MARICOPA ASSOCIATION of GOVERNMENTS

2015 STRATEGIC TRANSPORTATION SAFETY PLAN

ZERO DEATHS-INJURIES

October 2015

MARICOPA ASSOCIATION of GOVERNMENTS

P Preface

The Maricopa Association of Governments (MAG) was formed in 1967, and designated the Metropolitan Planning Organization (MPO) for transportation planning in the Phoenix metropolitan area in 1973. The MAG Metropolitan Planning Area (MPA) boundary encompasses the existing urbanized area and the contiguous area expected to become urbanized within a 20-year forecast.

MAG is responsible for the coordination of the regional planning activities including Multi-modal Transportation Planning, the 2035 Regional Transportation Plan (RTP), Air Quality, Wastewater, Solid Waste, Human Services, and Socioeconomic Projections.

The MAG Regional Council is the decision-making body of MAG. The Regional Council consists of elected officials from each member agency, the Chairman of Citizens Transportation Oversight Committee (COTC) and the Maricopa County representatives from the State Transportation Board. The policy and technical committees at MAG, including the MAG Transportation Safety Committee (TSC), develop planning recommendations for review and approval by the Regional Council. The Strategic Transportation Safety Plan (STSP or Plan), documented herein, was approved by the MAG Regional Council on October 28, 2015.

A Acknowledgements

MAG MEMBER AGENCIES

Apache Junction, City of
Arizona Department of Transportation
Avondale, City of
Buckeye, City of
Carefree, City of
Cave Creek, Town of
Chandler, City of
Citizens Transportation Oversight Committee
El Mirage, City of
Florence, Town of
Fort McDowell Yavapai Nation
Fountain Hills, Town of
Gila Bend, Town of
Gila River Indian Community
Gilbert, Town of
Glendale, City of
Goodyear, City of
Guadalupe, Town of
Litchfield Park, City of
Maricopa, City of
Maricopa County
Mesa, City of
Paradise Valley, Town of
Peoria, City of
Phoenix, City of
Pinal County
Queen Creek, Town of
Salt River Pima-Maricopa Indian Community
Scottsdale, City of
Surprise, City of
Tempe, City of
Tolleson, City of
Wickenburg, Town of
Youngtown, Town of

TRANSPORTATION SAFETY STAKEHOLDERS GROUP

Oversight for this project was provided by the MAG **Transportation Safety Stakeholders Group** (TSSG) that consisted of members of the MAG Transportation Safety Committee (TSC), Transit Committee, and Bicycle and Pedestrian Committee and other key stakeholders. A primary objective of the TSSG was to provide a broad view of transportation safety from the standpoints of a wide variety of user groups. They participated in seven project workshops at key points during the project.

The following organizations also served on the TSSG:

AAA, *Driver Education*

AARP, *Retired Persons*

Arizona Department of Health Services, *Health and Human Services*

Arizona Department of Public Safety, *Enforcement*

Cardon Children's Hospital, *Injury Prevention Education*

Driving Arizona LLC, *Driver Education*

Federal Highway Administration, Arizona Division

Governor's Office of Highway Safety, *Arizona Highway Safety Plan*

Valley Metro, *Regional Transit Agency*

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E Executive Summary

This Plan is a comprehensive update of the first Strategic Transportation Safety Plan (STSP) approved by MAG in 2005. The new STSP establishes the regional vision, goals, objectives, strategies, countermeasures, and performance measures for making systematic improvements in transportation safety. It is a data-driven, multi-year comprehensive plan that establishes goals, objectives, and key action areas and integrates the four E's of highway safety – Engineering, Education, Enforcement and Emergency Medical Services (EMS). The development of the STSP was closely coordinated with Arizona's 2014 Strategic Highway Safety Plan (SHSP) that was developed by the Arizona Department of Transportation (ADOT).

The MAG planning area is the most populous urban region of Arizona, resulting in crash patterns that are significantly different than statewide crash patterns. This has resulted in some expected differences between the emphasis areas identified in the state's SHSP and the Action Areas identified in this STSP. Nearly 50 percent of the deaths and nearly 70 percent of all crashes in the state occur in the MAG planning area. The review of historical crash data from 2008 through 2012 revealed that 21 percent of all fatal crashes involve a pedestrian. The MAG planning area has a crash injury rate of 7.77 persons injured per 1,000 population. However, in terms of fatalities, the Phoenix metropolitan area has an 8.75 rate per 100,000 persons, second highest in comparison with other urban regions.

Consensus was reached by the Transportation Safety Stakeholders Group (TSSG) on the following vision statement for all road users: "**Zero Deaths – Zero Injuries**". Working toward this regional vision, the MAG STSP established a regional target to reduce fatalities and serious injuries in the region by <u>three to seven percent in the next five (5) years</u>, from the base year of 2013. This is consistent with the State SHSP target and accounts for some uncertainty, such as possible variation in population/VMT (vehicle miles traveled). An extensive review of crash data by the TSSG resulted in the identification of the following five (5) Action Areas to be incorporated in the MAG STSP:

1. **Eliminate Death and Serious Injury from Impaired Driving**
2. **Eliminate Death and Serious Injury from Speeding and Aggressive Driving Behavior**
3. **Eliminate Death and Serious Injury Related to Intersections**
4. **Eliminate Death and Serious Injury for Vulnerable Road Users – Pedestrians, Bicyclists, and Persons with Disabilities**
5. **Eliminate Death and Serious Injury Involving Young Road Users**

One Action Area was added from the 2005 STSP due to its importance of continuing a data driven approach to transportation safety planning in the MAG region:

6. **Improve Data Collection, Quality, Availability, Integration, and Analysis for Decision Making**

Implementation of the STSP would span a 10-year time frame from MAG fiscal year 2016 to MAG fiscal year 2025 (July 2015 – June 2025). Implementing the strategies proposed will, in some cases, require changes in investment priorities and/or organizational changes. The strategies outlined provide the greatest opportunity of achieving the three to seven percent reduction in fatalities and serious injuries.

The cost to implement this 10-year STSP is estimated at $78 million, at an annual average cost of $7.8 million. The total funds available for road safety improvements from all current funding sources through FY 2018 is estimated at $4.8 million per year, which includes $1.9 million in federal Highway Safety Improvement Program (HSIP) funds suballocated to the MAG region. A new process, effective from FY 2019, for funding road safety improvements using federal HSIP funds was announced by ADOT in May 2015. The state receives nearly $42 million in HSIP annually from the federal government. The STSP recommends a new MAG program that would enable the region secure, sufficient HSIP funds for road safety improvements, possibly to a level that would be commensurate with the magnitude of the road safety problem that is present in the MAG planning area.

To monitor the effectiveness of regional road safety programs and initiatives, MAG will produce an annual Transportation Safety Performance Report that includes: (1) Crash Statistics and Trends; (2) Performance in Comparison to the Safety Target; and (3) Summary of Road Safety Projects & Activities in each Action Area, including their possible impact on road safety performance. This annual report will also include a comparison to highlight how the MAG region's safety improvement projects, programmed utilizing HSIP funding through FY 2018 and beyond, are affecting ADOT's ability to meet the road safety targets and safety performance measure requirements established in MAP-21. The MAG Transportation Safety Committee will continue to provide oversight to programs and projects and will guide these activities throughout the implementation time frame. Regular review of projects and programs that address these strategies will be done under the direction and recommendation of the MAG Transportation Safety Committee. Revisions or enhancements to the programs and projects, including further coordination with ADOT on the process of programming of HSIP funds, will be made throughout the implementation period as they relate to safety performance and toward the target. This STSP will be updated on a five-year cycle.

1 Overview: The STSP Development Process

The process of developing this STSP included the following individual work tasks, participated in and overseen by the TSSG:

1. *Review of Regional Crash Trends and Resources*
2. *Establish Regional Vision and Goals*
3. *Establish Action Areas and Performance Measures*
4. *Review of the Current MAG Network Screening Methodology for Prioritization of Road Safety Needs*
5. *Incorporating Safety in the Regional Transportation Plan*
6. *Develop a Strategy to Incorporate Safety Enhancements in Road Infrastructure Projects*
7. *Improve Safety via Traffic Operations and ITS Solutions*
8. *Monitoring and Reporting on System Performance and Program Effectiveness*
9. *Implementation Plan*
10. **Final Report**

Each task produced a technical memorandum (document links provided above) which were distributed to the TSSG for review and comment and made available on the project webpage which continues to be maintained at *stsp.azmag.gov*. Each of the draft technical memoranda provided input to the development of this plan.

Figure 1 – MAG 2015 STSP Visioning Workshop

In addition, the process included the Visioning Workshop and four TSSG workshop events and two meetings of a Working Group that explored ways to help mainstream road safety considerations within the MPO planning process. The work by this Working Group and its contribution to the development of several new practices is highlighted in the next section.

MAG WORKING GROUP TO INCORPORATE SAFETY INTO THE RTP AND ROAD INFRASTRUCTURE PROJECTS

The establishment of this Working Group was a first of its kind for any MPO in the nation. The Group consisted of members from: Transit, Bicycle and Pedestrian, and Transportation Safety Committees. They identified and ranked practices that can be developed or approved by MAG and member agencies to incorporate explicit safety considerations in future MAG programs and projects. A key objective of this Working Group was to recommend practices that would highlight the importance of multimodal safety, enhance awareness of bicycle and pedestrian safety, and increase the

attention to measures that would improve safer access to transit.

Eight individual practices were identified in break-out groups to address two specific Action Areas: intersections, and vulnerable road users (pedestrians, bicyclists and persons with disabilities). The practices were presented to the Streets, Bicycle and Pedestrians, and Transit committees seeking the approval of each committee to include them as recommended practices in the Plan. One of the recommended practices has already resulted in the modification of the MAG Transportation Improvement Program (TIP) project evaluation criteria. This particular practice would affect all future projects that are programmed in the TIP and as such, those committees who oversee the programming of projects in the TIP were provided an opportunity to review and comment on these practices with a request that they recommend approval of the practices. The practices were recommended by each committee including the Transportation Safety Committee, Intelligent Transportation Systems Committee, Transit Committee, Bicycle and Pedestrian Committee, and Streets Committee. The practices developed and recommended by the Working Group have been incorporated into this Plan as Strategies 3.1, 3.3c, 3.6, 3.8, 4.1, 4.9, 4.10, and 4.13 within Chapter 3, including the practice to:

> **Encourage submittal of TIP projects that include safety elements, for improving safer access for all modes, by including safety as an explicit project evaluation criteria for all TIP projects that currently have evaluation criteria as a means of prioritizing a list of projects. Exceptions to this practice are those Transit Maintenance and Operations programs funded through the MAG TIP.**

COORDINATION WITH THE 2014 ARIZONA SHSP

The preparation of the MAG STSP paralleled the activities of the 2014 Arizona Strategic Highway Safety Plan (SHSP). Future coordination between Arizona's and MAG's plans and programs will primarily occur at the TIP (short-range) level.

The 2014 Arizona SHSP, published at *www.azdot.gov/shsp* on October 29, 2014, is an overarching safety plan for all public roads in Arizona with the new vision of "*Towards Zero Deaths by Reducing Crashes for a Safer Arizona*". Under the SHSP, all highway safety programs in the state can leverage resources to address transportation safety issues. The SHSP identifies the State's key safety needs and guides Highway Safety Improvement Program (HSIP) investment decisions.

Twelve emphasis areas were established for Arizona. These were based on traffic crash characteristics and input from statewide safety stakeholders. Table 1 shows the correlation between the Arizona SHSP Emphasis Areas and the MAG STSP Action Areas. It should be noted that the MAG TSSG chose to use the phrase Action Area as opposed to Emphasis Area. Although the idea is one and the same, Action Area is the reference specific to the MAG Plan, whereas Emphasis Area will be in reference to the State SHSP focus areas for road safety improvements.

Table 1 – Comparison of Arizona Strategic Highway Safety Plan Update Emphasis Areas and MAG STSP Action Areas

Arizona SHSP Emphasis Areas	MAG STSP Action Areas
Speeding & Aggressive Driving	**Eliminate Death and Injury from Speeding and Aggressive Driving Behavior**
Impaired Driving (Alcohol, Illegal Drugs, Medication, Fatigued)	**Eliminate Impaired Driving**
Occupant Protection (Safety Belts, Child Safety Seats, Helmets)	Defer to State SHSP*
Motorcycles	Defer to State SHSP*
Distracted Driving	Defer to State SHSP*
Roadway Infrastructure & Operations Improvement (Lane Departure, Intersections, Rural Roads, Rail Crossings)	**Eliminate Death and Injury Related to Intersections**
Age Related (Younger/Older Drivers)	**Eliminate Death and Injury Involving Young Roadway Users**
Heavy Vehicles/Buses/Transit	Defer to State SHSP*
Non-Motorized Users (Pedestrians, Bicyclists, Transit Users, School Zone Users)	**Eliminate Death and Injury Involving Vulnerable Road Users – Bicyclist, Pedestrians, Persons with Disabilities**
Natural Risks (Weather, Animals)	Defer to State SHSP*
Traffic Incident Management (Secondary Collisions, Work Zones)	Defer to State SHSP*
Interjurisdictional Coordination	Defer to State SHSP*
Arizona Emphasis Area Support	**MAG Action Area Support**
Data Analysis Improvements	**Improve Data Collection, Quality, Availability, Integration, and Analysis for Decision Making**
Policy Initiatives	Defer to State SHSP*

* The MAG planning area is largely urbanized and has a unique set of issues and associated Action Areas that may not align with the State SHSP Emphasis Areas, such as those representing rural areas, or those which may be better emphasized in the State SHSP.

2 State of Road Safety in the MAG Planning Area

An analysis of crash data was performed for the years 2008 through 2012 to demonstrate crash numbers, types and severity prevalent in the MAG planning area. The results of this analysis provide an overview of road safety within MAG. Crash trends and patterns for fatal crashes (K) and serious injury crashes (A) are presented and discussed in Technical Memorandum No. 1.

