is important to note that the federal HSIP program requires a local match for the projects where HSIP funding will be used. For Oregon, this local match is 7.78% of the project cost.

Systemic vs. Hot Spot

The ARTS program is split into two main components; a "systemic" component and a "hot spot" component. This report documents the process used to identify hot spot projects, and summarizes the systemic process where the two overlap.

ARTS Systemic

Systemic projects address safety concerns along entire corridors, roadway segments, or throughout communities rather than specific points or locations in the roadway network. This approach attempts to address the random nature of crashes by applying the countermeasure to a larger section of roadway rather than specific locations where crashes have occurred. The systemic portion of this program is application-based, meaning that ODOT and local agencies are required to submit applications for locations they feel are in need of safety improvements in three focus areas (roadway departure, intersection ,and pedestrian/bicycle). ODOT will evaluate all applications for completeness and accuracy and will prioritize the projects based on the calculated benefit/cost ratio or cost-effectiveness index. To be considered for systemic funding, each project is required to:

- Use only approved "Systemic" countermeasures as listed in the Crash Reduction Factors list (see appendix).
- Not require the acquisition of significant amounts of right of way (more than 10% of project costs), preferably no right of way.

ARTS Hot Spot

Hot spot projects focus on specific locations within the roadway network such as intersections, curves, or short segments of roadways. Hot spot projects were identified using geo-coordinates attached to historical crash data to identify locations where the most crashes occurred. Once locations were identified, the characteristics and details about the crashes were used to select countermeasures for each location.

Funding Breakdown

The $166 million of available funds for the ARTS Program (both systemic and hot spot) has been allocated to each ODOT region based on the relative frequency of fatalities and serious injuries. About half of the funding was allocated for Hot Spots by Region, as shown in Table 1.

Systemic funding was then further split into Roadway Departure, Intersections and Pedestrian/Bicycle type projects as shown below in Figure 3 (this funding split is approximate and are statewide numbers). This split is consistent with strategies identified in the State's Transportation Safety Action Plan,[(1)] which identifies three key safety focus areas: intersections, roadway departure, and pedestrian and bicycle crashes.

Table 1: Approximate ARTS Hot Spot Funding Allocation

Region	2017-2021 Estimate
1	$27,384,019
2	$28,240,159
3	$12,876,808
4	$9,077,093
5	$5,613,273
Total	**$83,191,352**

Section Endnotes

(1) *Transportation Safety Action Plan, ODOT, October 2011, http://www.oregon.gov/ODOT/TS/docs/tsap_revised_03-20-12.pdf*

