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SAFETY ANALYSIS & SOLUTIONS MEMO

DATE: October 25, 2023

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SUBJECT: SKATS Metropolitan Transportation Safety Action Plan Project #22135-000

INTRODUCTION

The Salem-Keizer Area Transportation Study (SKATS) Metropolitan Planning Organization (MPO) has committed to developing a Metropolitan Transportation Safety Action Plan (MTSAP) to improve safety for all road users in the Salem-Keizer metropolitan area. This memorandum outlines the proposed methodology for completing the crash data and safety analysis needed to determine safety emphasis areas for the plan, to identify high-risk hotspot locations and systemic crash patterns and solutions, and to incorporate community feedback into the data-driven safety analysis process.

The development of emphasis areas, goals, and solutions will be consistent with the State of Oregon Transportation Safety Action Plan (OTSAP) which serves as the state's Strategic Highway Safety Plan (SHSP), which is a document required by federal law. The framework of the MTSAP will reflect the Safe System Approach, which is a holistic approach to addressing transportation safety. The Safe System Approach is centered on the following five principles and five objectives.

SAFE SYSTEM APPROACH PRINCIPLES

- **Humans make mistakes** – people will inevitably make mistakes; the transportation system should be designed to accommodate certain types of human errors
- **Humans are vulnerable** – humans can only tolerate a certain level of forces before serious injury or death occurs; the transportation system should be designed to reflect the physical limits of the human body
- **Responsibility is shared** – every individual plays an important role in preventing fatalities and serious injuries
- **Safety is proactive** – utilize proactive tools instead of waiting for crashes to occur
- **Redundancy is crucial** – if one element fails, the other elements should be robust enough to still protect people

SAFE SYSTEM APPROACH OBJECTIVES

- **Safer people** – encourage safe and responsible behaviors
- **Safer roads** – design the transportation system to mitigate for human mistakes, account for injury tolerances, and facilitate safe travel of vulnerable road users
- **Safer vehicles** – enhance vehicle design and features to prevent crashes and minimize impact forces

- **Safer speeds** – promote safer speeds in all roadway environments through design, speed limit setting, education, outreach, and enforcement
- **Post crash care** – enhance the quality and timeliness of emergency services, create a safe working environment for first responders, and prevent secondary crashes

The final MTSAP will include strategies covering all elements and objectives of the Safe System Approach. The solutions in this memorandum are primarily focused on engineering solutions within the safer roads category. However, opportunities to encourage safer people, safer speeds, safer vehicles, and improved post crash care should be explored and prioritized at any location where safety solutions are being considered.

MTSAP GOALS & EMPHASIS AREAS

The overarching goal of the MTSAP is to **eliminate fatal and serious injury crashes** in the SKATS metropolitan area. To achieve this goal, the MTSAP will focus on the following emphasis areas, which reflect the crash patterns and road users most represented in fatal and serious injury crashes in the metro area.

Emphasis Areas

- Intersections
- Pedestrians
- Bicyclists
- Speeding
- Impairment/Distraction
- Road User Age

IDENTIFYING CASE STUDY LOCATIONS

The MTSAP will highlight several "safety case studies" at high-crash and high-risk locations within the SKATS area. These safety case studies are intended to provide examples of common crash patterns and potential safety solutions that could be considered at other locations with similar characteristics and crash patterns. As such, the project team aimed to select a mix of location types and crash patterns from a longer list of the high crash and high risk locations. The final list of safety case study locations were identified using a combination of crash data, input from the steering committee and technical advisory committee, and input gathered during the first round of public engagement.

METHODOLOGY

Of the six safety emphasis areas that will be identified in the MTSAP, four emphasis areas (intersections, pedestrians, bicyclists, and speeding) were used to guide the identification of the safety case study locations in the project study area.

Crash data for the years 2017 to 2021 provided by the Mid-Willamette Valley Council of Governments (MWVCOG) was imported into GIS in five separate layers, with one layer for each of the four emphasis areas and one layer for all crashes.[1] The project team used a combination of spatial analysis (using a GIS heatmap), geolocated public comments from the first open house, and Equivalent Property Damage Only (EPDO) scoring to identify high-crash locations. Then, the project team viewed each emphasis layer area as a heat map weighted by Equivalent Property Damage Only values (EPDO) to visually identify high-risk segments and intersections. In addition to the spatial analysis, the project team identified locations that were flagged by public comments in each emphasis area. Using both the spatial analysis and public comments, two Safety Case Study locations were selected for each Emphasis Area.

HIGH-CRASH AND HIGH-RISK LOCATIONS

Table 1 shows the high-crash locations for each of the four emphasis areas as well as all crashes, along with their EPDO score and reason for selection.

[1] Two of the six emphasis areas, impairment/distraction crashes and road user age crashes, were excluded because they cannot be addressed by infrastructure countermeasures.

TABLE 1. CASE STUDY LOCATIONS FOR SKATS EMPHASIS AREAS

SAFETY CASE STUDY LOCATION	INTERSECTION OR SEGMENT	EMPHASIS AREA	SELECTION CRITERIA
GLENN CREEK ROAD FROM BURLEY HILL TO WALLACE ROAD	Segment	Bicyclists	Selected based on bicycle-involved crash history
SILVERTON ROAD FROM PORTLAND ROAD TO I-5	Segment	Bicyclists	Selected based on bicycle-involved crash history
COMMERCIAL STREET FROM HILFIKER LANE TO FABRY ROAD	Segment	Pedestrians	Selected based on pedestrian-related crash history
LIBERTY STREET AT FERRY STREET	Intersection	Pedestrians	Selected based on pedestrian-related crash history
LIBERTY STREET FROM SKYLINE ROAD TO COMMERCIAL STREET	Segment	Speeding	Selected based on public comments
HIGH STREET FROM PRINGLE CREEK TO LEFFELLE STREET	Segment	Speeding	Selected based on public comments
COMMERCIAL STREET AT MARION STREET	Intersection	Intersections	Selected based on intersection crash history
LOCKHAVEN DRIVE AT RIVER ROAD	Intersection	Intersections	Selected based on intersection crash history and location in Keizer
LANCASTER DRIVE FROM SUNNYVIEW ROAD TO MARKET STREET	Segment	All Crashes	Selected based on crash history
LANCASTER DRIVE AT SILVERTON ROAD	Intersection	All Crashes	Selected based on public comments

SAFETY CASE STUDIES

For each of the locations noted in Table 1, the project team studied a combination of crash data, roadway and roadside characteristics, and public comments to diagnose the underlying crash risks and develop a set of potential safety solutions. These safety solutions are focused on infrastructure improvements that may qualify for state and federal safety grant opportunities. Broader safety solutions covering all elements of the Safe System Approach are provided for the systemic crash trends presented later in the memorandum, as well as in the safety solutions toolbox in the appendix. (The appendix is not included in this version of the memorandum as it is still in progress.)