Crash rates can be an effective tool to measure the relative safety at a particular location. The combination of crash frequency (crashes per year) and vehicle exposure (traffic volumes or miles traveled) results in a crash rate. Crash rates are expressed as "crashes per Million Entering Vehicles" (MEV) for intersection locations and as "crashes per Million Vehicle Miles Traveled" (MVMT) for roadway segments. Some agencies in the MAG planning area have evaluated intersection and/or roadway segment crash rates in their agency transportation plan but many MAG member agencies do not have the resources to provide vehicle exposure data for comprehensive crash rate analysis. No agencies have large quantites of exposure data for pedestrians or bicyclists. There are continuing efforts to improve this data.

The Regional Transportation Safety Information Management System (RTSIMS) software was used to analyze the crash data pertinent to the MAG Metropolitan planning area. The primary source of crash data is the ALISS crash database maintained by the Arizona DOT. RTSIMS Version 1.0 serves as a key analytical tool at MAG for performing transportation safety analysis that is required for safety planning functions at the regional level. Any local agency in the MAG planning area can obtain free access to the software.

REGIONAL TRENDS IN CRASHES THAT INVOLVE FATALITIES AND SERIOUS INJURIES

K and A crashes represent nearly four percent of all crashes reported in the MAG planning area. Following a decline in 2009 and 2010, crashes in 2011 and 2012 increased, as shown in Table 2.

Table 2 – All Crashes, Fatal, and Serious Injury Crashes in the MAG Planning Area

Crashes	2008	2009	2010	2011	2012
Total	80,746	71,305	71,071	74,949	74,421
Serious Injury	2,426	2,280	2,141	2,304	2,239
Fatal	391	334	332	361	356

SAFETY PERFORMANCE DUE TO DRIVER CONDITION AND BEHAVIOR

Driver condition and behavior, including impaired driving, lack of restraint usage, and speeding, appears to influence a majority of crashes. “Impaired driving” in the ADOT SHSP, includes all cases where the physical description of one or more drivers involved in the crash indicated illness, physical impairment, fell asleep/fatigued, alcohol, drugs or medications as reported by the police officer. In the MAG planning area, 20 percent of serious injury crashes involve an impaired driver.

Impaired driving is more likely to result in a fatal crash and is a factor in approximately 44 percent of fatal crashes in the MAG planning area for the study period.

This analysis also reviewed impairment due to alcohol, drugs, or medications on its own. In the MAG planning area, approximately 42 percent and 16 percent of fatal crashes and serious injury crashes, respectively, involve impairment due to alcohol, drugs, or medications.

Other factors due to driver condition and behavior include lack of restraint usage and speeding. A comparison of these factors for fatal and serious crashes in the MAG planning area is provided in Figure 2 and Figure 3 , respectively. Percentages do not add up to 100 percent as there are often multiple factors involved in an individual crash.

Lack of restraint usage is defined as any driver or passenger not using a lap belt, shoulder and lap belt, or child restraint system. Although not required under Arizona law, this category also includes any motorcycle driver or passenger not using a helmet. The lack of restraint use (safety belt or helmet) reported for serious injury and fatal crashes in the MAG planning area are 26 percent and 46 percent, respectively, for the years 2008 through 2012.

"Speeding" in the context of this analysis is based on data entered by the reporting officer as: "speed too fast for condition" or "exceeded lawful speed". The reporting officers' assessments are based on traffic, roadway, and weather conditions at the time of the crash and do not necessarily represent speeds in excess of the posted speed limit. Speeding is a factor in approximately 33 percent of fatal crashes in the MAG planning area. Fatal crashes involving speeding have gone down in the most recent three years compared to the number of crashes in 2008 and 2009. Speeding involved in serious injury and fatal crashes in the MAG planning area are approximately 31 percent and 33 percent, respectively, for the years 2008 through 2012.

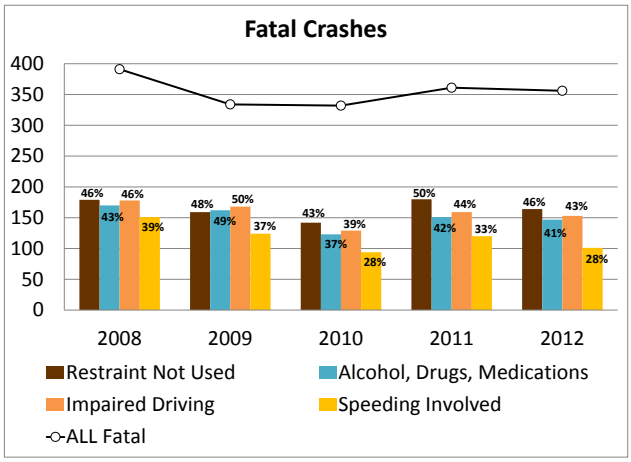


Figure 2 – Fatal Crashes in the MAG Planning Area by Driver Behavior

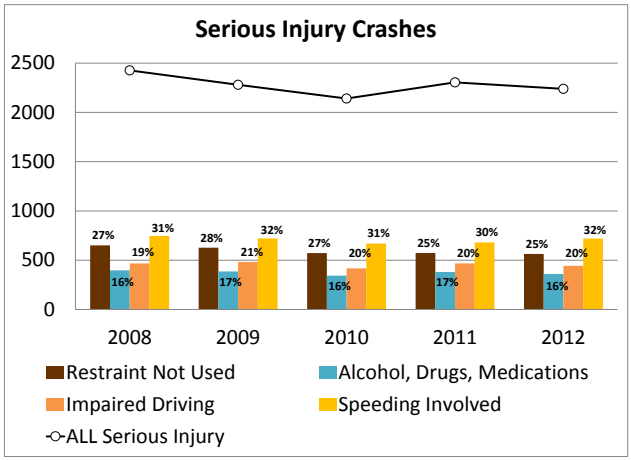


Figure 3 – Serious Injury Crashes in the MAG Planning Area by Driver Behavior

MOTOR VEHICLE CRASHES INVOLVING PEDESTRIANS

Arizona is a Focus state for the FHWA Focus Safety Approach Program in three areas. Phoenix, Tucson, and Mesa are the three cities that qualify Arizona as a Pedestrian Focus State with respect to pedestrian fatalities based on the number of fatal crashes per 100,000 population. Being identified as a focus city or state allows the FHWA the ability to provide additional resources to those agencies to improve pedestrian safety. The review of historical crash data from 2008 through 2012 revealed that 21 percent of all fatal crashes involve a pedestrian. The pedestrian crash statistics by year are shown in Figure 5.

Crashes involving non-motorized road users are not always identified in crash reports or databases. Crashes involving a single bicycle (run-off-road/path or falls), single pedestrian (trip and falls), bicycle-bicycle, or pedestrian-bicycle are not included in the motor vehicle crash database. As a result, it is likely that many crashes involving pedestrians and bicycles are not accurately reported or included in available crash statistics.

Figure 4 – Pedestrians Crossing at Signal

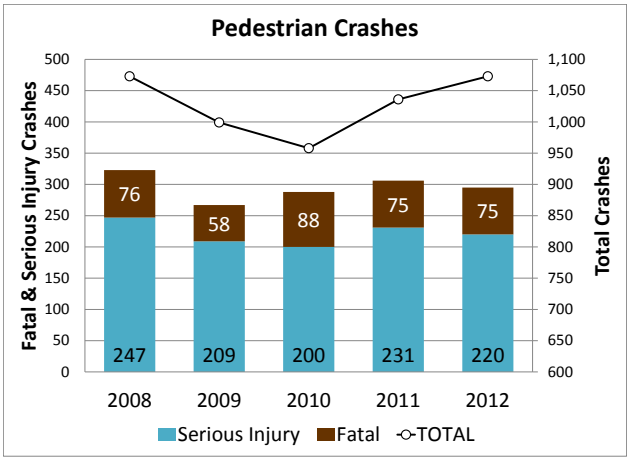


Figure 5 – 2008-2012 Crashes Involving a Pedestrian

SAFETY PERFORMANCE OF THE FREEWAY AND ARTERIAL STREET SYSTEMS

Freeway crashes are those that occur on controlled access, express highways including I-8, I-10, I-17, SR 51, SR 101, SR 143, SR 202, and US 60. The Loop 303 was not a limited access freeway until 2013 and was not included in the analysis. Crashes on state roads with at-grade intersections are included with data for arterial and local roads.

More than 75 percent of crashes on freeways are either single vehicle or rear end collisions as depicted in Figure 6.

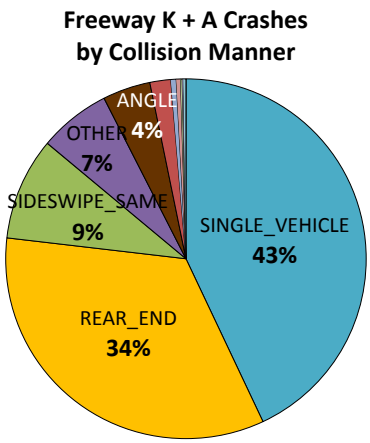


Figure 6 – 2008-2012 Fatal and Serious Injury Crashes in the MAG Planning Area on Freeways by Collision Manner

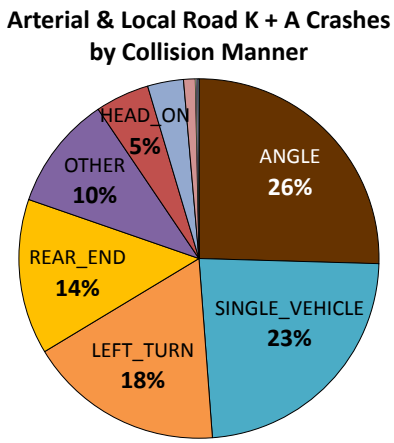


Figure 8 – 2008-2012 Fatal and Serious Injury Crashes in the MAG Planning Area on Arterials and Local Roads by Collision Manner

Fatal (K) and serious injury (A) crashes on arterial and local roads appear to follow a downward trend (Figure 7) resulting in a five-year reduction in K and A crashes of eight percent from 2008 to 2012. A chart indicating K and A crashes by collision manner is provided in Figure 8.

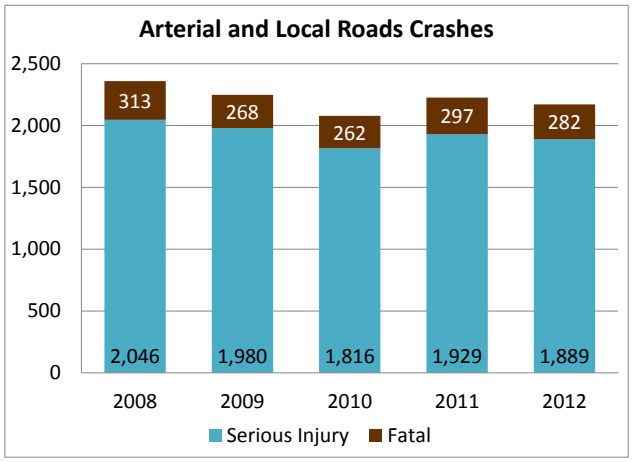


Figure 7 – 2008-2012 Fatal and Serious Injury Crashes in the MAG Planning Area on Arterials and Local Roads

The ADOT Highway Performance Monitoring System Daily Vehicle Miles of Travel (VMT) for Maricopa County compared to K and A crashes in the MAG region is shown in Figure 9 and Figure 10.

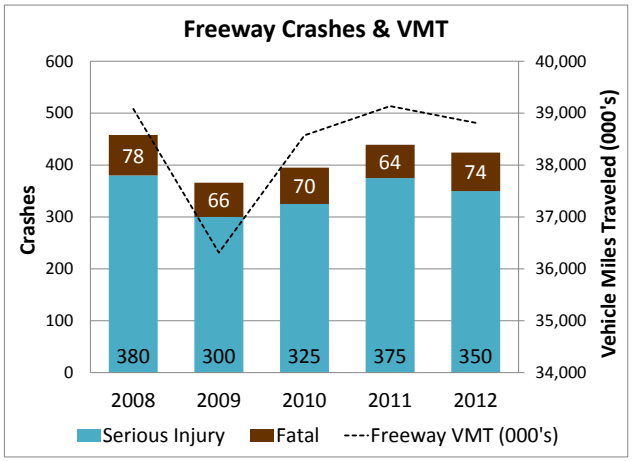


Figure 9 – Freeway Fatal and Serious Injury Crashes in the MAG Planning Area Compared to Maricopa County VMT

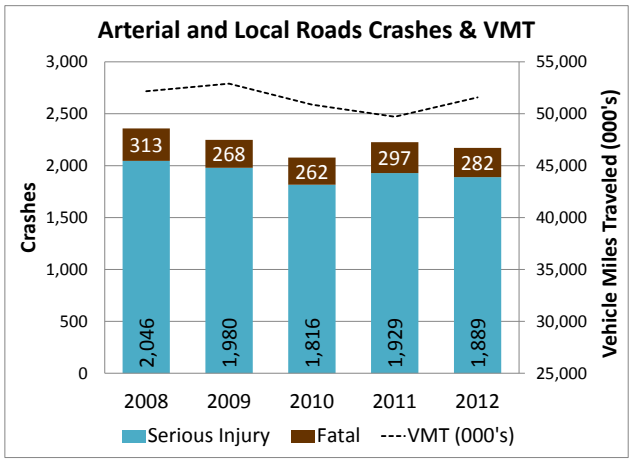


Figure 10 – Arterial and Local Road Fatal and Serious Injury Crashes in the MAG Planning Area Compared to Maricopa County VMT

COMPARISON OF THE MAG PLANNING AREA TO STATE OF ARIZONA

Nearly 70 percent of all crashes in the state of Arizona occur in the MAG region as depicted in Figure 11. Approximately half of fatal crashes in the state occur in the MAG planning area as depicted in Figure 12.