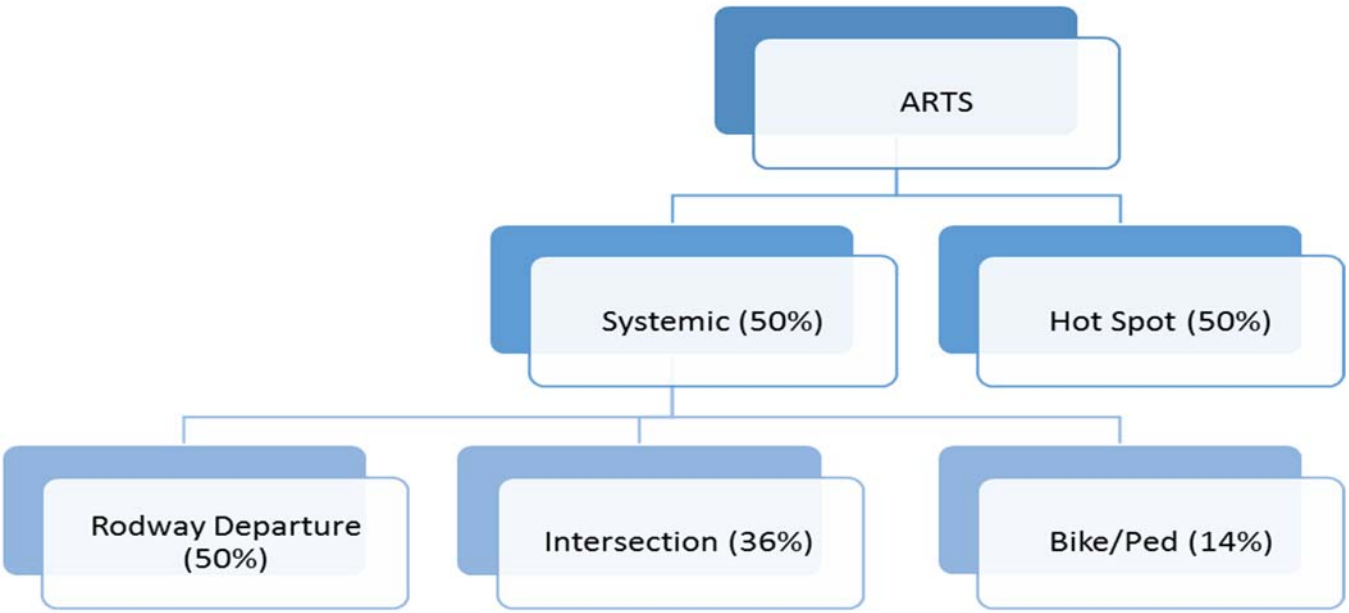
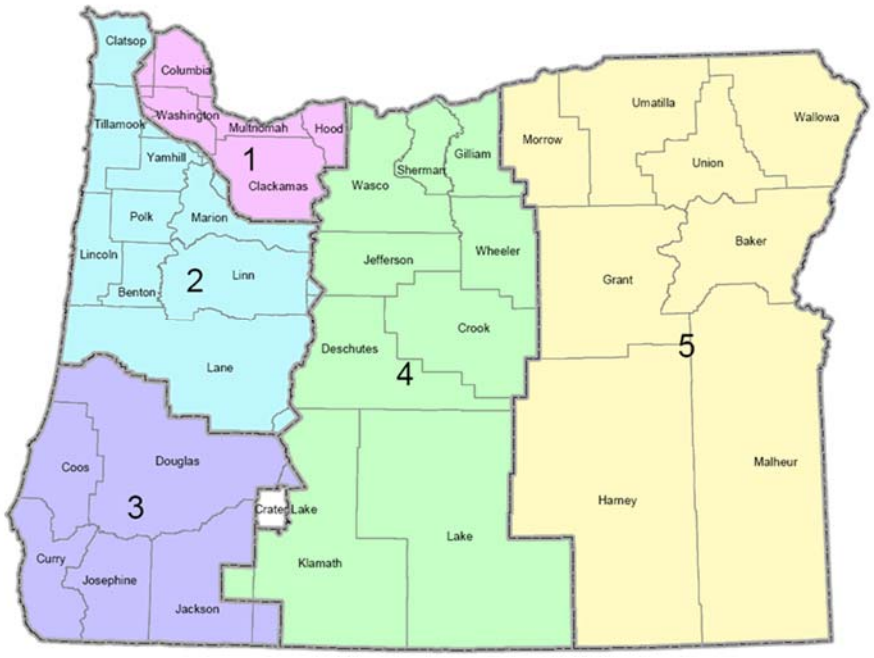


Figure 3: Approximate ARTS Funding Breakdown

2. Hot Spot Process



Oregon Department of Transportation Regional Map

This chapter provides an overview of how the potential hot spot projects list was developed in each ODOT Region. As a reminder, this is separate from the systemic portion of the ARTS Program.

This chapter includes:

- A summary of the guidelines used
- A description of how hot spot locations were identified
- Available countermeasures and how they were selected
- Cost estimates and benefit/cost ratios
- Cut sheets that were created to help evaluate each location.

This section concludes with the steps taken to prioritize the potential projects into a final 300 percent list.

Hot Spot Guidelines and Methodology

The overall goal of the ARTS program is to significantly reduce the occurrence of fatalities and serious injuries on all roads. Therefore, a data-driven approach was utilized to ensure that the maximum benefit is achieved. The following guidelines were used to ensure each project was evaluated consistently and works toward achieving the goals of this program.

All Projects:

- Used ODOT crash data (2009-2013) to identify hot spot locations and crash trends
- Had at least one fatal or injury A crash during this time period
- Addressed a specific safety problem contributing to fatalities and serious injuries
- Used only proven countermeasures from the approved ODOT Crash Reduction Factor list
- Used ODOT Benefit Cost method
- Were prioritized based on the Benefit/Cost Ratio for developing the 300% list

The methodology developed for the ARTS hot spot program and the prioritized project lists is outlined in Figure 4, on the next page. This process was performed for each ODOT Region based on the crash data and funding allocation described in Chapter 1.