Under the description of each case study location, specific safety treatments are listed. The purpose of the case studies is to demonstrate what treatments may be applicable at locations with similar characteristics within the SKATS area beyond each case study location. This means that the safety treatments listed are not particularly recommended at each location nor have they been evaluated for feasibility at each specific location.

Safety treatments often compromise vehicle operations to mitigate crash risk. When considering safety treatments in the SKATS area, it is important to recognize the balance between road user safety and traffic operations, noting that specific characteristics of each location may result in prioritization of some treatments over others. Additionally, some treatments may provide a safety benefit to one type of road user while creating a disbenefit to other road users. All of these factors, as well as the feasibility and cost effectiveness of each treatment, should be considered carefully when selecting a preferred safety solution.

EMPHASIS AREA: BICYCLES

People riding a bicycle were involved in 1.6% of all crashes in the SKATS region but represent approximately 4% of the fatalities and serious injuries that occurred between 2017 and 2021. The need for more comfortable and safe bicycle facilities was one of the most commonly heard concerns from the community.

CASE STUDY 1: Glenn Creek Road Segment (Wallace Road to Burley Hill Drive)

This segment of Glenn Creek Road is a two-lane road with some steep grades. It is classified as an urban minor arterial with a posted speed is 30 mph. Glenn Creek Road provides access to many local streets and private driveways in a largely residential area. Existing bike facilities include striped bicycle lanes in both directions, with some green conflict striping approaching the Wallace Road intersection.

- 65 total crashes, 5 involving bicyclists
- 3 serious injury crashes (none involving a bicyclist)
- In 80% of the bicyclist-involved crashes, a driver turning right struck a bicyclist traveling straight. Half of these occurred at driveways, half at intersections.
- All bicyclist-involved crashes occurred during the day
- Other predominant crash types were rear-end and turning crashes (50% and 43%, respectively). The most common contributing factors include drivers failing to avoid the vehicle ahead, drivers failing to yield, and inattention.
- Only one reported crash (not involving a bicyclist) was noted as speed-related; however, several public comments noted speed as a concern on this roadway

FIGURE 1. GLENN CREEK ROAD

Safety Improvement Considerations

The following table summarizes the key crash patterns identified in this case study, as well as the toolbox of potential safety treatments that could be considered to address similar challenges at this or other locations. The application of these potential safety treatments requires a site specific evaluation to determine feasibility. The safety treatments listed below have not been evaluated for feasibility at this specific location. Treatments noted with an asterisk (*) are already present at this case study location.

SAFETY CHALLENGES	TREATMENTS THAT MAY ADDRESS THESE CHALLENGES
Conflicts between bicycles and turning vehicles	• Install buffered bicycle lanes • Install green conflict paint at key intersections and high-volume driveways • Install signage reminding drivers to yield to bicyclists and pedestrians when turning • Restrict left and right turns on red at signalized intersections • Maintain vegetation to maximize sight distance for drivers exiting driveways and side streets • Implement access management strategies (e.g., consolidate or remove driveways, restrict turning movements at driveways, and redesign driveways and intersections to reduce vehicle speeds when turning)
Conflicts between through vehicles and turning vehicles (includes turning vehicles that are slowing or stopped)	• Install advanced intersection warning signs • Install turn lanes at intersections with high turning volumes • Install raised medians to restrict turning movements at driveways and intersections • Install a center two-way left-turn lane • Install dynamic turn restriction signs (can be tied to traffic volumes or time of day) • Implement access management strategies to reduce the number of access points
Speeding concerns	• Install speed feedback signs • Implement speed enforcement • Install traffic calming measures appropriate for the roadway functional classification

CASE STUDY 2: Silverton Road Segment (Portland Road to I-5)

This segment of Silverton Road is a four-lane road classified as an urban principal arterial with a posted speed of 35 mph. Land use in the area is primarily commercial and industrial. There is an at-grade rail crossing on Silverton Road near the Portland Road intersection. Narrow sidewalks (no landscape buffer) are present on both sides of the roadway, and there are no bicycle facilities. Pavement condition is poor in some areas.

- 307 crashes, 9 involved bicyclists, 9 involved pedestrians
- 10 serious injury crashes (none involving a bicyclist, 4 involving a pedestrian)
- Of the bicyclist-involved crashes, all occurred at intersections (77%) or driveways (23%). 55% of the bicyclist-involved crashes and 67% of the pedestrian-involved crashes occurred at a signalized intersection.
- The majority of bicycle crashes involved a driver turning right. Crashes involving a pedestrian involved a mix of drivers traveling straight, turning left, and turning right. The most common contributing factor in bicyclist and pedestrian crashes was a driver failing to yield.
- The majority of bicyclists were on the sidewalk or in a crosswalk when the crash occurred.
- Other predominant crash types were rear-end and turning crashes (44% and 38%, respectively). The most common contributing factors include drivers failing to avoid the vehicle ahead, drivers failing to yield, and inattention.

FIGURE 2. SILVERTON ROAD

Safety Improvement Considerations

The following table summarizes the key crash patterns identified in this case study, as well as the toolbox of potential safety treatments that could be considered to address similar challenges at this or other locations. The application of these potential safety treatments requires a site specific evaluation to determine feasibility. The safety treatments listed below have not been evaluated for feasibility at this specific location. Treatments noted with an asterisk (*) are already present at this case study location.