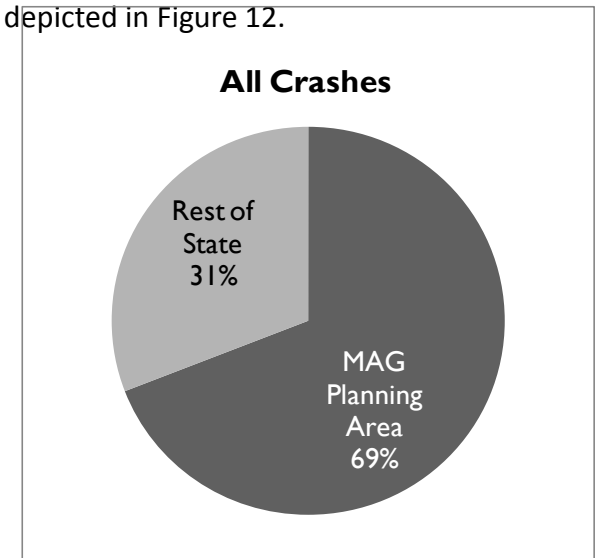


Figure 11 – 2008-2012 Total Crash Comparison of MAG Planning Area to State

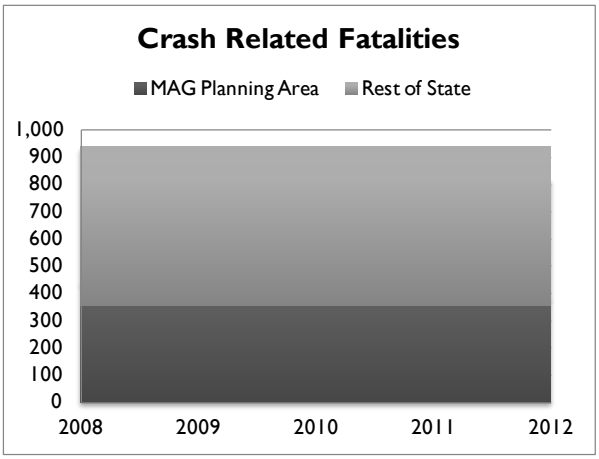


Figure 12 – 2008-2012 Fatality Comparison of MAG Planning Area to State

SAFETY PERFORMANCE OF THE MAG PLANNING AREA

"Crash Trees" for fatal and serious injury crashes in the MAG planning area are provided in Figure 13 and Figure 14. They are a tool to help identify and select the facility types and roadway and traffic characteristics of the locations where target crash types occur most frequently.

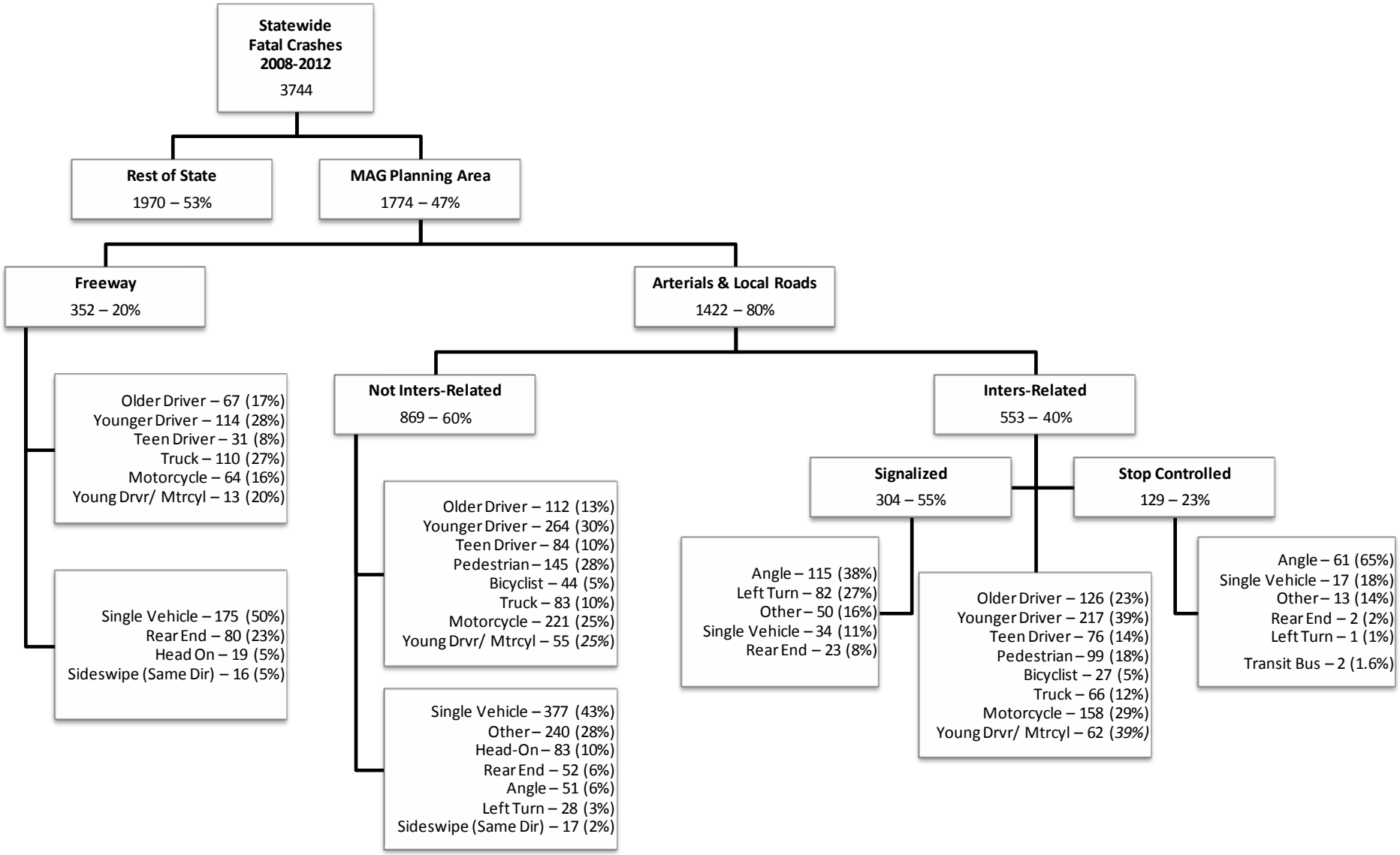


Figure 13 – Crash Tree of Fatal Crashes in the MAG Planning Area for 2008 – 2012 (Note: Lower blocks on this chart depict crash attributes that may not be mutually exclusive)

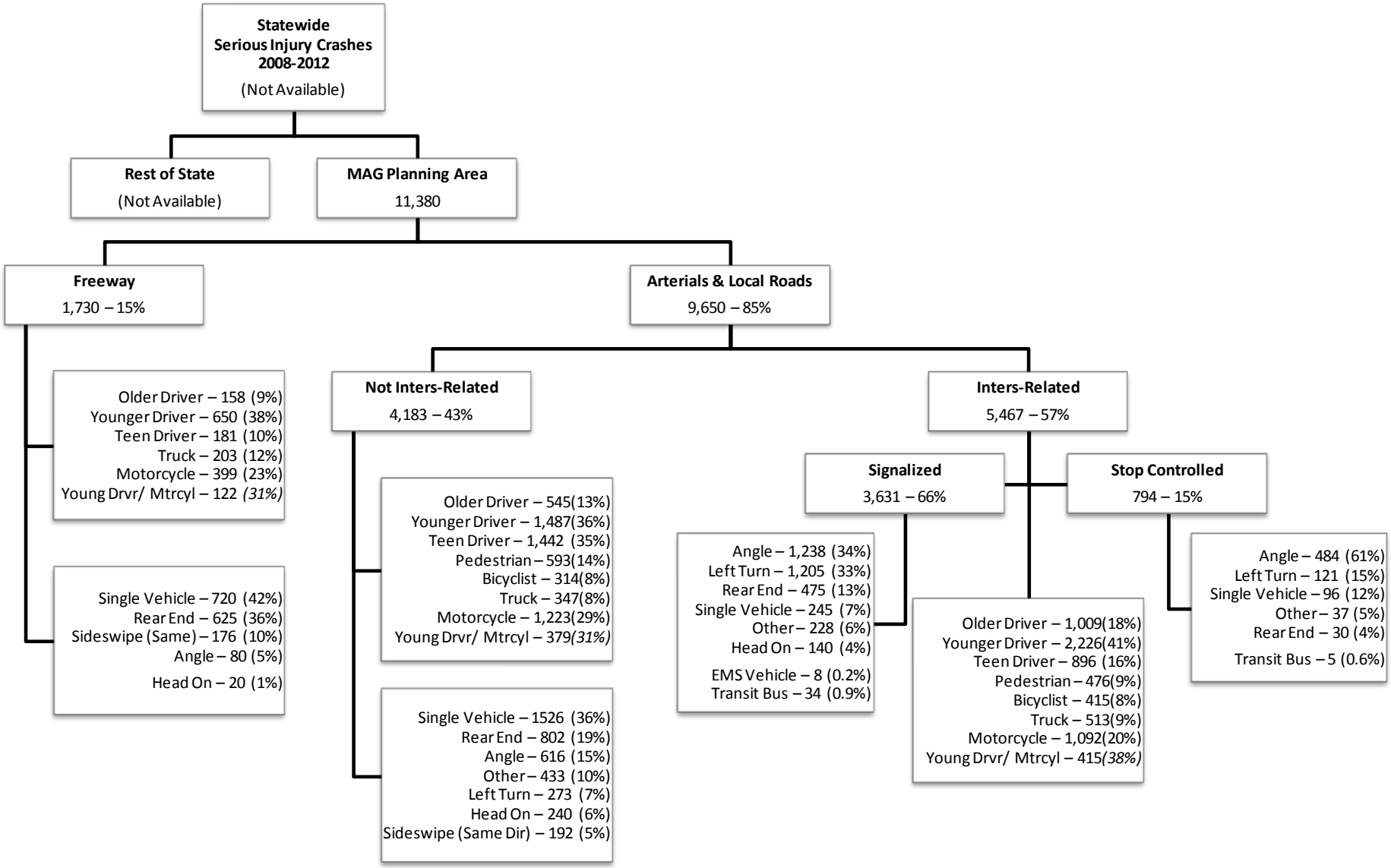


Figure 14 – Crash Tree of Serious Injury Crashes in the MAG Planning Area for 2008 – 2012 (Note: Lower blocks on this chart depict crash attributes that may not be mutually exclusive)

COMPARISON OF THE MAG PLANNING AREA TO OTHER SELECTED URBAN REGIONS

The Figure 15, on the following page, compares the MAG region's road fatality, injury rates based on population, and average annual HSIP dollars spent, to other similar urban regions. These comparisons are based on data included in "Crashes vs. Congestion – What's the Cost to Society" report prepared for AAA by Cambridge Systematics, Inc. in November 2011. The information provided in Figure 15 on Average Annual HSIP dollars ($) Spent in millions (M) in is based on total amount of HSIP dollars spent in each MPO/COG urban region. Other funding sources, in addition to HSIP funds, are often used to implement road safety improvements in the MAG region and other urban regions. However, this comparison was done simply to show what each urban region spends in HSIP dollars as the one common funding source. This information was obtained from each regional planning organization's TIP listing and state STIP listings available on the corresponding agency websites. The regions selected for comparison were Dallas, Denver, Houston, Las Vegas, Los Angeles, Sacramento, Salt Lake City, San Diego, and Seattle.

Note that the injury rate is per 1000 persons and the fatality rate is per 100,000 persons. This was done to provide conveniently-expressed rates. The population-based rate of fatalities is significantly lower than the rate of serious injuries. In addition, the Salt Lake City region did not have direct information on HSIP spending specific to that urban region and this is notated by *ND for "no data" available.

The MAG region has an injury rate of 7.77 injuries per 1000 population. Figure 15 reveals that this rate places it near the middle of the urban regions, is similar to rates found in the Seattle urban region, and slightly less than rates found in Dallas, Salt Lake City and Houston urban regions.

However, in terms of fatalities, the Phoenix urban region has the second highest rate of 8.75 fatalities per 100,000 population. The rate exceeds that of a group consisting of the Dallas, Las Vegas, San Diego and Sacramento urban regions and is only lower than the Houston urban region, which has the highest rate of fatalities per population (10 per 100,000 persons).

The average annual HSIP comparison for the Denver urban region, based on available information, indicated their HSIP spending is the second highest at $16.7M. Alternately, the Houston and Las Vegas urban regions available information indicated the lower end of about $4.5M. The Phoenix urban region falls in the middle of this comparison at just under $10M.

This comparison indicates that there is much room for improvement in the Phoenix region in terms of reducing both fatalities and injuries.