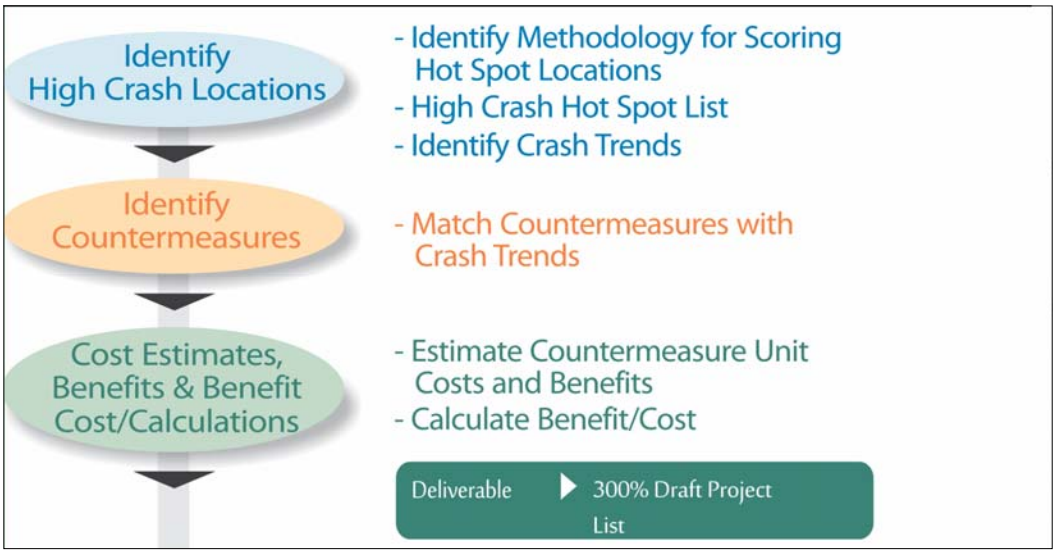


Figure 4: Methodology for Developing ARTS Prioritized Project Lists

Identify High Crash Locations

Based on MAP-21 guidance to use a data-driven approach, crash data played a key role in the development of the ARTS Program. It was the basis of allocating funds between the ODOT Regions and between the various components of the project. For this process, crash data was used exclusively to identify locations with high crash frequency and severity.

Crash data on state and local roads was obtained from the Oregon Department of Transportation (ODOT) Crash Analysis and Reporting Unit for the most recent five years of available data (2009 through 2013). Although the focus of this program is on the fatal and serious injury crashes, all crashes were included to help better identify and diagnose safety concerns.

It is known that as a self-reporting state, ODOT's crash records do not include all crashes; however fatal and serious injury crashes are almost always accounted for because of their critical nature and importance. Specifically, about 40 percent of all crashes are estimated to have police reports, but this percentage is much higher for fatal and serious injury crashes. Generally, all fatal crashes have police reports, and approximately 90 percent of serious injury "A" crashes are expected to have police reports.[1]

Since 2007, ODOT crash records have been geo-coded, meaning the locations have and assigned a latitude and longitude based on information available in crash reports. This allows the crashes to be displayed and analyzed using geographic information system (GIS) software. Figure 5 on the next page shows an example of several crashes mapped at a hot spot intersection.

Geocoding of crashes also allows for the distance between any two crashes to be calculated. A radius was drawn around each fatal or serious injury crash to aggregate crashes occurring within a specified distance. In urban areas, a 250-foot radius was used to capture all crashes at a given intersection without including crashes at adjacent intersections. In rural areas, a 500-foot radius was used to capture crashes that may be more spread out along a curve or

Figure 5: Example Hot Spot Crash Map

segment of roadway. However, for some locations these distances were slightly adjusted to ensure all crashes related to a hot spot are accounted for.

All the road segments/intersections identified as hot spot locations in the state were screened to create a list of potential hot spot projects. For a given location each crash was assigned a weight based on the crash severity as shown in Table 2. This method, known as Equivalent Property Damage Only (EPDO) Average Crash Frequency, is one of the many available performance measures mentioned in the Highway Safety Manual (HSM) for network screening.[2] An initial ranking was created for each "hot spot" location based on the EPDO of crashes located within the corresponding radius.

Table 2: Crash Severity Weighting

Severity	Weight
Fatal	100
Injury A	100
Injury B	10
Injury C	10
Property Damage Only (PDO)	1

For example, a crash location with 1 fatal crash (100 points), 2 injury A crashes (200 points), 4 injury B crashes (40 points), 4 injury C crashes (40 points) and 5 PDO crashes (5 points) would have a total weight of 385. The list of potential hot spot locations was sorted to identify the locations with the highest weight. This was the starting point for evaluating safety improvements for hot spot locations.

Approved Countermeasure List

In preparation for the ARTS program, ODOT staff worked to develop a toolbox of countermeasures that have been proven to reduce crashes. These countermeasures were selected based on a review of information in the Highway Safety Manual,[2] Crash Modification Factors Clearinghouse website hosted by the Federal Highway Administration,[3] as well as national and local research studies.

Hot spot countermeasures are proven countermeasures typically ranging from medium to high cost for addressing a particular location that may have multiple causes to address. Systemic countermeasures are limited to low cost, proven measures that are ideal for applying over a corridor. For the ARTS program, hot spot countermeasures were not allowed to be used in systemic project. However, systemic countermeasures were allowed to be used for hot spot locations as these countermeasures were often found to be an appropriate solution for a specific crash trend.