SAFETY CHALLENGES	TREATMENTS THAT MAY ADDRESS THESE CHALLENGES
Conflicts between bicycles or pedestrians and turning vehicles (at intersections and driveways)	• Install buffered bicycle lanes • Install green conflict paint at key intersections and high-volume driveways • Install bike boxes at intersections (if bicycle lanes are provided)

SAFETY CHALLENGES	TREATMENTS THAT MAY ADDRESS THESE CHALLENGES
	• Install signage reminding drivers to yield to bicyclists and pedestrians when turning • Restrict left and right turns on red at signalized intersections • Restrict permissive left turns when pedestrians are present • Install leading pedestrian intervals (LPI) at signalized intersections • Maintain vegetation to maximize sight distance for drivers exiting driveways and side streets • Install curb extensions • Install high visibility crosswalks • Implement a 4-to-3 lane conversion (road diet) and install bicycle lanes • Install supplemental signal heads on signal poles that are more visible to bicyclists • Implement access management strategies (e.g., consolidate or remove driveways, restrict turning movements at driveways, and redesign driveways and intersections to reduce vehicle speeds when turning)
Conflicts between through vehicles and turning vehicles (turning crashes)	• Install advanced intersection warning signs • Install turn lanes at intersections with high turning volumes • Install raised medians to restrict turning movements at driveways and intersections • Install a center two-way left-turn lane • Install dynamic turn restriction signs (can be tied to traffic volumes or time of day) • Implement access management strategies to reduce the number of access points
Conflicts between through vehicles approaching intersections (rear end crashes)	• Improve visibility of signal indications • Install advanced intersection warning signs • Install advanced dilemma zone detection • Modify corridor signal timing and progression

EMPHASIS AREA: PEDESTRIANS

People walking or rolling are involved in just 2% of all crashes in the SKATS region but represent almost 13% of the fatalities and serious injuries that occurred between 2017 and 2021. Pedestrian safety was one of the most commonly mentioned concerns in the public comments received.

CASE STUDY 1: Commercial Street Segment (Hilfiker Lane to Fabry Street)

This segment of Commercial Street has a five-lane cross section (center two-way left-turn lane) with a bicycle lane in both directions. It is classified as an urban principal arterial and provides access to a busy commercial area with grocery stores, restaurants, and strip malls as well as several apartment complexes. All signalized intersections have crosswalks on each leg. On average, marked crossings are about 1,500 feet apart. There is one RRFB crossing, shown below in Figure 3, at Royvonne Avenue near several apartment complexes. Sidewalks are present and in good condition for the entirety of the segment.

- 410 total crashes (23 involved pedestrians, 5 involved bicyclists)
- 2 fatal crashes (both involved pedestrians) and 11 serious injury crashes (4 involved pedestrians)
- 57% of pedestrian crashes occurred at night
- 49% of pedestrian-involved crashes were near an intersection
- 43% of pedestrian-involved crashes involved a driver making a turning maneuver (equal number of right- and left-turns)
- 34% of pedestrian-involved crashes were attributed to a driver failing to yield to the pedestrian, and another 26% involved a pedestrian crossing in-between intersections, not at a legal crossing
- Other predominant crash types were rear-end and turning crashes (approximately 40% each). The most common contributing factors include drivers failing to avoid the vehicle ahead, drivers failing to yield, and inattention.

FIGURE 3. RRFB CROSSING ON COMMERCIAL STREET

Safety Improvement Considerations

The following table summarizes the key crash patterns identified in this case study, as well as the toolbox of potential safety treatments that could be considered to address similar challenges at this or other locations. These safety improvements have not been evaluated for feasibility at this specific location. Treatments noted with an asterisk (*) are already present at this case study location.

SAFETY CHALLENGES	TREATMENTS THAT MAY ADDRESS THESE CHALLENGES
Conflicts between pedestrians and turning vehicles (at intersections and driveways)	• Restrict left and right turns on red • Restrict permissive left turns when pedestrians are present • Install leading pedestrian intervals (LPI) at signalized intersections • Upgrade pedestrian warning signs • Install signage reminding drivers to yield to pedestrians when turning • Install curb ramps and curb extensions • Implement access management strategies (e.g., consolidate or remove driveways, restrict turning movements at driveways, and redesign driveways and intersections to reduce vehicle speeds when turning)
Conflicts between pedestrians and vehicles mid-block	• Install additional enhanced mid-block crossings (RRFBs, curb extensions, median islands, pedestrian lighting)
Pedestrian crashes at night (dark, dawn, or dusk lighting conditions)	• Upgrade or install intersection and segment lighting • Install pedestrian-level lighting • Install high-visibility crosswalks*
Conflicts between through vehicles and turning vehicles (turning crashes)	• Install advanced intersection warning signs • Install turn lanes at intersections with high turning volumes* • Install raised medians to restrict turning movements at driveways and intersections* • Install a center two-way left-turn lane* • Implement access management strategies to reduce the number of access points
Conflicts between through vehicles approaching intersections (rear end crashes)	• Improve signal visibility (may include supplemental signal heads, larger lenses, backplates, etc.) • Install advanced intersection warning signs • Install advanced dilemma zone detection • Modify corridor signal timing and progression

CASE STUDY 2: Liberty Street at Ferry Street

Liberty Street at Ferry Street is a high-traffic intersection in Salem's downtown area. Both Ferry Street and Liberty Street are classified as urban principal arterials. Ferry Street is a state highway under ODOT jurisdiction. There are dual northbound left turn lanes and a leading pedestrian interval (LPI) for pedestrians crossing this movement in the west crosswalk. Curb extensions are present on all four corners.

- 32 total crashes, 7 involving pedestrians
- Zero fatal or serious injury crashes
- 6 of the 7 pedestrian crashes involved a driver making a northbound left-turn who failed to yield to the pedestrian in the crosswalk. One crash involved an impaired driver who turned the wrong way onto Liberty Street and struck a pedestrian in the crosswalk.
- 57% of pedestrian crashes occurred in dark, dawn, or dusk conditions, compared to 24% of vehicle-only crashes
- Other predominant crash types are rear-end, angle, and turning. Drivers failing to avoid the vehicle ahead and disregarding the traffic signal indication are the most common contributing factors.

FIGURE 4. LIBERTY STREET AT FERRY STREET

Safety Improvement Considerations

The following table summarizes the key crash patterns identified in this case study, as well as the toolbox of potential safety treatments that could be considered to address similar challenges at this or other locations. The application of safety treatments requires a site specific evaluation to determine feasibility. The potential safety treatments listed below have not been evaluated for feasibility at this specific location. Treatments noted with an asterisk (*) are already present at this case study location.