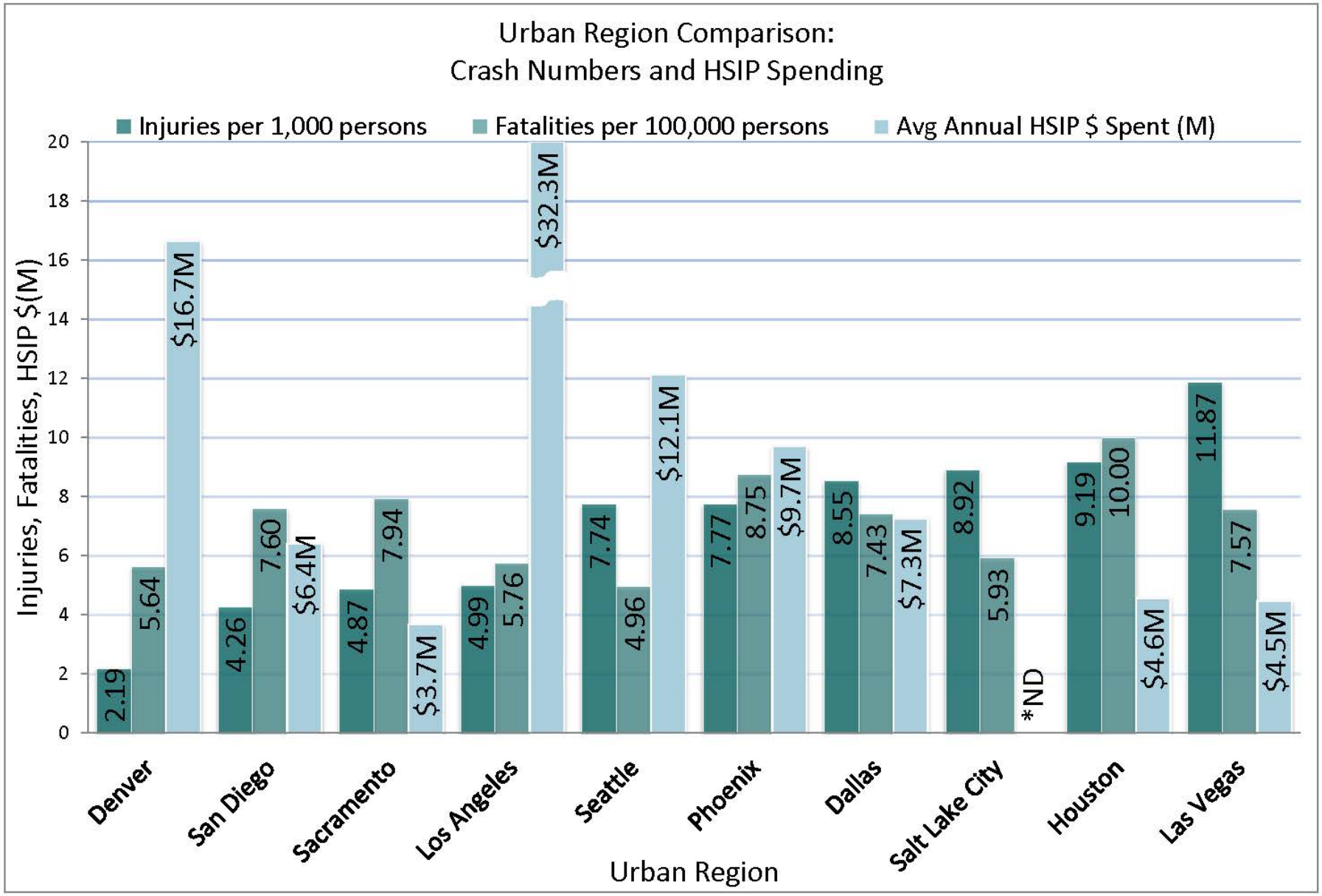


Figure 15 – Injuries per 1,000 Persons, Fatalities per 100,000 Persons in Select Urban Regions, Source: *What's the Cost to Society* prepared for AAA by Cambridge Systematics, Inc., November 2011, and HSIP Spending ($M)

3 Regional Strategies & Practices for Transportation Safety

This chapter provides the background and intent of the 47 MAG STSP strategies and practices recommended for reducing the number and severity of traffic crashes within the MAG planning area. Although noted in Chapter 1, those noteworthy strategies that are being addressed in the State's SHSP are omitted in this Chapter. The numbering of the strategies described in the following pages refers to the Implementation Plan Matrix in Table 4. The numbering scheme indicates the Action Area number before the decimal and then a number for each strategy under that action area after the decimal. Example: 1.1 is strategy number 1 under Action Area 1.0.

1.0 Eliminate Death and Serious Injury from Impaired Driving

In the MAG planning area, approximately 42 percent of fatal crashes and approximately 16 percent of serious injury crashes involve impairment due to alcohol, drugs, or medications.

Figure 16 – No Drinking and Driving Symbol; Source: www.glogster.com

1.1 Implement wrong-way detection systems to reduce wrong-way crashes on freeways.

Vehicles that utilize exit ramps by entering in the wrong direction present one of the most serious traffic hazards on the national highway system. This typically occurs when the errant driver is impaired or confused.

In Arizona, an average of 30 wrong-way crashes occur yearly with approximately 11 of those crashes resulting in fatalities. According to Arizona Department of Public Safety (DPS), there are approximately 25 wrong-way calls a month throughout the state. Of those calls, 90 percent do not result in crashes. During the first six months of 2014 in Arizona, six wrong-way crashes have left eight people dead and nine severely injured.

ADOT is aggressively trying to identify a resolution for this problem and has on-going research efforts of wrong-way detection systems to reduce wrong-way crashes on the Phoenix Freeway Management System. The intent of this strategy is to work with ADOT to implement detection systems region wide.

1.2 Conduct high visibility DUI saturation patrols.

Saturation patrols are currently conducted in the MAG planning area, which GOHS has assisted with funding DUI saturation patrols and the purchase of DUI processing vans. A more widespread application of this type of enforcement patrol is recommended. This strategy will encourage local agencies to

conduct more of these patrols for which this funding source may be able to provide additional funding.

1.3 Develop materials for educating target groups for impaired driving including mass-media campaigns on DUI dangers and penalties.

Arizona has some of the toughest DUI laws in the country with some of the harshest penalties. Crashes involving impaired drivers are more likely to result in high severity or fatalities. Currently, the GOHS has a strong campaign against impaired driving and supports a DUI Abatement Council, and "Know Your Limit program." More materials and strategies are needed to educate the high risk portions of the community, most notably younger drivers, and identify the most effective means to get this information out to those individuals through social marketing and community intervention. Agencies that can assist in the development and distribution effort include MVD, AAA, AARP and other civic organizations.

2.0 Eliminate Death and Serious Injury from Speeding and Aggressive Driving

"Speeding" in the context of this report is based on data entered by the reporting officer as: "speed too fast for condition" or "exceeded lawful speed". Speeding involved in fatal and serious injury crashes in the MAG planning area account for 33 percent and 31 percent, respectively, for the years 2008 through 2012. There is also a strong relationship between speeding/aggressive driving and red-light running.

Aggressive driving is defined as a progression of unlawful driving actions such as: exceeding the posted limit or driving too fast for conditions; improper or excessive lane changing: failing to signal intent, failing to see that movement can be made safely, or improper passing; or improper passing -- failing to signal intent, using an emergency lane to pass, or passing on the shoulder.

NCHRP Report 500 states that "*Because the topic of aggressive driving is a relatively new one, and because arriving at an operational definition has not been easy, there is a lack of data available about the nature of crashes involving aggressive driving. Although some crash reports provide for indication of driver-contributing circumstances, such categories do not allow one to identify all truly aggressive driving actions.*"

2.1 Support and encourage the implementation of infrastructure-based ITS technologies that show promise for reducing fatalities and serious injuries.

MAG is currently developing a study that will guide long-term regional investments in the area of system management and operations on freeways and arterials. Infrastructure-based technology such as transit signal priority, adaptive traffic signal control, expansion of Closed Circuit Television (CCTV) capabilities, expansion of communication networks, and use

of arterial Dynamic Message Signs (DMS) is not well established in the MAG planning area. Active Traffic Management (adaptive ramp metering, dynamic lane use control, dynamic merge control, dynamic shoulder lanes, dynamic speed limits, and queue warning) does not currently exist. Providing real-time, accurate communications to drivers gives them actionable information that improves speed harmonization and their ability to make better decisions about their travel routes and times of travel. The implementation of infrastructure-based technologies that show promise for reducing fatalities and serious injuries is supported and encouraged. These technologies include the use of driver speed feedback signs, real-time driver information, and changeable speed limits signs.

2.2 Administer projects that develop ICM strategies for handling incident diversions from freeways onto City arterials to address secondary crashes.

MAG currently organizes multi-agency efforts to develop Integrated Corridor Management (ICM) strategies for handling incident diversions from freeways onto City arterials. These strategies employ the use of traffic signal operations (special incident timing plans), trailblazing signs, freeway and arterial CCTV and coordinated efforts with the ADOT Freeway Management System. Some local agencies have special timing plans that can be implemented in the event of a special event or incident. Greater coordination is needed between ADOT, Maricopa County Department of Transportation (MCDOT) and local agencies for detecting nonrecurring incidents and implementing special event timing plans.

2.3 Develop best practice guidelines for use of automated enforcement to improve safety.

One of the most documented successes with speed-related strategies is the use of automated speed enforcement, which has a direct impact on compliance and the overall improvement of operations. DPS removed automated speed enforcement from Arizona freeways in lieu of traditional speed enforcement. Some agencies in the MAG planning area currently utilize automated red light and speed enforcement, but there is no central guidance on when and where to best deploy automated enforcement techniques (either fixed or mobile assets), who should operate the automated system, and how the contracts should be structured to be manageable for the local agency, while being fair and responsive to the public to address high crash/severity locations. Automated enforcement should not be used for generating revenue, but should be used to supplement traditional enforcement and only for the goal of improving overall roadway safety, and founded on crash data and speed analyses performed by the agency's road safety and traffic engineering staff.

As specified in section 1533 of MAP-21, HSIP funds may not be used for any program to purchase, operate, or maintain an automated

traffic enforcement system. However, HSIP funds may be used for automated traffic enforcement systems used to improve safety in school zones. Automated traffic enforcement systems may be eligible for other Federal-aid funding and local funding.

2.4 Utilize automated enforcement where appropriate to address speeding.

Support local initiatives of MAG member agencies and ADOT to:

- Conduct (or expand the use of) automated speed enforcement. This highly effective countermeasure can be deployed at permanent locations, such as signalized intersections and school zones, or at temporary locations using mobile speed vans.
- Implement (or expand the use of) automated red light and/or speed enforcement at high crash intersections. This highly effective countermeasure is typically a permanent installation, but the cameras may be rotated to different high crash locations from time to time as crash patterns change.

The intent of this strategy would be to utilize the product resulting from Strategy 2.3 to encourage effective and proper use for the only goal of improving overall roadway safety.

As detailed in Section 260 of the ADOT Traffic Engineering Policies, Guidelines, and Procedures, "*ARS 28-1206 requires a city of town desiring to install [or wanting to renew a permit for] a photo enforcement system for speed violations on a roadway owned or operated by the State to provide ADOT with sufficient information for ADOT to determine that the photo enforcement system is necessary for public safety*".

2.5 Conduct enforcement in all work zones and increase enforcement in school zones.

Ensuring the safety of both motorists and workers in roadway work zones has long been a stated goal of essentially all road agencies and road contractors nationwide. Safety of children walking to and from school receives a very high level of attention throughout the country as well as in the MAG planning area. Some local agencies have implemented automated enforcement programs that focus largely or entirely on schools zones and other school related crossings. Often contractors in work zones are required to employ off-duty officers for traffic control, but these officers do not conduct enforcement. Enforcement techniques can either be traditional or automated and may be used with dynamic speed limit systems associated with active work zones or school zones. Added enforcement in both types of zones would help protect vulnerable road users and reduce high risk crashes, and would be supported by the public.

3.0 Eliminate Death and Serious Injury Related to Intersections

Arizona has been identified by FHWA as a Focus State for Intersection as well as Lane Departure

crashes. This Action Area focuses on strategies related to intersections. Strategies to eliminate death and serious injury related to Lane Departure crashes are not identified in this MAG STSP as it is mostly a rural road safety issue and, as noted in Table 1, are deferred to and better emphasized in the Arizona SHSP. However, due to the recent expansion of the MAG planning area to include agencies with predominantly rural conditions, Lane Departure and other strategies specified as deferred to the State SHSP will also be supported by MAG as a priority for rural communities demonstrating a predominance of these crash types.

Intersections constitute only a small part of the overall roadway system, yet intersection-related crashes constitute 31 percent of all fatal crashes in the MAG planning area. A brief summary of 2008-2012 fatal crash data for the MAG planning area indicates that:

- 17 percent of all fatal crashes occurred at signalized intersections,
    - 55 percent of fatal crashes at intersections occurred at signalized intersections,
- Nine percent of all fatal crashes occurred at STOP-controlled intersections,
    - 23 percent of fatal crashes at intersections occurred at STOP-controlled intersections.

Good geometric design combined with good traffic control can result in an intersection that operates efficiently and safely according to NCHRP 500 Volume 12: A Guide for Reducing Collisions at Signalized Intersections. In addition, it has been recognized that strategies that encourage safety enhancements in all phases of the development of intersection improvement projects will be a key component in reducing fatalities and serious injury crashes region wide.

3.1 Encourage submittal of TIP projects that include safety elements, for improving safer access for all modes, by including safety as explicit project evaluation criteria for all TIP projects that currently have evaluation criteria as a means of prioritizing a list of projects. Exceptions to this practice are those Transit Maintenance and Operations programs funded through the MAG TIP.

This has the support of MAG technical committees that evaluate projects that are incorporated into the TIP. MAG staff, with oversight by the Safety Committee, has developed Safety Evaluation Criteria including guidelines for scoring projects. The actual safety scoring will be done by individual modal committees as part of their normal TIP project review process.

3.2 Identify new practices or standards that integrate safety into planning and design.

The greatest opportunity for safety benefits tend to occur in the planning and design stages of a project. Changes to improve the safety performance of a facility are typically easier to implement in these early stages. Once a design

has progressed into construction, these changes can become more difficult, costly and time-consuming. In addition, safety assessment reviews conducted at the early stages of a project offer greater flexibility for incorporating more large-scale improvements that may offer maximum safety benefit.

One method of integrating safety as a performance measure is to use methods developed in the American Association of State Highway and Transportation Officials (AASHTO) Highway Safety Manual (HSM). The predictive methods in the HSM provide the ability to quantify the anticipated safety performance for each alternative in terms of its anticipated crash frequency and severity. Training is needed for local agencies to use this tool to assess projects.