The full list of countermeasures is included in the appendix and can be downloaded from ODOT's ARTS website. The ARTS website also has an appendix that accompanies the countermeasure list and provides additional details about each countermeasure and how it should be applied. The following information is available for each countermeasure included in the toolbox:

- Description
- Applicable crash types (turning, angle, rear end, etc)
- Applicable crash severities (injury, PDO)
- Service life (5, 10, or 20 years)
- Applicable traffic control type (signalized/ unsignalized)
- Applicable Setting (Urban vs. Rural)
- Crash Reduction Factor (CRF) %

Selecting countermeasures

The highest ranked locations were examined to identify deficiencies and countermeasure(s). Key characteristics were summarized to identify trends. Key data included crash type, crash cause, lighting condition, and time-of-day. Special attention was given to characteristics and causes of fatal and injury A crashes. However, it was helpful to look at all crashes to get a better understanding of crash trends at a specific location.

At each potential hot spot location, crash data was summarized and mapped. Each fatal and serious injury crash was examined in detail. Overall crash trends, including less severe crashes, were also evaluated to see if they were consistent with severe crash trends observed for the fatal and serious injury crashes. Figure 6 shows an example of the types of summaries used when evaluating crashes at each location.

Based on the crash trends and an assessment of existing conditions at the location, appropriate countermeasures were identified which are proven to reduce the frequency and/or severity of crashes. In some cases, groups of countermeasures were considered before a recommendation was made. For example, a traffic signal would be potential countermeasure for a two-way stop-controlled intersection. However, this is a high cost countermeasure and may result in a low benefit/cost ratio when the number of crashes is low. An

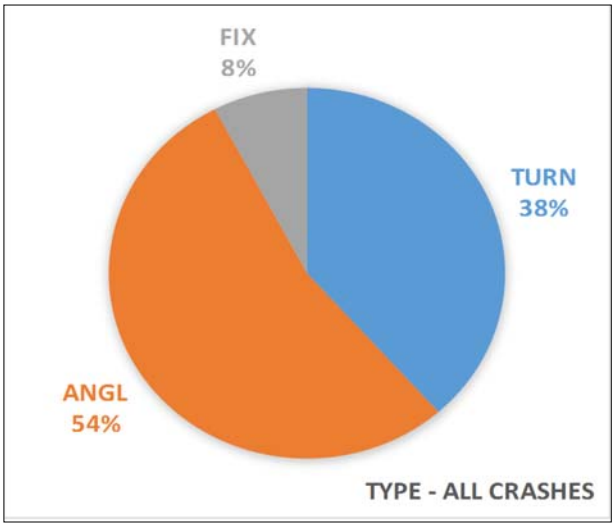


Figure 6: Example Crash Trend Summaries

alternative group of low-cost countermeasures for the existing traffic control were also considered, such as signing and advanced flashers. Some locations had no apparent countermeasures that fit the situation due to physical constraints or lack of applicable countermeasures. These locations remained on the project list and included a note that no countermeasures were identified (a separate list was created for Region 1).

Cost estimates

In order to consistently compare potential hot spot projects, a standard cost estimate was derived for each countermeasure. OBEC Consulting Engineers provided planning level cost estimates for civil components, such as sidewalks, curb ramps, earthwork, paving and environmental assessments. In addition to the construction cost, a 66% markup was included to account for design (26%), contingency (30%) and temporary protection and direction of traffic (10%). Due to the urban nature and additional cost of construction in Region 1, the markup was increased to 100% of the construction cost. Additionally, right-of-way cost and hazardous materials mitigation costs were added to applicable countermeasures.

For the majority of hot spot locations, the standard cost estimates were used. However, costs were adjusted based on specific location characteristics in a few cases. For example, a stream or railroad tracks adjacent to an intersection would likely increase the cost associated with any significant intersection improvements; therefore, adjustments were made where deemed appropriate.

Benefit Calculations

The economic benefits of each countermeasure were calculated based on the expected crash reduction and the Comprehensive Economic Value per Crash established by ODOT (Table 3). When multiple countermeasures were proposed for a single location, a combined benefit was calculated consistent with ODOT and Highway Safety Manual methodology. In short, the benefit associated with two different countermeasures was not simply added together, rather a diminishing returns approach was used to combine benefits. For example, if the first countermeasure reduces the number of crashes by 25%, the second countermeasure would only apply to the remaining 75% of crashes.

Table 3: Comprehensive Economic Value per Crash

Highway Type	Urban	Rural
Property Damage Only		
All facilities	$19,400	$19,400
Moderate (Injury B) and Minor (Injury C) Injury		
Interstate	$69,300	$79,200
Other State Highway	$70,600	$81,900
Off System	$72,400	$83,900
Fatal and Severe (Injury A) Injury		
Interstate	$1,150,000	$2,330,000
Other State Highway	$1,170,000	$1,680,000
Off System	$870,000	$1,670,000

Economic costs per crash are calculated using cost source and procedures shown in Appendix 4A of the Highway Safety Manual, updated to 2012 dollars.