SAFETY CHALLENGES	TREATMENTS THAT MAY ADDRESS THESE CHALLENGES
Conflicts between pedestrians and turning vehicles at signalized intersection	• Restrict left and right turns on red • Restrict permissive left turns when pedestrians are present • Install leading pedestrian intervals (LPI) at signalized intersections • Add a pedestrian-only signal phase (requires pedestrian detection) • Upgrade pedestrian warning signs • Install signage reminding drivers to yield to pedestrians when turning* • Install curb ramps and curb extensions* • Convert dual turn lanes to single turn lanes • Install left-turn traffic calming treatments

SAFETY CHALLENGES	TREATMENTS THAT MAY ADDRESS THESE CHALLENGES
Pedestrian crashes at night (dark, dawn, or dusk lighting conditions)	• Upgrade or install intersection lighting* • Install pedestrian-level lighting • Install high-visibility crosswalks
Drivers disregarding the traffic signal	• Improve signal visibility (may include supplemental signal heads, larger lenses, backplates, etc.) • Install red light running cameras

EMPHASIS AREA: SPEEDING

Unsafe speeds were noted in approximately 7.5% of crashes, but contributed to just over 16% of fatal and serious injury crashes in the SKATS region. Speeding was one of the most common safety concerns shared by the public during community engagement activities.

CASE STUDY 1: Liberty Road Segment (Commercial Street to Skyline Road)

This segment of Liberty Road is a four-lane roadway that serves high-density residential, commercial, office, and restaurant land uses. Two elementary schools are also located within the vicinity of this section of Liberty Road. Liberty Road is classified as an urban minor arterial with a posted speed limit of 35 mph. There are sidewalks on both sides of the road with bicycle lanes present south of Browning Avenue. On the north end of the corridor, there is no center median. South of Browning Avenue, there is a center two-way left turn lane median with some raised medians spaced intermittently throughout. Most of the signalized intersections have permissive left-turn phasing and about half of the intersections provide left turn lane pockets.

FIGURE 5. NORTH END OF LIBERTY ROAD SEGMENT

- 181 total crashes, including 4 serious injury crashes
- 44% of all crashes involved a turning movement, most of which were attributed to drivers that failed to yield to oncoming traffic at both signalized and stop-controlled intersections
- 34% of all crashes were rear ends, most of which were attributed to drivers who failed to avoid vehicles that were slowed or stopped to turn at side-streets and driveways
- 2 crashes involved a bicyclist (one resulted in serious injury) and 6 involved a pedestrian (one resulted in serious injury)
- Approximately 25% of all crashes occurred during dark, dawn, or dusk conditions
- Speed was officially noted as a contributing factor in just six crashes; However, speeds were mentioned as a concern in numerous public comments on this roadway segment

Safety Improvement Considerations

The following table summarizes the key crash patterns identified in this case study, as well as the toolbox of potential safety treatments that could be considered to address similar challenges at this or other locations. The application of safety treatments requires a site specific evaluation to determine feasibility. The potential safety treatments listed below have not been evaluated for feasibility at this specific location. Treatments noted with an asterisk (*) are already present at this case study location.

SAFETY CHALLENGES	TREATMENTS THAT MAY ADDRESS THESE CHALLENGES
Conflicts between through traffic and turning vehicles (includes driveways and intersections)	• Install left-turn lanes at key intersections • Provide protected left-turn phasing at signalized intersections (would require dedicated turn lanes) • Install intersection warning signs • Install raised medians to restrict turning movements • Install a 4-to-3 lane conversion (road diet) and provide turn lanes and bicycle lanes • Install dynamic turn restriction signs (can be tied to traffic volumes or time of day) *
Crashes at night (dark, dawn, or dusk lighting conditions)	• Upgrade or install intersection and segment lighting* • Upgrade to high-visibility signs and markings • Install raised or recessed pavement markers (RPMs)
Speeding concerns	• Install speed feedback signs • Implement speed enforcement • Install traffic calming measures appropriate for the roadway functional classification

CASE STUDY 2: High Street Segment (Pringle Creek to Leffelle Street)

This segment of High Street is a two-lane roadway in a residential area with some frontage along Bush's Pasture Park. High Street is classified as an urban major collector. The posted speed is 25 mph. There is on-street parking on one side of the roadway. North of Mission Street, there is a steep grade with restricted sight distance where one serious injury head-on crash occurred in 2021. Sidewalks are present on both sides of the road and there are no bicycle lanes.

- 20 total crashes (1 involving a bicyclist, none involving a pedestrian)
- 2 serious injury crashes
  - 1 head-on, 1 sideswipe – meeting
  - Both occurred in dark conditions
- The primary crash types include angle, rear-end, and turning.
- The most common contributing factors include drivers failing to avoid a vehicle ahead, inattention, and drivers not yielding.
- 10% of crashes were attributed to speeding or driving too fast for conditions

FIGURE 6. HIGH STREET NEAR BUSH'S PASTURE PARK

Safety Improvement Considerations

The following table summarizes the key crash patterns identified in this case study, as well as the toolbox of potential safety treatments that could be considered to address similar challenges at this or other locations. The application of safety treatments requires a site specific evaluation to determine feasibility. The potential safety treatments listed below have not been evaluated for feasibility at this specific location. Treatments noted with an asterisk (*) are already present at this case study location.

SAFETY CHALLENGES	TREATMENTS THAT MAY ADDRESS THESE CHALLENGES
Speeding concerns	• Install speed feedback signs • Implement speed enforcement • Install traffic calming measures appropriate for the roadway functional classification
Vehicle conflicts at intersections (angle, turning, and rear-end crashes)	• Install advanced intersection warning signs • Install turn lanes at intersections with high turning volumes • Convert two-way stop controlled intersections to all-way stop control • Increase intersection sight distance by removing obstructions (e.g., vegetation, on-street parking, signs, and poles, etc.)