3.3 Enhance the MAG Road Safety Assessment (RSA) Program:

3.3.1 Refine RSA location nominating criteria:

Priority (1) - High crash risk locations

Priority (2) - Locations where there are known high volumes of bicyclists and pedestrians.

MAG Network Screening Methodology for Intersections is used to develop the Top 100 list of high crash risk intersection locations annually.

Similarly, MAG would develop a network screening methodology to rank locations with high exposure for bicyclists and pedestrians. Example locations with large volumes of people walking and biking include transit stops, transit stations, event venues, central business districts, and intersections of roadways and multi-use paths. There is limited exposure data for pedestrians or bicyclists with continuing efforts to improve this data. MAG conducted its first region-wide bicycle count in 2013 and bicycle counts are also being collected through the MAG RSA program.

Any other location with a transportation safety concern may also be nominated based on input from MAG Transportation Safety Committee members.

Figure 17 – Road Safety Assessment Meeting

3.3.2 Conduct safety assessment reviews during the design phase.

The project development process includes all engineering, construction, and administrative functions required to advance a highway transportation project from conception through design and construction and into operation and maintenance of the project. The process is accomplished through a systematic interdisciplinary approach involving many stakeholders including local, state and federal

agencies. The goal of performing formal safety assessment reviews is to promote safety using a more systemic and substantive safety process in addition to relying on design standards/guidelines that provide a nominal level of safety. Design standards provide a consistent, predictable roadway environment, but may not necessarily result in the desired level of safety for a particular roadway environment.

The existing MAG RSA program has recently been expanded to include formal safety assessment reviews of proposed improvements during the 15 percent design phase as part of Project Assessment document development.

Additionally, local agencies could request the formal safety assessment review for proposed improvements within their agency, independent of the project's funding source. It is also feasible to develop a simple and understandable safety assessment process guide or template that could be used by local agencies to review private developer as well as local agency projects. This guide or template could be considered for use by MAG and local agencies for design level RSAs conducted in the MAG region.

Ideally, formal safety assessment reviews would also be conducted during the 60 percent design phase. At this stage the design plans would have sufficient details for the Safety Assessment Review Team (SART) to perform a comprehensive safety evaluation while still being able to incorporate revisions, if necessary, without costly and time-consuming plan changes. The safety review would be conducted by a multi-disciplinary team independent of the project. Safety assessment review after the scoping phase would need to be promoted from the State or local agency level. A framework for integrating safety into roadway design and a recommended strategy for facilitating the introduction of "safety assessment review" in the project development process are included in Technical Memorandum No. 6.

3.3.3 Develop a Bicyclist Safety Assessment (BSA) program that focuses on bicyclist safety countermeasures at high risk intersections of roadways and bike paths.

The BSA program could be incorporated into the existing MAG RSA program and possibly be expanded for high exposure intersections as the bicycle counts and RSA programs increase the amount of data available. BSAs could be accomplished in conjunction with the State Bicycle Safety Committee and ADOT bike coordinator.

Countermeasures could include a leading bicycle phase to coincide with a leading pedestrian phase; bicyclist signals; continuous bike lanes through intersections, minimum green times at signals to accommodate bicyclists, and bicycle detectors/sensors.

3.4 Prioritize Improvements based on screening for high crash risk intersections.

Network screening enables an agency to systemically assess locations where there are opportunities for safety improvements. The existing network screening methodology for intersections used by MAG should be enhanced and it would be desirable to adopt a comprehensive method for performing network screening for locations to better identify those intersections or segments that would benefit most from safety improvements. The current Network Screening Methodology for Intersections (NSM-I) technique provides a well-constructed procedure for overcoming many of the known limitations associated with intersection network screening methods. The creation of a composite Intersection Safety Score (ISS) is a very useful approach for an overall network screening evaluation. MAG has recently made enhancements to the existing NSM with the support of the TSC and based on recommendations provided in Technical Memorandum No. 4.

3.5 Implement systemic improvements based on identifying characteristics of high risk intersections.

It is the intent of this strategy to work with local agencies to identify safety deficiencies and implement appropriate treatments at similar intersections (such as lighting or countdown pedestrian signals, etc.) This can be done for similar high-risk intersections, for intersections along one or more high risk corridors, or area-wide across an agency or the entire MAG planning area. The prioritization of the high risk intersections or intersection features can assist in developing funding priorities.

3.6 Develop Complete Streets Implementation Guidelines that integrate safety analysis and design throughout the planning process.

A MAG Complete Streets guide was published in 2011, and some MAG member agencies have developed and adopted Complete Streets policies or ordinances for roadway design and operation. The intent would be to outline what kind of corridors would be good candidates for these practices from a safety perspective with consideration of connecting or abutting conditions as well as how complete streets policies are implemented/enforced, and incorporating known safety countermeasures into Complete Street projects.

3.7 Prepare a "best practices" guide for design of pedestrian and bicycle accommodations at roundabouts.

The installation of roundabouts is one of the nine proven safety countermeasures being promoted by the FHWA. The 2010 edition of the FHWA Roundabout Information Guide is published as NCHRP Report 672. Other reports include:

- NCHRP Report 572: Roundabouts in the United States (2007),
- NCHRP Report 674: Crossing Solutions at Roundabouts and Channelized Turn

Lanes for Pedestrians with Vision Disabilities (2011), and

- Pedestrian Access to Roundabouts: Assessment of Motorists' Yielding to Visually Impaired Pedestrians and Potential Treatments To Improve Access, FHWA-HRT-05-080, (2006).

The intent would be to provide designers with guidance on infrastructure that has the greatest potential to reduce the risk of fatal and serious injury crashes at roundabouts involving bicyclists and pedestrians, especially for those pedestrians that are visually impaired. This guide would incorporate the proposed Guidelines for Pedestrian Facilities in the Public Right-of-way (PROWAG) that is expected to be adopted in the near future, and could provide guidance on improving safety at existing roundabouts.

3.8 Prepare technical resource that summarizes and documents regional and national research on effectiveness of safety countermeasures for all E's.

This is already being done at the national level but could be done through a MAG project at a regional level as more safety countermeasures are implemented that can reflect local conditions and practices. As of now, only the systemic countermeasures that have been installed through HSIP can be documented. A more comprehensive program would need to be defined to align determination of safety countermeasures with what is being implemented regionally and national standards.

The following references may be useful:

- Safety in Geometric Design Standards (Hauer, 1999),
- A Case for Evidence Based Road-Safety Delivery (Hauer, 2007),
- TRB Special Report 300 - Achieving Traffic Safety Goals in the United States: Lessons from other Nations (Morris, 2011),
- SWOV Institute for Road Safety Research Fact Sheets, Netherland, and
- Young Drivers: The Road to Safety (OECD 2006).

3.9 Conduct targeted enforcement of high crash risk intersections.

Support initiatives of MAG member agencies and ADOT to conduct red light and/or speed enforcement at high crash intersections. The enforcement should target the types of violations that lead to the largest number of fatal and serious injury crashes, and locations with high numbers of severe crashes should experience periodic enforcement. This can be accomplished with automated or traditional forms of enforcement.

3.10 Utilize automated enforcement at high crash risk intersections where appropriate.

See Strategy 2.4

3.11 Partner with local professional societies to hold an annual workshop to educate roadway designers on safety tools available to assess and improve substantive safety.

These would be accomplished in conjunction with FHWA and ADOT via their Local Public Agency Manual (for federally funded projects) or local agencies incorporating safety into the scope for roadway design projects. Using this process would require public agency or private consultant roadway designers to learn about assessing and improving substantive safety.

3.12 Develop and distribute educational materials related to intersection safety.

Support and work with ADOT, MAG member agencies, and other organizations such as AAA, AARP, GOHS, MADD, etc., to develop and distribute educational materials to improve the safety of all types of road users. Materials can include videos, radio PSAs, print materials, social media, and information on agency websites, among others. Additional intersection safety information can also be added to the Arizona Driver License Manual, and the Arizona Commercial Driver Manual.

3.13 Perform comprehensive review of current EVP practices and develop a recommended practice for the region to follow.

Currently, Emergency Vehicle Preemption (EVP) is installed at a number of signal-controlled intersections throughout the MAG planning area that are independently controlled and operated by individual jurisdictions. Because the EVP equipment may be purchased from different vendors, if operated in a "coded" (or closed) system, the EVP will not respond to emergency responders using a different system. This is an issue particularly along agency borders since the emergency responders do not typically recognize borders. Another issue is with individuals illegally purchasing transponders that will activate the EVP if operated in an "open" system.

MAG is currently conducting a study to perform a comprehensive review of the current EVP practices within the MAG region and across the country, to determine the best practices, and to develop a recommended practice for the region to follow. The EVP study will outline the best practices, including analysis of the practices in terms of benefits in safety, emergency response time, mobility and other measures of effectiveness.

4.0 Eliminate Death and Serious Injury for Vulnerable Road Users – Pedestrians, Bicyclists, and Persons with Disabilities

During 2008 through 2012, 21 percent of all traffic fatalities and nearly 10 percent of all serious injuries in the MAG planning area were pedestrians. Bicyclists comprised approximately 4 percent of traffic fatalities and nearly 7 percent of serious injuries during that same time. More than 65 percent of statewide bicycle and pedestrian injuries from crashes occur in the MAG planning area. More than

half of pedestrian fatalities from crashes occur in the MAG planning area. A brief summary of the 2008-2012 crash data involving a pedestrian or bicyclist in the MAG planning area is listed below:

- 59 percent of serious injury and fatal pedestrian crashes occur at mid-block locations and 41 percent occur at intersections
- 15 to 19-year old pedestrians are involved in the most pedestrian and bicycle crashes (followed by those in the 20 to 24, and 10 to 14-year old age groups, respectively)
- For the nighttime hours of 7 PM to 6 AM, 42 percent of pedestrian crashes are fatal and serious injury
- Pedestrians over 60 are more likely to sustain serious injuries or die from a crash
- 55 percent of serious injury and fatal bicyclist crashes occur at intersections
- bicyclist crashes peak at 7 AM and 4 PM
- for the nighttime hours of 7 PM to 6 AM, fatal and serious injury crashes for bicyclists represent 19 percent of all bicyclist crashes

An emerging issue with pedestrian safety is cell phone and electronic devices used as a source of distraction, not only for motorists, but for pedestrians. Another issue with respect to pedestrians is the wide streets and often the high speeds and long distances between controlled crossing points within the MAG planning area. Multiple-threat crashes (which occur on multilane streets) tend to have higher severity. Intersection crashes more often involves turning traffic.

4.1 Encourage submittal of TIP projects that include safety elements, for improving safer access for all modes, by including safety as an explicit project evaluation criteria for all TIP projects that currently have evaluation criteria as a means of prioritizing a list of projects. Exceptions to this practice are those Transit Maintenance and Operations programs funded through the MAG TIP.

See Strategy 3.1.

4.2 Promote practices that ensure safety and multimodal connectivity in planning and design.

Figure 18 – Pedestrian Alighting at Bus Stop in Phoenix, Arizona

This strategy aims to support initiatives between MAG member agencies and Valley Metro to work cooperatively to ensure that there is full connectivity between modes, primarily bus transit, rail, pedestrians, and bicyclists that provides accessible accommodations and avoids or minimizes exposure to high risk crossings by pedestrians or bicyclists.

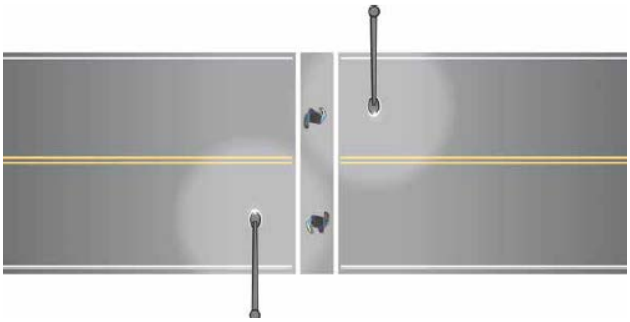
4.3 Promote and administer Safe Routes to School framework studies to identify school traffic issues and produce walking and biking route maps through the MAG TA non-infrastructure program

In July 2012, Congress passed a transportation bill: Moving Ahead for Progress in the 21st Century (MAP-21), which modified the original 2005 National SRTS legislation. Beginning in October 2012, SRTS activities were eligible to compete for funding under the Transportation Alternatives Program (TAP). MAG, local agencies, and school officials have worked cooperatively to develop Safe Routes to School (SRTS) studies for the development of School Walking and Bicycling Maps, as well as the development of other Non-Engineering programs (Education, Encouragement and Enforcement) for schools serving students in grades K – 8. The school walking and bicycling maps will help promote more walking and biking to schools by identifying and prioritizing safety enhancements needed in school areas.

4.4 Identify high risk locations for potential implementation of enhanced pedestrian crossings that would have a favorable benefit/cost ratio.

Support local initiatives to review and evaluate high risk crossing locations and identify improvement projects using a Benefit-Cost Ratio (B/C) that exceed 1.5, thereby showing a positive financial benefit to the safety project. Guidance and assistance can be provided to local agencies in evaluating the benefits of pedestrian and bicycle safety projects using Crash Reduction Factors (CRFs) that have high 'star ratings' contained in the CMF Clearinghouse. An example of this could include providing upgraded lighting at these locations as shown in Figure 19 below.

Traditional midblock crossing lighting layout



New midblock crosswalk lighting layout

Figure 19 – Traditional and Recommended Street Light Placement for Crosswalks; Source: 2012 FHWA Lighting Handbook

4.5 Install Pedestrian Hybrid Beacons (HAWKs).

The installation and use of Pedestrian Hybrid Beacons (formerly called the HAWK) is one of the nine proven safety countermeasures being promoted by the FHWA. This special pedestrian crossing device was developed in Arizona and adopted in the 2009 Manual on Uniform Traffic Control Devices (MUTCD). Local initiatives that result in the installation of enhanced crossings for pedestrians and

bicyclists should be supported. These initiatives include Pedestrian Hybrid Beacons (PHBs), as well as Pedestrian User Friendly Intelligent Intersection (PUFFIN) detectors, and devices that are not yet in the MUTCD, such as Rectangular Rapid-Flash Beacons (RRFBs), and BikeHAWKs.