The benefit also accounted for the expected service life of the countermeasure. For example, installing a traffic signal is expected to provide safety benefits for 20 or more years, while new striping or pavement markings might wear off in a few years. Therefore, the annual benefit is multiplied by a corresponding present worth factor as shown in Table 4. For example, the annual benefit for a countermeasure with an expected service life of 20 years would be multiplied by 12.46 to estimate the overall benefit.

Table 4: Uniform Series Present Worth Factor

5 Years	10 Years	20 Years
4.33	**7.72**	**12.46**

A spreadsheet was provided to Region staff that documents the benefit calculations. This should allow for easy modifications during the project scoping process if countermeasures are changed.

Cut Sheets

A cut sheet was created for each location to summarize the crash trends and countermeasure selection process (see sample cut sheet in Figure 7). Each cut sheet included basic information about the location, map, crash data summaries, and a detailed list of each fatal or serious injury crash. It also included the expected benefit and cost associated with each proposed countermeasure, as well as any notes that describe the reasoning for including a particular countermeasure. The appendix includes a cut sheet for each location on a 300% list.

Prioritization and 300% List

The cumulative product from the previous steps was a 300% project list for each ODOT Region. Each Region's list contains enough projects to spend 300%

the amount of available funding in the Region, which provides flexibility when scoping and delivering projects. The list was prioritized based on benefit/cost ratio so the most cost effective projects would receive funding first. The 300% hot spot list for each Region is included in the appendix and for each project it has the location description, roadway jurisdiction, benefit, cost, and a brief description of each proposed countermeasure.

Ultimately, this effort looked at over 400 locations throughout the state and identified potential hot spot projects at 260 locations. In addition to projects on ODOT facilities, projects were proposed on roadways owned by 16 different cities and 12 different counties. Of the 260 potential project locations, 145 (55%) are on ODOT roadways, 85 (33%) are on city roadways, and 30 (12%) are on county roadways.

Section Endnotes

(1) *Doug Bish,* ODOT
(2) *Highway Safety Manual, 1st Edition (2010), AASHTO*
(3) *http://www.cmfclearinghouse.org/*