SAFETY CHALLENGES	TREATMENTS THAT MAY ADDRESS THESE CHALLENGES
Crashes at night (dark, dusk, or dawn lighting conditions)	• Upgrade or install intersection and segment lighting • Upgrade to high-visibility signs and markings • Install raised or recessed pavement markers (RPMs)

EMPHASIS AREA: INTERSECTIONS

Crashes at intersections comprise the highest proportion of all crashes (48%) as well as the highest proportion of fatal and serious injury crashes (47%). Intersections serve competing demands for all modes of travel and are inherently concentrated areas for conflicts.

CASE STUDY 1: Commercial Street at Marion Street

The intersection at Commercial Street and Marion Street is a high-traffic intersection of two one-way streets (southbound and westbound) leading to the bridge toward West Salem. At this location, both streets are classified as urban principal arterial roadways. On the southbound approach, there is a right-turn lane and shared through-right turn lane. There is a left-turn lane and shared through-left turn lane on the westbound approach. No sight distance restrictions are present.

- 102 total crashes (3 involving a pedestrian, 4 involving a bicyclist)
- 3 serious injury crashes
  - Two angle/turning movement
  - One sideswipe - overtaking
- Predominant crash types are turning (51%), rear-end (18%), angle (15%), and sideswipe overtaking (12%).
- 48% of crashes involved vehicles turning right from Commercial Street onto Marion Street (bridge). Of these crashes, 50% involved two southbound vehicles, one turning right and one going straight. Another 26% involved two right-turning vehicles, and 16% involved a bicyclist or pedestrian.
- 41% of all crashes involved a driver disregarding the traffic signal or other traffic control device. The next most common contributing factor was drivers making an improper turn (17%).

FIGURE 7. WESTBOUND APPROACH OF COMMERCIAL STREET AT MARION STREET

Safety Improvement Considerations

The following table summarizes the key crash patterns identified in this case study, as well as the toolbox of potential safety treatments that could be considered to address similar challenges at this or other locations. The application of safety treatments requires a site specific evaluation to determine feasibility. The potential safety treatments listed below have not been evaluated for feasibility at this specific location. Treatments noted with an asterisk (*) are already present at this case study location.

SAFETY CHALLENGES	TREATMENTS THAT MAY ADDRESS THESE CHALLENGES
Drivers in inside turn lane continuing straight and conflicting with turning drivers in the shared through-turn lane	• Install delineators, curbs, or traffic separators to prohibit drivers in the dedicated turn lane to continue straight • Install guide striping through the intersection to designated vehicle travel paths* • Install overhead lane assignment signs* • Improve visibility of pavement markings and lane assignment signs • Install supplemental signal heads (one per lane) • Convert shared through-turn lane to a dedicated turn lane or dedicated through lane
Conflicts between all road users and turning vehicles at signalized intersections	• Improve visibility of pavement markings and lane assignment signs • Install signage reminding drivers to yield to bicyclists and pedestrians when turning • Restrict left and right turns on red at signalized intersections • Install leading pedestrian intervals (LPI) at signalized intersections • Install curb ramps and curb extensions* • Restrict right and left turns on red • Install red light running cameras • Install green conflict paint at key intersections and high-volume driveways • Install bike boxes at intersections (if bicycle lanes are provided) • Convert dual turn lanes to single turn lanes
Drivers disregarding the traffic signal	• Improve signal visibility (may include supplemental signal heads, larger lenses, backplates, etc.) • Install red light running cameras

CASE STUDY 2: Lockhaven Drive at River Road

The intersection at Lockhaven Drive and River Road is a wide, skewed intersection of two urban principal arterial roadways. This location is in a high-traffic commercial area. On most intersection approaches, there are separate left and right turn lanes with no sight distance limitations for any movement. Each approach has marked pedestrian crossings. The intersection's westbound approach has a channelized right turn with a separate signal head.

- 31 total crashes, no fatalities or serious injuries, none involving a bicyclist or pedestrian
- 78% of crashes were rear ends
- 32% of crashes occurred in dark conditions
- 45% of crashes involved vehicles traveling southbound on River Road, and 39% of crashes involved vehicles heading northbound on River Road
- The primary contributing factors were drivers failing to avoid the vehicle ahead and careless driving.

FIGURE 8. LOCKHAVEN DRIVE AT RIVER ROAD

Safety Improvement Considerations

The following table summarizes the key crash patterns identified in this case study, as well as the toolbox of potential safety treatments that could be considered to address similar challenges at this or other locations. The application of safety treatments requires a site specific evaluation to determine feasibility. The potential safety treatments listed below have not been evaluated for feasibility at this specific location. Treatments noted with an asterisk (*) are already present at this case study location.

SAFETY CHALLENGES	TREATMENTS THAT MAY ADDRESS THESE CHALLENGES
Conflicts between through vehicles approaching intersections (rear end crashes)	• Improve signal visibility (may include supplemental signal heads, larger lenses, backplates, etc.) • Install advanced intersection warning signs • Install advanced dilemma zone detection • Modify corridor signal timing and progression • Improve visibility of pavement markings and signs
Crashes at night (dark, dawn, or dusk lighting conditions)	• Upgrade or install intersection and segment lighting* • Upgrade to high-visibility signs and markings • Install raised or recessed pavement markers (RPMs)

HIGH CRASH LOCATIONS

The locations examined in the following two case studies were chosen as high-crash locations in the entire SKATS region based on the overall number and concentration of crashes.

CASE STUDY 1: Lancaster Drive Segment (Sunnyview Road to Market Street)

This segment of Lancaster Drive is a five-lane road with a two-way left turn lane median as well as right and left turn lanes at the Sunnyview Road and Market Street intersections. Lancaster Drive is classified as an urban principal arterial. The segment is in a busy commercial area. There are sidewalks and bike lanes on both shoulders, with green bicycle conflict striping on the northbound approach to Lancaster Drive & Sunnyview Road and the southbound approach to Lancaster Drive & Market Street. There is a high density of driveways and intersections that provide access to a variety of retail and commercial uses along the segment.