4.6 Install medians and pedestrian crossing islands.

The installation of medians and crossing islands in urban and suburban areas is one of the nine proven safety countermeasures being promoted by the FHWA. Local initiatives should be supported that assist member agencies to identify where it is feasible and desirable to install continuous raised median islands or pedestrian crossing islands at individual crossing locations to help facilitate safe pedestrian and bicycle crossings along arterial streets and select wide collector streets.

Figure 20 – Raised Median with Two-Stage Island on Van Buren Street west of 32nd Avenue in Phoenix, Arizona

4.7 Provide bicycle detection at signalized intersections.

Bicyclists are permitted to ride on all public streets within the MAG planning area (except interstate freeways); therefore, all traffic signals should be designed to accommodate bicycle traffic. The intent of this strategy is to support initiatives by MAG member agencies to implement technologies that will provide for the convenient actuation or the accurate automated detection of bicyclists at all traffic signal approaches or movements where signal actuation is required.

In addition, local agencies would be encouraged to implement minimum green times at traffic signals to accommodate bicycles at all fixed time or actuated signals. A supplemental activity of this strategy would be to compile useful information on bicyclist detection, volume, and minimum green times for use by local agencies.

Figure 21 – Bicycle Detector Pavement Marking; Source: MUTCD Figure 9C-7

4.8 Develop Complete Streets Implementation Guidelines that integrate safety analysis and design throughout the planning process.

See Strategy 3.6.

4.9 Prepare a "best practices" guide for high risk intersections and high exposure bicycle and pedestrian crossing nodes employing safety countermeasures.

Safety countermeasures provide consistent traffic signal detection and operations for pedestrians and bicyclists and installation of enhanced crossing treatments (such as improved lighting, shorter crossings, median treatments, widened crosswalks for pedestrians and bicyclists, bulb outs, ladder-style or higher visibility crosswalk markings and consideration of enhanced traffic control devices such as PHBs, RRFBs, advance signing or pavement markings, or two-stage crossings.)

Figure 22 – Pedestrian Hybrid Beacon (PHB aka HAWK) Treatment in Phoenix, Arizona

Consideration should be given to methods for collecting, storing, and analyzing bicycle and pedestrian volume data over time in order to better identify high exposure crossings and better understand the relationship between the number of crashes and various levels of exposure. Methods of collecting volume data are already part of the MAG RSA Program and other MAG modal planning efforts in order to address these considerations.

4.10 Develop short-range action program oriented to 1) high transit activity stops and 2) new routes that would enhance transit stop safety.

The intent of this program would be to employ the checklist from the MAG Designing Accessible Communities and tie it to the Valley Metro Service Standards. This would be heavily reliant on the support of RPTA as the administrators of the Public Transportation Funds and agreement with local agencies and towns who own the facilities.

4.11 Decrease wrong-way riding and traffic control violations by bicyclists.

Arizona law (ARS 28-812) requires bicyclists riding in the street or on the adjoining shoulder to follow the laws that pertain to motor vehicle traffic (where appropriate) which includes riding in the same direction as motor vehicles and obeying all traffic control devices. Member agencies should be encouraged to develop bicyclist education and enforcement programs to promote safe riding practices and compliance with state laws and local ordinances. Education should begin with elementary school children and should continue with adults and senior citizens. Education is also needed for police on bicycle laws and violations that lead to high severity crashes, as well as the importance of enforcement. MAG should also support local initiatives for the implementation of

appropriate traffic control measures where repeated wrong-way bicycling is detected in the street.

4.12 Produce a white paper on wrong way bicycle crashes and model ordinances to prevent crashes.

Arizona law (ARS 28-812) requires bicyclists riding in the street or on the adjoining shoulder to follow the laws that pertain to motor vehicle traffic (where appropriate) which includes riding in the same direction as motor vehicles. There is no such state law governing bicycles on sidewalks, but some local jurisdictions, such as Tempe, have adopted an ordinance that require bicyclists on sidewalks to ride in the same direction as motorists in the adjacent travel lanes. The unexpected wrong-way bicyclist movement on sidewalks, in bike lanes or elsewhere in the street results in crashes that can be quite serious. A study should be initiated to evaluate the extent of this type of crash problem in the MAG planning area, and explore ways that jurisdictions across the country have dealt with this issue through legislation, education, engineering, and enforcement to provide guidance for member agencies.

4.13 Develop on-going training and public information bicycle and pedestrian safety campaigns.

Campaigns would focus on multiple audiences, e.g. elementary schools, MVD, AAA, bicyclists, motorists, police, engineers, planners, teachers, health care industry, etc., and include all types of media (video, printed media, special instruction, radio PSAs, social media and information on agency websites.) GOHS funding could be used for this training and information campaign. Pedestrian safety education should not be limited to pedestrians, but include educational efforts directed at motorists, engineers, police and teachers.

4.14 Share best practices among regional stakeholders on best safety practices for getting to and from school; including developing recommended walk or bike to school routes for all schools in the region and administration of SRTS programs.

ADOT produces and maintains Traffic Safety for School Areas Guidelines 2006 (with input from local agencies statewide) and serves as the lead agency for school traffic control guidelines. MAG should partner with ADOT and member agencies to promote the exchange of best practices among member agencies, schools, identify best practices used by agencies across the country that represent model SRTS programs and practices, including School Walking and Bicycling Maps, and expand SRTS programs throughout the planning area. School and local officials need to learn how to best work together to promote SRTS programs and the implementation of plans that support all four E's (Engineering, Education, Encouragement and Enforcement). This can be done through a MAG sponsored SRTS workshop or conference and through continued educational efforts to promote a cooperative exchange of ideas. It should be noted that

some MAG member agencies are nationwide leaders in developing and implementing SRTS programs and MAG is a leader in crossing guard training.

4.15 Support a regional training program for school crossing guards.

The regional training in cooperation with GOHS and AAA to provide crossing guard training opportunities and materials (videos, PSAs, printed materials, information on agency websites) for school crossing guards within the MAG region should continue. These efforts should continue to encourage proper crossing techniques, the use of appropriate safety vests, equipment, and other safety apparel, and the proper placement and removal of portable signs at 15 mph school crossings. School officials should be encouraged to require that all of their guards undergo periodic training, including substitute guards. Safety professionals at MAG member agencies should be encouraged to work with local schools to facilitate additional training if desired.

Figure 23 – Brandon Forrey, City of Peoria, providing crossing guard training

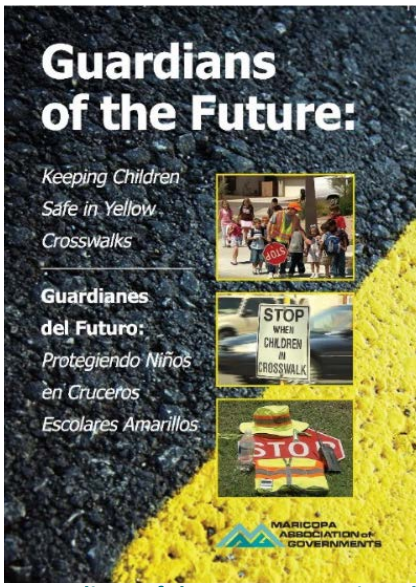


Figure 24 – Guardians of the Future: *Keeping Children Safe in Yellow Crosswalks* video; Source: MAG

4.16 Explore and release a smartphone application to educate vulnerable users.

Explore the possibility to partner with Valley Metro and ASU to develop and release a smart phone application that would educate vulnerable road users on the dangers of walking or riding while being distracted, especially when travelling to or from transit. An application that combined humorous animation and a catchy song was developed to reduce accidents on the Melbourne Metro train system. The rail agency reported a 30 percent in collisions or near misses between vehicles and pedestrians at level crossings after the implementation of the Melbourne Metro phone application.

5.0 Eliminate Death and Serious Injury Involving Young Road Users

Inexperience and immaturity combine to make young drivers especially at-risk in five circumstances: at night; after drinking alcohol; with passengers; when unbelted; and when using cell phones. A brief summary of the 2008-2012 crash data for the MAG planning area involving young drivers (age 25 or younger) is listed below.

- 28 percent of fatal freeway crashes
- 30 percent of fatal non-intersection related crashes on arterials and local roads
- 39 percent of fatal intersection related crashes on arterials and local roads
- 38 percent of serious injury freeway crashes
- 36 percent of serious injury non-intersection related crashes on arterials and local roads
- 41 percent of serious injury intersection related crashes on arterials and local roads

5.1 Identify best practices for promoting or implementing Safe Driving pledge campaigns.

Support initiatives and work with MAG member agencies, along with GOHS, MADD, AAA and other insurance companies or civic organizations to implement local safe driving programs within communities for young drivers and their families, and to encourage communities to adopt local safe driving campaigns. This information can be made available on the MAG website for member agencies and area schools to use.

5.2 Explore methods of educating young road users through Mass-media campaigns.

Support and work with ADOT, MAG member agencies, and other organizations such as AAA, GOHS, MADD, insurance companies and civic organizations to develop and distribute education materials to improve the safety of all types of road users, specifically those directed at young drivers (ages 16 to 25). Materials can include videos, radio PSAs, print materials and information on agency websites, among others. Once developed, these materials can be made available to member agencies and area schools on the MAG website.

5.3 Partner with ADOT, Valley Metro, and other organizations to deploy distracted driver safety awareness campaigns.

According to a 1973 USDOT report, 'Human Factors', including driver and pedestrian distractions, are commonly identified as the probable cause in more than 90 percent of traffic accidents. In response, this strategy is to partner with ADOT, Valley Metro, AAA, other insurance companies, health agencies, other civic organizations along with member agencies to educate motorists, bicyclists and pedestrians on hazards of driving or walking while distracted by electronic devices or by other means. Materials can include videos, radio PSAs, print materials, social media, and information on agency websites, among others.

Once developed, these materials can be made available to member agencies and area schools on the MAG website. Local police should be encouraged to assist with educational efforts and conduct enforcement of distracted-driving related violations.

Figure 25 – Distracted Driver

6.0 Support Action Area – Improve Data Collection, Quality, Availability, Integration, and Analysis for Decision Making

This Support Action Area is carried over from the 2005 STSP as an on-going priority of transportation safety planning in the MAG region. It is not possible to have a high quality data-driven plan without accurate, timely and comprehensive data available for the analysis and decision-making process.

6.1 Enhance the existing network screening methodology for intersections and segments

Enhancing the existing network screen methodology for intersections and adopting a comprehensive method for performing network screening for segment locations would better identify those intersections or segments that would benefit most from safety improvements. Recommendations include exploring a network screening procedure for use in the MAG region to identify potential locations for improving safety. Some modifications were recommended for the existing MAG network screening methodology for intersections. These network screening modifications were approved by the TSC at their December 9, 2014 meeting. Other recommendations address guidelines for screening roadway segments largely based on HSM techniques.

6.2 Enhance the Regional Transportation Safety Information Management System

Software tools such as the MAG RTSIMS software can be enhanced to enable an agency to have all crash data, for a specified period (e.g. three years), to identify and prioritize locations for road safety improvement.

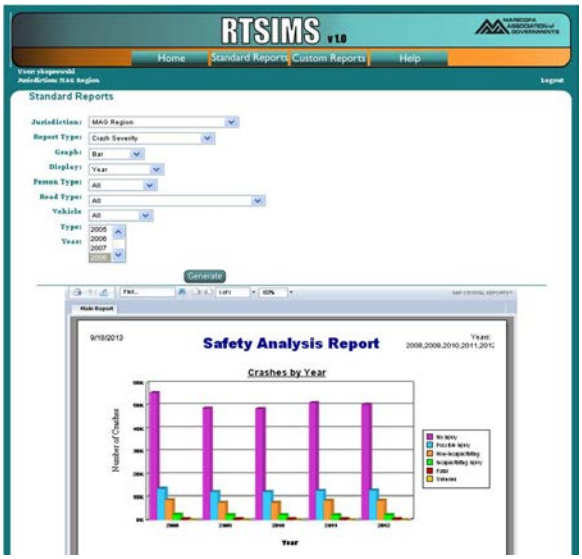


Figure 26 – Regional Transportation Safety Information Management System (RTSIMS) Screenshot; Source: MAG

6.3 Develop or purchase a comprehensive safety assessment tool based on HSM methodologies.

Application of evidence-based, data-driven and scientific tools and techniques require a break from the traditional approach of providing nominal safety through compliance with standards and standard practices and an embracing of the concept of substantive safety. This change in approach is being adopted in an evolutionary manner, and requires more analysis and data than simple reliance on standards. Change typically comes slowly, and adoption of new safety analysis tools is no exception. Many agencies and transportation professionals are beginning to use these techniques to improve roadway safety. Local agencies are developing tools based on HSM techniques to automatically compare similar intersections and roadway segments for network screening purposes that provide a more rigorous comparison than crash frequency or rates. These tools also permit efficient evaluation and comparison of design alternatives based on safety.

A comprehensive safety assessment tool would enhance the ability to more accurately identify and prioritize locations having the highest priority for safety improvements. The tool must be user-friendly and have the ability to present results that are easily understandable for MAG and local agency staff. Full or partial funding of the software or other tool used by local agencies could be provided if it is purchased for the entire planning area.