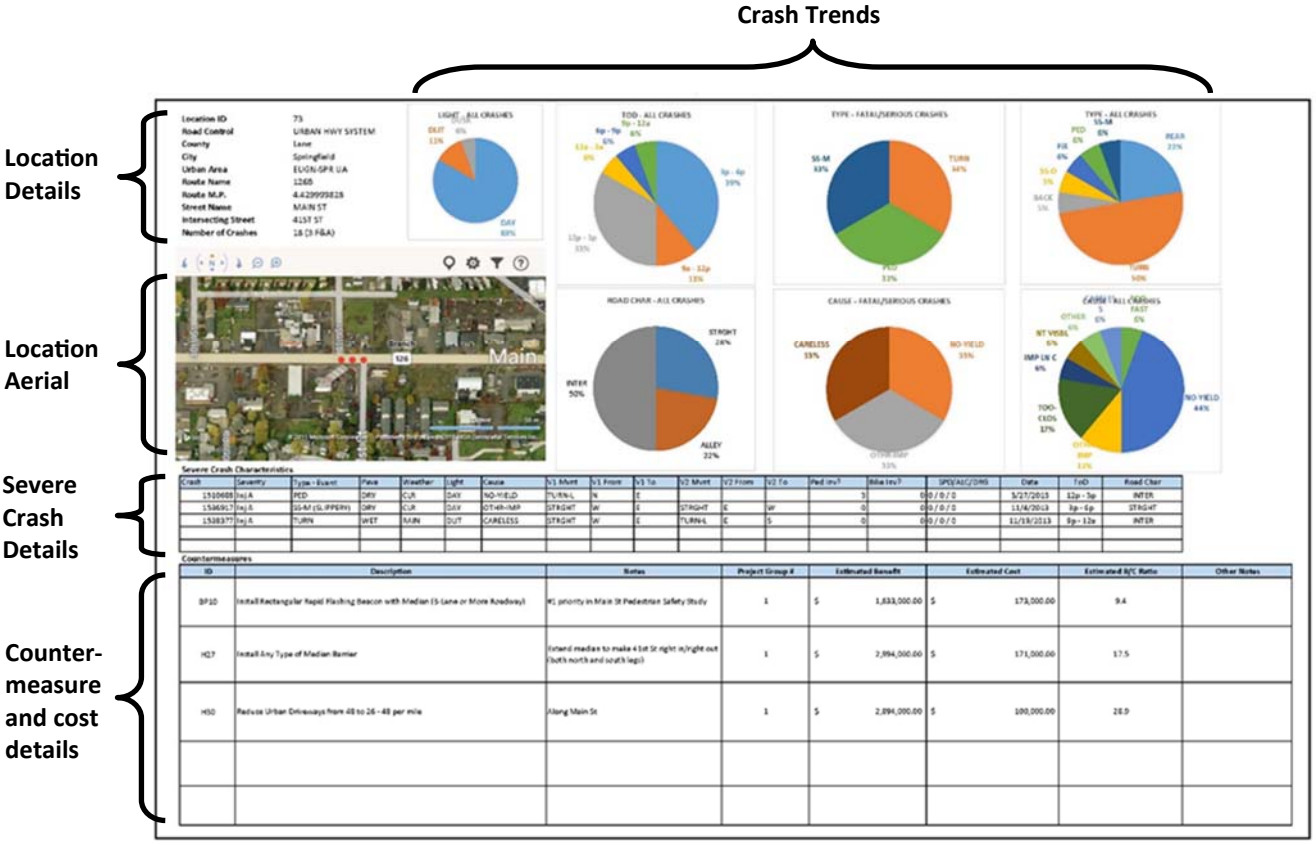


Figure7: Sample Cut Sheet

3. Agency Coordination

The project team discusses potential projects with local agency staff.

ODOT and local agency staff involvement throughout this process has been key to ensuring that the high priority locations are selected and appropriate solutions are identified. This chapter discusses the engagement process with local agency and ODOT staff in developing each Region's 300% project list.

Draft Project List/Cut Sheets

DKS provided ODOT Region staff with a draft project list and associated cut sheets for ODOT to perform an initial review of the hot spot locations and proposed countermeasures. ODOT staff were able to identify locations that should be removed from the list (usually due to recent or programmed/funded projects) and suggest changes to the proposed countermeasures that reflect additional understanding of existing conditions and local agency preferences. DKS staff met with ODOT staff from each Region to discuss the recommended changes and prepare the draft 300% list for distribution to local agencies.

Local Agency Kick-Off Meetings

DKS worked with ODOT to coordinate meetings with local agency staff in each Region. In March, 2015, DKS and ODOT representatives met with local agency staff to review the overall goals of the ARTS program, provide details about the hot spot methodology used to develop the project list, and present the draft 300% list. Local agencies were invited to stay after the meeting to discuss specific locations with DKS and ODOT staff.

Local Agency Feedback

After meeting with ODOT and local agencies to present the hot spot methodology and draft 300% list, the local agencies were given a chance to provide additional feedback related to proposed projects on the 300% list. In some cases, ODOT staff met directly with local agencies to solicit input. Specifically, local agencies and ODOT Region staff were asked to provide the following feedback:

- Do you agree that there are safety concerns at the location identified?
- Is there a planned project at this location?
- Do the proposed countermeasures address the crash trends, or is there another countermeasure that makes more sense?
- Does the cost estimate seem reasonable, or do you have reason to believe that it should be modified (higher/lower)?
- If the proposed project makes the 100% list, will you support it and be able to provide the local match of 7.78%?

Supplemental Applications

In addition to providing feedback on the 300% list, local agencies were invited to submit applications for additional locations that would be good candidates for hot spot safety projects (in Region 1, these were referred to as local appeals to avoid confusion with systemic project applications with a similar naming convention). To be considered for inclusion on the 300% list, each supplemental location had to be consistent with ARTS hot spot methodology by meeting the following criteria:

- Each location shall have at least one fatal or serious injury crash from 2009 to 2013
- The proposed solution shall only include countermeasures from the ODOT CRF list
- The cost estimate shall use standard costs identified for this program unless there is local agency justification for modified cost estimates
- The project will be prioritized based on the benefit/cost ratio determined using ODOT methodology

To assist ODOT and local agency staff in preparing supplemental applications and to ensure all the necessary information was included, a standard form was developed. The one-page form includes sections to identify the submitting agency, location, crash summary, proposed countermeasures, cost, and resulting benefit/cost ratio. Local agencies were also asked to include any available supporting information such as crash records, pictures, and benefit/cost calculations. DKS reviewed each supplemental application for consistency and accuracy, and when appropriate, incorporated them into the 300% project list.

In addition to the applications, DKS received many local agency requests to take an initial look at possible hot spot locations to determine if the crash history would make it eligible for consideration. DKS was able to quickly examine each location to determine if sufficient crash history included injury A or fatal crashes that would make it a candidate for further consideration. This assisted local agencies in determining whether to take the time to complete an appeal application.