- 245 total crashes, 5 resulting in serious injury (no fatalities)
- 43% of all crashes were turning movement, with twice as many left turning crashes as right turning crashes
- Approximately half of the turning movement crashes occurred at driveways and half occurred at intersections
- 40% of all crashes were rear ends
- 20% of all crashes occurred in dark, dawn, or dusk conditions
- 2% of all crashes involved pedestrians; none resulted in fatal or serious injury
- No bicycle-involved crashes
- Most common contributing factor was failure to yield

FIGURE 9. LANCASTER DRIVE

Safety Improvement Considerations

The following table summarizes the key crash patterns identified in this case study, as well as the toolbox of potential safety treatments that could be considered to address similar challenges at this or other locations. The application of safety treatments requires a site specific evaluation to determine feasibility. The potential safety treatments listed below have not been evaluated for feasibility at this specific location. Treatments noted with an asterisk (*) are already present at this case study location.

SAFETY CHALLENGES	TREATMENTS THAT MAY ADDRESS THESE CHALLENGES
Conflicts between through traffic and turning vehicles (includes driveways and intersections)	• Install left-turn lanes at key intersections* • Provide protected left-turn phasing at signalized intersections* • Install intersection warning signs • Install raised medians to restrict turning movements • Implement access management strategies (e.g., consolidate or remove driveways, restrict turning movements at driveways, and redesign driveways and intersections to reduce vehicle speeds when turning)
Conflicts between through vehicles approaching intersections and driveways (rear end crashes)	• Improve signal visibility (may include supplemental signal heads, larger lenses, backplates, etc.) • Install advanced intersection warning signs • Install advanced dilemma zone detection • Modify corridor signal timing and progression • Improve visibility of pavement markings and signs
Crashes at night (dark, dusk, or dawn lighting conditions)	• Upgrade or install intersection and segment lighting • Upgrade to high-visibility signs and markings • Install raised or recessed pavement markers (RPMs)

CASE STUDY 2: Lancaster Drive at Silverton Road

The intersection of Lancaster Drive at Silverton Road is a wide intersection with six or more lanes (including through and turn lanes) on each approach. Ther are bicycle lanes and sidewalks on all approaches. Both Lancaster Drive and Silverton Road are classified as urban principal arterial roadways. Land use around the intersection is primarily commercial and retail. There is a raised center median separating opposing traffic on all approaches.

FIGURE 10. SILVERTON ROAD AT LANCASTER DRIVE

- 66 total crashes, no fatal or serious injury
- 61% of crashes were rear ends, evenly split among all approaches
- 29% of crashes involved turning movements (roughly 50% more left-turns than right-turns)
- The most common contributing factor was a driver failure to avoid the vehicle ahead
- 31% of crashes occurred during dark, dawn, or dusk conditions
- No bicycle or pedestrian-involved crashes, but 4 crashes were attributed to an "indirect pedestrian" where a driver traveling straight stopped or slowed for a pedestrian and was rear-ended by another vehicle. These crashes may involve pedestrians that have not finished crossing the street when vehicles receive a green indication, or pedestrians that are crossing near the intersection outside of the crosswalk.

Safety Improvement Considerations

The following table summarizes the key crash patterns identified in this case study, as well as the toolbox of potential safety treatments that could be considered to address similar challenges at this or other locations. The application of safety treatments requires a site specific evaluation to determine feasibility. The potential safety treatments listed below have not been evaluated for feasibility at this specific location. Treatments noted with an asterisk (*) are already present at this case study location.

SAFETY CHALLENGES	TREATMENTS THAT MAY ADDRESS THESE CHALLENGES
Conflicts between through vehicles approaching intersections (rear end crashes)	• Improve signal visibility (may include supplemental signal heads, larger lenses, backplates, etc.) * • Install advanced intersection warning signs • Install advanced dilemma zone detection • Modify corridor signal timing and progression • Improve visibility of pavement markings and signs
Conflicts between through traffic and turning vehicles	• Restrict right and left turns on red • Provide protected left-turn phasing at signalized intersections*

SAFETY CHALLENGES	TREATMENTS THAT MAY ADDRESS THESE CHALLENGES
	• Improve visibility of pavement markings and lane assignment signs
Indirect pedestrian conflicts	• Extend the walk time for pedestrian crossings • Install passive pedestrian detection to dynamically extend the pedestrian phase when pedestrians are in the crosswalk
Crashes at night (dark, dusk, or dawn lighting conditions)	• Upgrade or install intersection and segment lighting • Upgrade to high-visibility signs and markings • Install raised or recessed pavement markers (RPMs)

SYSTEMIC CRASH PATTERNS

Systemic crash trends are those that are repeatedly contributing to fatal and serious injury crashes in the SKATS region. These trends often highlight underlying risk factors that can be treated by implementing low-cost safety solutions on a broad scale. The following four systemic trends were identified using a combination of crash data and input gathered during the first round of public engagement. The systemic trends are listed below and described in the following sections.

1. Pedestrian Crashes in Dark/Dusk/Dawn Conditions on Road Segments
2. Fixed Object Crashes on Two-Lane Roads
3. Head-On Crashes on Urban Arterials
4. Left Turn Crashes on Urban Arterials

SYSTEMIC TREND #1

PEDESTRIAN CRASHES IN DARK/DUSK/DAWN CONDITIONS ON ROAD SEGMENTS

From 2017 to 2021, there were 74 total fatal and serious injury crashes involving pedestrians. 43% of these crashes occurred at intersections or driveways, while 57% occurred on road segments at non-intersection locations. Most of these occurred on straight segments rather than on a curve or grade. Most fatal and serious injury crashes on segments (62%) occurred on urban arterial roadways. About half occurred on two-lane roads, and half occurred on roads with four or more lanes.

In addition, 57% of pedestrian-involved crashes occurred in dark, dusk, or dawn conditions. Nearly all of the nighttime non-intersection pedestrian crashes involved a pedestrian crossing the roadway in-between intersections. Other commonly reported contributing factors included drivers failing to yield to pedestrians and "pedestrian not visible."