6.4 Develop a tool to conduct benefit-cost analyses and calculate Crash Modification Factors (CMFs).

The Florida Department of Transportation uses the Crash Reduction Analysis Safety Hub (CRASH) program for this purpose. The intent of this tool is to identify and prioritize project locations for safety improvements based on the benefit-cost analysis. Crash data before and after a project is implemented would provide the basis for calculating CMFs specific to the region. CMFs are generally calculated based on multiple projects in which the same types of project improvements were applied. CRFs could be developed, that do not currently exist, for improvements such as implementation of adaptive signal control technology. Project data could be entered from the TIP for use by local agencies. Local agencies could also choose to submit their locally funded projects for B/C evaluation based on safety improvement.

6.5 Develop local calibration factors for existing national HSM SPFs specific to the MAG planning area.

An initial step toward improved safety assessments and applying safety analysis techniques is to identify essential data needs and develop a strategy for enhanced roadway data collection. Many of the evolving safety procedures can be incrementally applied over time. Systematically developing safety analysis techniques can assist with what may initially seem a challenging task.

Recent enhancements to safety assessment techniques have resulted in evidence-based and data-driven statistical procedures known as safety performance functions (SPFs). The AASHTO Highway Safety Manual (HSM) includes nationally derived SPFs for a variety of segment and intersection locations. These SPFs, in concert with companion crash modification factors (CMFs), act as tools for predicting crash performance for various highway types and associated characteristics. Because road and driver characteristics can vary between regions and since regional environmental and enforcement issues may also contribute to local safety conditions, the SPFs should be calibrated for the MAG planning area prior to establishing or adopting the use of regional SPFs. It would be optimal for the MAG partners to develop a strategy to systematically calibrate existing SPFs and develop MAG-specific SPFs for facilities.

Until that time when the ability and resources are available to perform these refinements, procedures can still be used to develop relative values for safety evaluations (i.e. may not be able to confidently predict 12 crashes for alternative A and 22 for alternative B, but could definitely determine that alternative A would have fewer crashes than alternative B). This type of incremental analysis process will ultimately lead to robust safety assessments and a culture of safety throughout the agency's procedures, discussions, and decisions.

4 Implementation Plan FY2016 – FY2025

STRATEGIES

The Implementation Plan Matrix, provided in Table 4 on the following pages, organizes the 2015 MAG STSP Action Areas, strategies, and corresponding lead agencies, planning level unit costs, return on investment, and implementation time frame.

All annual safety programs that resulted from the 2005 MAG STSP will be continued. Most of the new strategies can be considered a promotion or enhancement of strategies identified in the 2005 MAG STSP. Three of the proposed strategies are new:

1.1 Implement wrong-way detection systems to reduce wrong-way crashes on freeways.

2.1 Support and encourage the implementation of infrastructure-based ITS technologies that show promise for reducing fatalities and serious injuries.

2.3 Develop best practice guidelines for use of automated enforcement to improve safety.

INVESTMENT REQUIREMENTS

The need to improve road safety is prominently identified in the MAP-21 legislation. National performance goals for federal highway programs were set and the safety goal was at the top of the list:

> *"Safety – To achieve significant reduction in traffic fatalities and serious injuries on all public roads, including non-State-owned public roads and roads on tribal lands"*

MAG member agencies are able to obtain federal funds dedicated for implementing eligible road safety improvements. These funds are available through ADOT, MAG, and the Governor's Office of Highway Safety (GOHS), including certain set-asides within the programs below:

- National Highway Performance Program (NHPP)
- Surface Transportation Program (STP)
- Highway Safety Improvement Program (HSIP)
- Congestion Mitigation and Air Quality Improvement Program (CMAQ)
- MAG Unified Planning Work Program (UPWP)
- Transportation Alternatives Program (TAP)
- Fixing and Accelerating Surface Transportation (FAST)
- NHTSA Funds (164, 402, 405 and 410 grants) (GOHS)

Additionally, local agency funds may be a funding resource for plan implementation.

The 2035 MAG Regional Transportation Plan (January 2014) identifies the first of four goals as "System Preservation and Safety: Transportation infrastructure that is properly maintained and safe, preserving past investments for the future". Promoting and ensuring transportation safety will require resources commensurate with the importance of safety to the region's values.

Securing adequate resources to implement this plan will be a challenge. In some cases, current programs will be enhanced and existing resources are already identified. Other strategies will require new funds.

TIME FRAME

Implementation of this plan spans a 10-year time frame from MAG fiscal year 2016 to MAG fiscal year 2025 (July 2015 – June 2025). Implementing the strategies outlined in this STSP provides the greatest opportunity of achieving the goal of reducing fatalities and serious injuries by three percent to seven percent in the next five (5) years from the base year of 2013.

IMPLEMENTATION COST

Planning level cost estimates were developed for each strategy based on prior experience and local agency/expert input. The following resources were used to estimate costs when local information was not available:

- 2009 FHWA Low-Cost Safety Enhancements for Stop-Controlled and Signalized Intersections
- 2013 FHWA Costs for Pedestrian and Bicyclist Infrastructure Improvements
- BIKESAFE: Bicycle Safety Guide and Countermeasure Selection System
- PEDSAFE: Pedestrian Safety Guide and Countermeasure Selection System

Costs for DUI Enforcement and Pedestrian and Bicycle Crossing Enforcement were estimated by taking the amount of NHTSA funds awarded to MAG member agencies as a low from the years 2013 through 2015. This information was obtained from the GOHS annual reports from 2013 and 2014 and provided by GOHS staff for FFY 2015.

The planning level unit costs were projected to a 10-year total cost of $78,040,000 to implement this plan. The summary of assumptions used to arrive at this total cost is provided in Appendix B: Implementation Plan Cost Estimate Assumptions. The resulting annual average cost of implementation is $7,804,000.

The projected funding resources based on those currently available through FY 2018 for implementation of this Plan totaled about $4,770,000 (see Table 3), which results in a remaining need of $3,025,250, annually. This funding shortfall is depicted in Figure 27, and was also highlighted in presentations to MAG decision makers.

Table 3 – Estimated Funding Resources for Plan Implementation

Funding Resources	FY15-18
MAG UPWP	$584,000
HSIP Sub-Allocation	$1,900,000
TA Non-Infrastructure Allocation	$400,000
TA Infrastructure Allocation (portion)	$320,000
GOHS	$1,566,000
TOTAL	**$4,770,000**

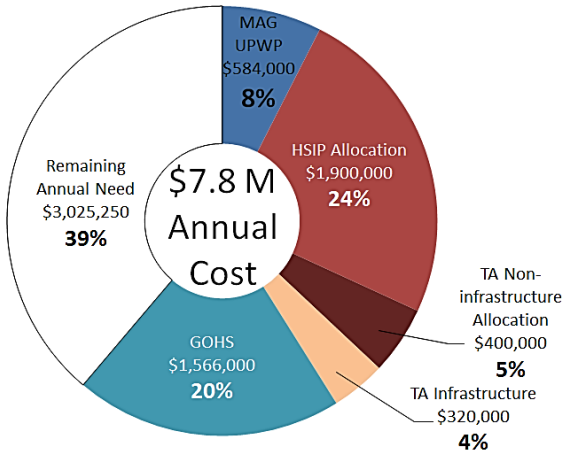


Figure 27 – Annual Cost of Implementation vs. Current Funding Resources ($7.8M Annually) through FY2018

MAG GUIDANCE FOR FUNDING PLAN IMPLEMENTATION

The MAG Regional Council and MAG Transportation Policy Committee provided guidance to MAG staff regarding funding the $3 million Implementation Plan shortfall. The direction given to MAG staff, by Regional Council action, was 1) to have discussions with ADOT to explore the possibility of increasing the safety funding suballocation to the MAG region by at least an additional $3 million annually to help implement the strategies identified in the MAG Strategic Transportation Safety Plan, and 2) to work cooperatively with ADOT in demonstrating how increasing the MAG allocation would assist ADOT in meeting the statewide road safety targets and performance measure as required in MAP-21.

2015 HSIP MANUAL & NEW GUIDANCE ON FEDERAL ROAD SAFETY FUNDS

Shortly after the MAG guidance was provided to address fund needed to implement the Plan, the Arizona DOT released the new 2015 HSIP manual which outlined a new HSIP programming process and the planned transition to a statewide program in FY 2019. The new HSIP process and related guidance states that all future programming of federal HSIP funds for road safety projects will be based on new project eligibility criteria designed to approve ONLY the funding of safety improvement projects that: 1) include countermeasures that would reduce fatal and serious injury crash occurrence, 2) demonstrate a benefit cost ratio (B/C) of 1.5 or greater, with the B/C ratio calculated using Crash Modification Factors with at least a four-star rating, and 3) have a minimum total project cost of $250,000.

The programming of HSIP funds for safety projects through FY2018 will continue under the new project eligibility rules. The new HSIP process that will begin in FY2019 will terminate the suballocation of HSIP funds to MAG (and all MPOs and COGs). Starting in FY2019 all

candidate road safety projects will be evaluated and recommended to the Arizona DOT by MAG for multiple program years. All projects would compete for the statewide HSIP allocation of approximately $42 million in each fiscal year.

Based on the crash history of the MAG planning area (in comparison to the entire state) and the execution of the new HSIP process, it is estimated that about 50 percent of the state's annual HSIP allocation, or $21M, would need to be allocated to qualifying road safety projects in the MAG region. This anticipated outcome starting in FY2019, if realized, would fully address the funding needs for road safety improvements in the MAG planning area.

However, this assumes that, for each fiscal year, MAG recommends a sufficient number of excellent candidate road safety improvement projects for locations that have experienced fatal and serious injury crashes. To obtain $21M in HSIP funds, a total of 42 successful project applications would be required, at an average project cost of $500,000. The generation of HSIP project applications to meet the new HSIP criteria is a rather complex task that some smaller member agencies may find challenging, despite having sites with road fatalities and serious injuries. Assuming that the HSIP process remains unchanged, to ensure that the MAG region is able to compete successfully for HSIP, it may be necessary to establish a new MAG program that would provide assistance to local agencies in preparing successful project applications through on-call consultants.

RETURN ON INVESTMENT

The MAG Transportation Safety Committee provided subjective input on the potential of each strategy to provide a low, medium, or high return on investment for the region. Projecting the cost for strategies that are indicated to provide a high rate of return on investment resulted in a total estimated cost requirement of nearly $68 million dollars, which is 87 percent of the estimated total cost of Plan implementation. Implementation costs in relation to return on investment over the 10-year implementation time frame is illustrated in Figure 28.

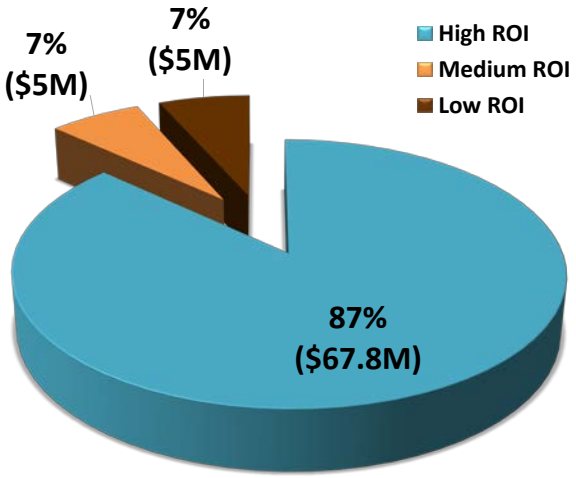


Figure 28 – Implementation Cost vs. Return on Investment over 10 years ($78M Total)

MONITORING THE EFFECTIVENESS OF REGIONAL ROAD SAFETY PROGRAMS AND INITIATIVES

MAG will produce an annual Transportation Safety Performance Report that includes: (1) Crash Statistics and Trends; (2) Performance in Comparison to the Safety Target; and (3) Summary of Road Safety Projects & Activities in

each Action Area including their possible impact on road safety performance. This annual report will also include a comparison to highlight how the MAG regions safety improvement projects, programmed utilizing HSIP funding through FY 2018 and beyond, are effecting ADOT's ability to meet the road safety targets and performance measures requirements established in MAP-21. The MAG Transportation Safety Committee will continue to provide oversight to programs and projects and will guide these activities throughout the implementation time frame. Regular review of projects and programs that address these strategies will be done under the direction and recommendation of the MAG Transportation Safety Committee. Revisions or enhancements to the programs and projects, including further coordination with ADOT on the process of programming of HSIP funds, can be made throughout implementation as they relate to safety performance toward the target. This STSP will be updated on a five-year cycle.