Revised Project List and Final Review

DKS worked with ODOT to address all agency comments and suggestions received from ODOT and local agency staff. The draft 300% list was revised to incorporate the suggested changes and additional locations identified through the supplemental application process. The revised list was then distributed to ODOT Region staff and local agencies for a final review. A second round of regional meetings with local agencies is scheduled to discuss any changes to how projects were evaluated and gather any final feedback on the 300% list.

4. Next Steps

The final product of this project is a 300% list of potential hot spot projects for each ODOT Region. ODOT will be responsible for scoping the highest priority projects, incorporating them into the upcoming Statewide Transportation Improvement Program (STIP) cycle, and ultimately working with local agencies to deliver the safety projects.

This chapter discusses the next steps to advance the implementation of the ARTS program. In addition, since this is the first cycle of an ARTS program in Oregon there are a few unknowns. This chapter closes with several lessons learned during this cycle that may guide future ARTS cycles.

Next Steps

ODOT will select the top 150% of the projects for scoping from the 300% projects list developed here. ODOT will collaborate with local agencies to refine the understanding of the contributing factors to crashes and the appropriate solution for each location. The expected reduction in crashes, economic benefit, and project cost will be reassessed. Local agencies will need to confirm that there is local support for the required 7.78% match. It is expected that some issues will be revealed during scoping that could not be identified as part of this process (i.e. higher costs, environmental issues, right-of-way, etc.) and some projects will be removed from the list. This is why the top 150% will be scoped in order to assure enough projects are advanced to spend the available funding.

Once all projects have been scoped and a revised benefit/cost ratio has been calculated, the project list will be reprioritized. The top 100% of projects will advance to the STIP. Some projects will be amended into the 2015-2018 STIP and the rest incorporated into the 2019-2021 STIP. Figure 8 summarizes the next steps and the anticipated timeline for completed each task. Ultimately, ODOT Region staff will work with jurisdictions to determine the delivery methods, delivering agency, and timelines (applicable

Figure 8: ARTS Program Next Steps

funding year). For projects involving local agencies, the ODOT regions will work with jurisdictions to develop an Intergovernmental Agreement. The delivering agency will be accountable for timely and fiscally responsible delivery or funding could be pulled from the local agency project and applied to another project.

Lessons Learned

This is the inaugural cycle of the statewide safety program for all public roads. There have been several lessons learned along the way that could be used to create a better process in the future. This section presents some of the ideas that worked well, and some that could be better addressed as part of the next ARTS STIP scoping cycle.

Hot Spot Identification

Hot spot locations were identified by grouping crashes in the same vicinity using the geo-coordinates for each crash record. By automating this process, hot spot locations were quickly and consistently identified without regard for roadway jurisdiction. Using geo-coordinates rather than street names to identify locations also eliminated common data cleaning problems associated with inconsistent roadway names.

One of the most challenging aspects of this approach was specifying the appropriate radius to group all crashes related to a given location without also including unrelated crashes. The 250 foot radius in urban areas and 500 foot radius in rural areas seemed to achieve this goal on facilities in Regions 2 through Region 5. However in Region 1, roadways and intersections are so closely spaced, in many cases, that this method often identified hot spot locations that captured crashes at several adjacent facilities. This created an extra step to the quality review to verify initial groups, and to manually clean up the selected records, as needed. If a similar approach is used in the future, it may be beneficial to experiment with different radius options to see if this issue can be easily addressed.

Another challenge with this approach was accounting for grade-separated roadways (i.e. freeway interchanges and overpasses). Some hot spot locations included crashes that occurred on the freeway, ramps, and surface streets, which were often the result of different factors and unrelated to each other. The potential for these locations to show up was statewide, however it was mostly a concern in Region 1 due to the high number of grade-separated intersections and elevated roadways. Again, this required manual editing of the initial groupings at each location to remove the unrelated crashes. Perhaps the grouping criteria could be modified to add another variable, such as including a combination of geo-coordinates and street names to resolve this issue.

Finally, the strategy of selecting locations with the highest number of crashes sometimes resulted in an over-representation of large, urban, signalized intersections. This was especially true in Region 1, where there are numerous intersections of high volume, congested arterials. Many of these intersections already have upgraded signal equipment, turn lanes on all approaches, and don't appear to have any deficiencies. At these locations, the high number of crashes is likely due to congestion and high traffic volumes.

It has been discussed that using the HSM's predictive method would help determine if there really is a safety problem at these locations. The predictive method takes into account traffic volumes and other geometric considerations to estimate the number of crashes that should be expected for a given location. This type of analysis would be very data intensive, and in many cases it would be difficult to find accurate volume data. However, it may show that some of these high crash locations are actually

operating better than average based on high levels of traffic when compared to similar sites.