Percent of all severity SKATS crashes: 0.5%

Percent of fatal and serious injury SKATS crashes: 4.7%

Solutions

- *Safer People*: Create an educational campaign to encourage safe driver behavior (e.g., not speeding, driving impaired, distracted, or drowsy, etc.), increased awareness of pedestrians, and legal requirements to stop for pedestrians (in Oregon)
- *Safer People*: Create an educational campaign to encourage safe pedestrian behavior, (e.g., obeying traffic control devices, crossing at intersections or designated crossing locations, wearing reflective clothing at night, etc.)
- *Safer Speeds*: Implement traffic calming measures such as speed humps, lane narrowing, or medians to encourage lower speeds on segments
- *Safer Speeds*: Implement speed enforcement campaigns
- *Safer Speeds*: Install speed feedback signs
- *Safer Roads*: Ensure all sidewalks are present and in good condition
- *Safer Roads*: Improve segment lighting

- *Safer Roads*: Install enhanced mid-block crosswalks and lighting at locations that connect to key destinations such as multi-family housing, schools, grocery or convenience stores, and transit stops
- *Safer Roads*: Enhance existing crosswalks at midblock locations (such as Portland Road near Wayside Terrace) with flashing beacons or RRFBs
- *Safer Vehicles*: In-vehicle technology for collision avoidance
- *Safer Vehicles*: Improved vehicle design to minimize forces on vulnerable road users

SYSTEMIC TREND #2

FIXED OBJECT CRASHES ON TWO-LANE ROADS

Fixed object crashes occur when a single vehicle collides with a fixed object such as a curb, utility pole, or median. From 2017 to 2021, there were 91 total fixed object crashes that resulted in fatal or serious injury. Most crashes involved vehicles striking a curb, tree, or ditch, with a handful of others. 38 out of these 91 crashes (42%) involved alcohol or drug impairment.

The majority of fixed object crashes resulting in fatal or serious injury (58 out of 91 or 64%) occurred on two-lane roads. Road characteristic was evenly split between curved roads and straight roads, with one crash occurring on a bridge and two crashes occurring on a grade. Risky behaviors were common in these crashes, as 41% involved speeding, 38% involved alcohol or drug impairment.

Percent of all SKATS crashes: 4.5%

Percent of fatal and serious injury SKATS crashes: 10.1%

Solutions

- *Safer People*: Create an educational campaign targeting prevention of risky driver behaviors such as speeding, impaired driving, distracted driving, and drowsy driving
- *Safer Speeds*: Implement traffic calming measures such as speed humps, lane narrowing, or medians to encourage lower speeds on segments
- *Safer Speeds*: Implement speed enforcement campaigns
- *Safer Speeds*: Install speed feedback signs
- *Safer Roads*: Install shoulder treatments such as rumble strips, post mounted delineators, or wider shoulders to reduce the risk of roadway departure
- *Safer Roads*: Remove, relocate, or shield roadside fixed objects
- *Safer Vehicles*: In-vehicle technology for lane-keeping and collision avoidance
- *Safer Vehicles*: Improved vehicle design for occupant protection

SYSTEMIC TREND #3

HEAD-ON CRASHES ON URBAN ARTERIALS

From 2017 to 2021, there were 99 total head-on crashes, with 39 resulting in fatal or serious injury. Various crash characteristics including lighting conditions, roadway characteristics, driver errors, speeding, and impaired driving were examined. 38% of the 39 crashes occurred in dark or dark-lit conditions. 46% of crashes involved speeding, and 26% involved alcohol or drug impairment. All except one crash occurred on a roadway with no median. About 75% of these crashes occurred on two-lane roadways, with the remaining crashes taking place on roadways with four or more lanes. Although posted speed was not coded consistently in the crash reports, it is likely that most roadways had a posted speed of 35 mph or higher due to their functional classification.

Most head-on crashes that resulted in fatal or serious injury occurred on urban minor arterial or urban principal arterial streets (62%). On urban arterial streets, a high percentage of crashes occurred in dark or dark conditions (42%) and involved alcohol or drug impairment (33%).

Percent of all SKATS crashes: 0.6%

Percent of fatal and serious injury SKATS crashes: 4.2%

Solutions

- *Safer People*: Create an educational campaign targeting prevention of risky driver behaviors such as speeding, impaired driving, and drowsy driving
- *Safer Roads*: Install centerline treatments such as rumble strips or raised medians to reduce the risk of head-on crashes
- *Safer Roads*: Improve lighting on urban arterial streets
- *Safer Speeds*: Implement traffic calming measures such as lane narrowing or medians to encourage lower speeds on segments
- *Safer Speeds*: Implement speed enforcement campaigns
- *Safer Speeds*: Install speed feedback signs
- *Safer Vehicles*: In-vehicle technology for lane-keeping and collision avoidance

SYSTEMIC TREND #4

LEFT-TURN CRASHES ON URBAN ARTERIALS

From 2017 to 2021, there were 95 total fatal or serious injury crashes involving left turning vehicles at intersections or driveways. Approximately 80% of crashes occurred at intersections (an equal split between signalized and stop-controlled intersections), and 20% occurred at driveways. Approximately 12% of all left-turn crashes involved pedestrians.

The majority of the 95 fatal and serious injury left turn crashes (85%) occurred on urban minor arterial or urban principal arterial streets. Streets with four or more fatal and serious injury crashes include Center Street, Commercial Street, Hawthorne Avenue, Lancaster Drive, and River Road.

Percent of all SKATS crashes: 11.1%

Percent of fatal and serious injury SKATS crashes: 14.1%

Solutions

- *Safer People*: Create an educational campaign targeting prevention of risky driver behaviors such as speeding, impaired driving, and drowsy driving
- *Safer Speeds*: Implement traffic calming measures such as lane narrowing or medians to encourage lower speeds
- *Safer Roads*: Install two-way left turn lanes and turn lanes to reduce conflicts between through and turning (slowed or stopped) vehicles;
- *Safer Roads*: Provide protected left-turn phasing at signalized intersections;
- *Safer Roads*: Prohibit left-turns when pedestrian calls are present at signalized intersections
- *Safer Roads*: Improve visibility of traffic control devices (stop signs, signals, pavement markings, and warning signs)
- *Safer Roads*: Install medians to restrict left-turns at driveways and low-volume public streets

EQUITY CONSIDERATIONS

The Oregon Department of Transportation (ODOT) has developed a statewide social equity index (SEI)[2] that combines eight different demographic and equity metrics into a single score which then feeds into four disparity level categories: High Disparity, Medium-High Disparity, Medium-Low Disparity, and Low Disparity. Crashes within the SKATS region were overlaid with the SEI data to better understand the relationship between equity disparity and crashes[3].

As shown in Table 2, a higher proportion of bicycle and pedestrian crashes than vehicle-only crashes occur in high-disparity areas. Similarly, a lower proportion of bicycle and pedestrian crashes occur in medium-low and low disparity areas than vehicle-only crashes.

TABLE 2. PROPORTION OF CRASHES BY MODE AND SEI LEVEL

SOCIAL EQUITY INDEX (SEI) DISPARITY LEVEL	PROPORTION OF VEHICLE-ONLY CRASHES	PROPORTION OF PEDESTRIAN-INVOVLED CRASHES	PROPORTION OF BICYCLE-INVOVLED CRASHES
HIGH	49.4%	53.9%	59.9%
MEDIUM-HIGH	30.6%	33.8%	29.9%
MEDIUM-LOW	10.2%	5.3%	5.8%
LOW	9.8%	7.0%	4.4%

There are many reasons why crashes involving vulnerable road users (people walking, biking, and rolling) are more likely to occur in areas of higher equity disparity. There is often a higher number of people walking and biking in higher disparity areas because lower income households may not have access to a personal vehicle and rely on walking, biking, and transit to travel. In addition, the roadways that present the highest risks for pedestrians and bicyclists, like multi-lane urban arterials, are often located in areas of higher equity disparity. Figure 5 presents a map of vulnerable road user crashes overlaid on the SEI disparity levels. The combination of high-risk roadway characteristics, high-disparity levels, and concentrations of bicycle and pedestrian crashes are notable on several roadway segments, including Lancaster Drive, Wallace Road, River Road North, Market Street, Portland Road, and Silverton Road.

On a national level, investments in transportation improvements in areas of high disparity have historically been under-funded, especially when compared to the increased occurrence and risk of crashes. In the Salem-Keizer region, many recent transportation investments have focused on implementing multimodal projects in higher disparity areas. SKATS and its member agencies will continue to prioritize safety improvements in these areas, particularly for people walking, biking, and rolling.

[2] SEI Map Online: https://geo.maps.arcgis.com/apps/View/index.html?appid=bbd3d9861fcd40ffa4085d457e4361a7&extent=-124.9708,44.4145,-119.6973,46.2239

[3] If a crash was located on the border of one or more disparity levels, the higher disparity level was selected.

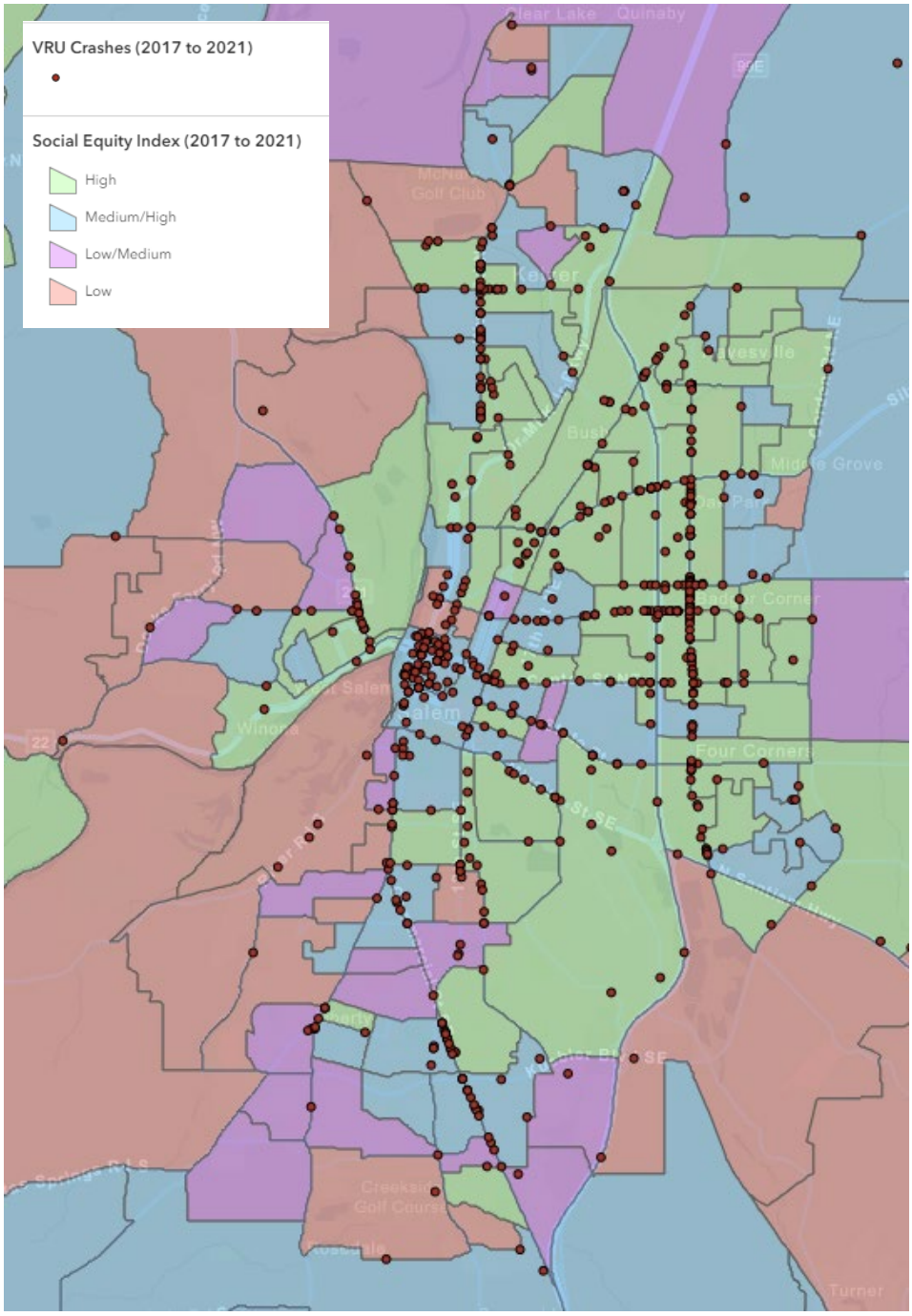

FIGURE 5. MAP OF VULNERABLE ROAD USER (BIKE AND PED) CRASHES RELATIVE TO SEI LEVEL