Countermeasure List

In preparation for the ARTS program, ODOT compiled a list of proven countermeasures to be considered for both hot spot and systemic projects. An initial list was sent to Region staff and local agencies for comments and review, and the approved list of approximately 110 countermeasures was established by the start of this project. The intent of having a set list of proven countermeasures was to support a fair and consistent evaluation of potential safety improvements. However, there were many locations where the desired improvement or countermeasure was not included in the list. Some examples of desired countermeasures included installing guide signage, restricting right turn on red, and adding acceleration lanes. There was some confusion about how to proceed at these locations and if additional countermeasures could be added to the list. Ultimately, countermeasures were added to the list when a reliable study could be found that established a documented crash reduction factor for that improvement. If a reliable study could not be found, the countermeasure was not considered.

Even though the revised list includes nearly 120 countermeasures, there are still some beneficial engineering solutions that are not available for use in this project due to the lack or reliable data. Future iterations of this process should find a way to balance the need for consistently using proven countermeasures and providing the flexibility to use engineering judgment when applying other countermeasures.

Cost Estimates

Accurately estimating the cost associated with each project is critical when using the benefit/cost ratio to prioritize potential hot spot projects. Without scoping each project to fully understand the existing conditions and required solution, it is a challenge to establish an accurate cost estimate. Given that this is a planning level effort, the decision to use a standard cost estimate for each countermeasure with the ability to adjust cost based on specific location characteristics seemed to work well. One possibility for improvement on this approach would be to establish a separate set of cost estimates for each Region. Construction tends to be less expensive in areas with a lower population density, such as Region 5, than in more urbanized areas with limited right-of-way, such as Region 1.

Benefit Calculations

The economic benefit associated with each project was calculated based on the crash reduction factor (CRF) assigned to each countermeasure. The procedure used to determine the expected reduction in crashes achieved by applying one or more countermeasures was consistent with the HSM and ODOT methodology. However, there are still several concerns about some of the assumptions used.

The first concern relates to how the CRF is applied to crashes within the hot spot. The CRF identified for most of the countermeasures is intended to apply to all crashes at that location — some identify a specific type of crash that they should be applied to. For some countermeasures, the study that established the CRF also identified several other CRFs, each

applying to different subsets of the total crashes. To reduce the complexity of benefit calculations, the CRF for all crashes was selected when possible.

For example, installing a right turn lane on one approach to an urban signalized intersection is reported to have a CRF of 4%, for all crashes at the intersection. However, some would argue that installing a right turn lane on a single approach would only reduce crashes on that approach rather than the intersection as a whole. Taking it a step further, the argument could be made that the right turn lane would only apply to right-turning crashes on that approach. In this case, the supporting study identified a CRF for each scenario, with the percent reduction in crashes increasing each time the subset of crashes is reduced. One suggestion to help reduce some of this confusion is to add more detail to the approved countermeasure list that more clearly identifies what crashes the CRF should be applied to. Another option would be to provide a different CRF for each of the scenarios described above and let the analyst determine which is the most appropriate.

The other concern relates to how the combined CRF is calculated when multiple countermeasures are proposed for a single location. As previously described in Chapter 2, a diminishing returns approach was used rather than simply adding the reduction from multiple countermeasures. However, when three or more countermeasures are applied, the overall reduction could still reach upwards of 70% depending on the countermeasures. Most agree that this level of improvement is not likely to occur, but there is no state or national guidance that identifies a better approach. Some of these issues identified will likely be addressed as part of future methodology updates included in the HSM.

Cut Sheets

For each hot spot location, a cut sheet was created to summarize key information about the location and aid in selecting the appropriate countermeasures. This tool was used for the initial assessment of crash trends and existing conditions as well as documenting the proposed countermeasures, economic benefit, and cost assumptions. It also provides a location to store additional notes that give details about what is intended with each countermeasure that will be helpful during project scoping; for example, what approach a turn lane is intended to be installed. This tool received positive feedback from local agencies that appreciated having a summary of the most important information included on one sheet. As a stand-alone document, the final 300% list is missing a lot of key information about the intended project. Final cut sheets for each Region are provided in the appendix for each location and should be used in conjunction with the 300% list.

Local Agency Outreach

Engaging local agencies was a key component to this process as many of the proposed projects will need their support. Using their local knowledge of the roadway network and existing safety concerns helped ensure that the best projects possible were selected. However, it seems that some local agencies have been reluctant to participate in the program. It may be that they are not fully aware of how the program works, or they are too shorthanded to invest the time necessary to take advantage of the opportunities. Regardless, ODOT staff should continue working with local agencies to encourage participation and find ways to help meet their needs.

Several local agencies have also expressed a concern for providing the required local match of 7.78%. Many agencies lack funding for safety projects and will have a difficult time finding money for the local match. In some cases, high-cost countermeasures have been removed in favor of low-cost systemic countermeasures that lessen the local match burden on the local agencies.