Table 4 – 2015 MAG STSP Implementation Plan Matrix

	Strategies	Lead Agency	Unit Cost (1000's)	Unit	Return on Investment (Subjective)	Time Frame (Short, Medium, Long)	10-yr Total Cost ($1000)
3.13	Perform comprehensive review of current EVP practices and develop a recommended practice for the region to follow.	MAG Work Program currently underway					
2.1	Support and encourage the implementation of infrastructure-based ITS technologies that show promise for reducing fatalities and serious injuries.	MAG ADOT	$	na	High	Short	$ 0
3.1	Encourage submittal of TIP projects that include safety elements, for improving safer access for all modes, by including safety as an explicit project evaluation criteria for all TIP projects that currently have evaluation criteria as a means of prioritizing a list of projects. Exceptions to this practice are those Transit Maintenance and Operations programs funded through the MAG TIP.	MAG	$	na	High	Short	$ 0
3.2	Identify new practices or standards that integrate safety into planning and design.	MAG ADOT Local Agencies	$	na	High	Short	$ 0
3.4	Prioritize Improvements based on screening for high crash risk intersections.	Local Agencies MAG ADOT	$	na	High	Short	$ 0
4.1	See Strategy 3.1 - Also to be applied under Action Area 4.0: Eliminate Death and Injury Involving Vulnerable Road Users (Bicyclists, Pedestrians, Persons with Disabilities) as Strategy 4.1.	MAG Local Agencies	$	na	High	Short	$ 0

	Strategies	Lead Agency	Unit Cost (1000's)	Unit	Return on Investment (Subjective)	Time Frame (Short, Medium, Long)	10-yr Total Cost ($1000)
4.14	Share best practices among regional stakeholders on best safety practices for getting to and from school; including developing recommended walk or bike to school routes for all schools in the region and administration of SRTS programs.	ADOT MAG School Districts Local Agencies	$	na	High	Short	$ 0
4.4	Identify high risk locations for potential implementation of enhanced pedestrian crossings that would have a favorable benefit/cost ratio.	MAG	$ 0	na	High	Short	$ 0
4.15	Support a regional training program for school crossing guards.	MAG	$	per year for 3 annual training workshops	High	Short	$ 40
3.9	Conduct targeted enforcement of high crash risk intersections.	Local Agencies ADOT	$ 18	ea intersection	High	Short	$ 8,910
5.2	Explore methods of educating young road users through Mass-media campaigns.	ADOT GOHS Local Agencies AAA MAG	$ 30	ea	High	Short	$ 30
3.5	Implement systemic improvements based on identifying characteristics of high risk intersections.	Local Agencies	$ 46	ea intersection	High	Short	$ 22,770
4.13	Develop on-going training and public information bicycle and pedestrian safety campaigns.	GOHS MAG Local Agencies	$ 60	ea	High	Short	$ 60

Strategies		Lead Agency	Unit Cost (1000's)	Unit	Return on Investment (Subjective)	Time Frame (Short, Medium, Long)	10-yr Total Cost ($1000)
4.6	Install medians and pedestrian crossing islands.	Local Agencies	$ 75	ea crossing	High	Short	$ 1,500
6.2	Enhance the Regional Transportation Safety Infromation Management System	MAG	$ 80	ea	High	Short	$ 80
3.3	Enhance the MAG RSA Program:						
3.3.2	Conduct safety assessment reviews during the design phase.	MAG Local Agencies	$ 80	per annual program administered	High	Short	$ 800
4.5	Install pedestrian Hybrid Beacons (HAWKs).	Local Agencies	$ 85	ea	High	Short	$ 1,700
1.2	Conduct high visibility DUI saturation patrols.	Local Agencies GOHS	$ 114	per year	High	Short	$ 1,140
2.5	Conduct enforcement in all work zones and increase enforcement in school zones.	Local Agencies	$ 180	per year	High	Short	$ 1,800
3.3	Enhance the MAG RSA Program:						
3.3.1	Refine RSA location nominating criteria: Priority (1) High crash risk locations Priority (2) Locations where there are known high volumes of bicylists and pedestrians accessing transit.	MAG	$ 300	per annual program administered	High	Short	$ 3,000
4.3	Promote and administer Safe Routes to School framework studies to identify school traffic issues and produce walking and biking route maps through the MAG TA non-infrastructure program.	MAG Local Agencies	$ 400	na	High	Short	$ 4,000

	Strategies	Lead Agency	Unit Cost (1000's)	Unit	Return on Investment (Subjective)	Time Frame (Short, Medium, Long)	10-yr Total Cost ($1000)
3.11	Partner with local professional societies to hold an annual workshop to educate roadway designers on safety tools available to assess and improve substantive safety.	FHWA ADOT MAG	$	na	Medium	Short	$ 0
6.1	Enhance the existing network screening methodology for intersections and segments.	MAG	$	na	Medium	Short	$ 0
4.7	Provide bicycle detection at signalized intersections.	Local Agencies	$	ea intersection approach	Medium	Short	$ 88
2.2	Administer projects that develop ICM strategies for handling incident diversions from freeways onto City arterials to address secondary crashes.	MAG ADOT DPS Local Agencies	$ 180	ICM project/year	Medium	Short	$ 1,800
4.2	Promote practices that ensure safety and multimodal connectivity in planning and design.	Local Agencies MAG ADOT	$	na	Low	Short	$ 0
4.12	Produce a white paper on wrong way bicycle crashes and model ordinances to prevent crashes.	MAG	$ 10	ea	Low	Short	$10
3.3	Enhance the MAG RSA Program:						
3.3.3	Identify best practices for promoting or implementing Safe Driving pledge campaigns.	MAG	$ 30	ea	Low	Short	$ 30
4.11	Develop a Bicylist Safety Assessment program that focuses on bicyclist safety countermeasures on bike paths.	MAG	$ 100	per annual program administered	Low	Short	$ 1,000

	Strategies	Lead Agency	Unit Cost (1000's)	Unit	Return on Investment (Subjective)	Time Frame (Short, Medium, Long)	10-yr Total Cost ($1000)
3.7	Decrease wrong-way riding and traffic control violations by bicyclists.	GOHS Local Agencies	$ 381	per year	Low	Short	$ 3,810
5.3	Partner with ADOT, Valley Metro, and other organizations to deploy distracted driver safety awareness campaigns.	ADOT GOHS DOEd AAA MAG	$ 30	ea	High	Medium	$ 30
2.4	Utilize automated enforcement where appropriate to address speeding.	Local Agencies	$ 77	ea location	High	Medium	$ 3,465
3.10	Utilize automated enforcement at high crash risk intersections where appropriate.	Local Agencies ADOT	$ 77	ea intersection	High	Medium	$ 18,480
1.3	Develop materials for educating target groups for impaired driving including mass-media campaigns on DUI dangers and penalties.	MAG ADOT Local Agencies GOHS	$ 50	ea	Medium	Medium	$ 500
2.3	Develop best practice guidelines for use of automated enforcement to improve safety.	MAG	$ 80	ea	Medium	Medium	$ 80
3.6	Prepare a "best practices" guide for Road Diet and Complete Streets projects that incorporates safety countermeasures in project development.	MAG	$ 80	ea	Medium	Medium	$ 80
4.8	Develop Complete Streets Implementation Guidelines that integrate safety analysis and design throughout the planning process.	MAG	$ 80	ea	Medium	Medium	$ 80
4.9	Prepare a "best practices" guide for high risk intersections and high exposure bicycle and pedestrian crossing nodes.	MAG	$ 80	ea	Medium	Medium	$ 80

	Strategies	Lead Agency	Unit Cost (1000's)	Unit	Return on Investment (Subjective)	Time Frame (Short, Medium, Long)	10-yr Total Cost ($1000)
1.1	Implement wrong-way detection systems to reduce wrong-way crashes on freeways.	ADOT DPS MAG	$ 200	per year	Medium	Medium	$ 2,000
3.12	Prepare a "best practices" guide for design of pedestrian and bicycle accommodations at roundabouts.	MAG	$ 60	ea	Low	Medium	$ 60
4.10	Explore and release a smartphone application to educate vulnerable users.	MAG ADOT RPTA ASU	$ 60	ea	Low	Medium	$ 60
4.16	Develop and distribute educational materials related to intersection safety.	AAA ADOT AARP GOHS MAG	$ 60	ea crash type addressed	Low	Medium	$ 60
5.1	Develop short-range action program oriented to 1) high transit acitivity stops and 2) new routes that would enhance transit stop safety.	RPTA Local Agencies	$ 80	ea	Low	Medium	$ 80
6.4	Develop a tool to conduct benefit-cost analyses and calculate crash reduction factors (CRFs).	MAG	$ 30	ea	Medium	Long	$ 30
3.8	Prepare technical resource that summarizes and documents regional and national research on effectiveness of safety countermeasures for all E's.	MAG	$ 100	ea	Medium	Long	$ 100
6.3	Develop or purchase a comprehensive safety assessment tool based on HSM methodologies.	MAG	$ 100	ea	Medium	Long	$ 100
6.5	Develop local calibration factors for existing national HSM SPFs specific to the MAG planning area.	MAG Local Agencies ADOT	$ 100	ea	Medium	Long	$ 100

APPENDIX A Acronyms and Definitions

A	**Incapacitating Injury (Serious Injury) Crash**
AAA	American Automobile Association
AARP	American Association of Retired Persons
AASHTO	American Association of State Highway and Transportation Officials
ADOT	Arizona Department of Transportation
ALISS	(ADOT) Accident Location Identification Surveillance System
ARS	Arizona Revised Statutes
ASU	Arizona State University
B/C	Benefit-Cost Ratio
BAC	Blood alcohol concentration in the body, expressed in grams of alcohol per deciliter (g/dL) of blood, usually measured with a breath or blood test.

APPENDIX A Acronyms and Definitions

BSA	Bicyclist Safety Assessment
CCTV	Closed Circuit Television
CMAQ	(Federal) Congestion Mitigation and Air Quality Improvement Program
CMF	Crash Modification Factors
COTC	Chairman of Citizens Transportation Oversight Committee
CRASH	Crash Reduction Analysis Safety Hub
CRF	Crash Reduction Factor
DMS	Dynamic Message Sign
DOT	Department of Transportation
DPS	Department of Public Safety
DUI	Driving Under the Influence
EMS	Emergency Medical Services

APPENDIX A Acronyms and Definitions

EVP	Emergency Vehicle Preemption
FAST	Fixing and Accelerating Surface Transportation
FFY	Federal Fiscal Year
FHWA	Federal Highway Administration
FY	Fiscal Year
GOHS	(Arizona) Governor's Office of Highway Safety
HSIP	Highway Safety Improvement Program
HSM	Highway Safety Manual
ICM	Integrated Corridor Management
ISS	Intersection Safety Score
ITS	Intelligent Transportation Systems
K	Fatal Crash
MADD	Mothers Against Drunk Driving.

APPENDIX A Acronyms and Definitions

MAG	Maricopa Association of Governments
MAP-21	Moving Ahead for Progress in the 21st Century
MCDOT	Maricopa County Department of Transportation
MEV	Million Entering Vehicles (Intersection Crash Rate)
MPA	Metropolitan Planning Area
MPO	Metropolitan Planning Organization. MPOs are designated by the governor to coordinate transportation planning in an urbanized area of the state. MAG is an MPO.
MUTCD	Manual on Uniform Traffic Control Devices
MVD	(ADOT) Motor Vehicle Division
MVMT	Million Vehicle Miles Traveled (Roadway Segment Crash Rate)

APPENDIX A Acronyms and Definitions

NCHRP	National Cooperative Highway Research Program
NHPP	(Federal) National Highway Performance Program
NHTSA	National Highway Traffic Safety Administration
NSM-I	Network Screening Methodology for Intersections
PBT:	Preliminary breath test device, a small hand-held alcohol sensor used to estimate or measure a driver's BAC.
PHB	Pedestrian Hybrid Beacons
PROWAG	Pedestrian Facilities in the Public Right-of-way
PUFFIN	Pedestrian User Friendly Intelligent Intersection
RPTA	Regional Public Transportation Authority (aka Valley Metro)
RRFB	Rapid-Flash Beacons

APPENDIX A Acronyms and Definitions

RSA	(FHWA) Road Safety Audit
RSA	(MAG & ADOT) Road Safety Assessment
RTP	Regional Transportation Program
RTSIMS	(MAG) Regional Transportation Safety Information Management System
SART	Safety Assessment Review Team
SHSP	(ADOT) Strategic Highway Safety Plan
SPF	Safety Performance Function
SRTS	Safe Routes to Schools
STP	Surface Transportation Program
STSP	(MAG) Strategic Transportation Safety Plan
TAP	(Federal) Transportation Alternatives Program

APPENDIX A

Acronyms and Definitions

TIP	(MAG) Transportation Improvement Program
TSC	(MAG) Transportation Safety Committee
TSSG	(MAG) Transportation Safety Stakeholders Group
UPWP	(MAG) Unified Planning Work Program
USDOT	United States Department of Transportation
VMT	Vehicle miles traveled

APPENDIX B

Implementation Plan Cost Estimate Assumptions

1.1 The cost is based on a January 2015 estimate from ADOT Transportation Technology Group of $2,000,000 to instrument the Phoenix Freeway Management System interchanges with wrong-way detection systems. The 10-year total cost assumes the implementation of the wrong-way detection system is phased-in over 10 years ($200,000 per year).

1.2 Information provided by GOHS indicates an amount of $98,000 was spent for similar DUI Saturation Patrols in a total of 18 agencies. A goal was assumed of an increase in implementation of DUI Saturation Patrols from 18 member agencies to 21 member agencies per year. The annual cost estimate was increased to $114,000 to account for the goal of increased participation. The 10-year cost would be $1,140,000.

1.3 The amount to prepare a "best practices" guide for design of pedestrian and bicycle accommodations at roundabouts is based on historical costs to develop this type of document (MAG consultant services Task Orders).

2.1 There is no cost for MAG to implement this strategy.

2.2 This amount assumes three Integrated Corridor Management (ICM) projects a year at $60,000 each, for a total annual cost of $180,000, and a 10-year cost of $1.8 million.

2.3 The amount to develop best practice guidelines for use of automated enforcement is based on historical costs to conduct this type of document (MAG consultant services Task Orders).

2.4 The amount for automated enforcement is based on the amount spent for automated enforcement recently by one local agency at 39 locations ($3 Million divided by 39 locations) for a per location unit cost of $77,000. The total cost was based on identifying 91 locations in the MAG region (based on the 2008-2012 data) with two or more total fatal/serious injury crashes where one or both drivers were speeding or met another definition of aggressive driving. It was assumed that half of these locations may be appropriate for automated enforcement (45 locations), for a 10-year cost of $3,465,000.

2.5 This amount assumes a goal of half of the local agencies in the MAG region (18) will conduct school zone enforcement per year, increased from two (2) in 2013, where approximately $21,000 total was provided in GOHS grants for these efforts for 2 agencies (rounded down to $180,000 per year). The total amount was obtained by multiplying the 10 years of STSP implementation. An amount for work zone enforcement was not included as this would be included in project construction costs.

3.1 There is no cost for MAG to implementing this strategy.

3.2 There is no cost for MAG to implementing this strategy.

3.3 The Strategy to enhance the RSA program is broken into three separate sub-strategies below.

3.3.1 The funding assigned to RSAs will be focused on high crash risk locations or priority locations where there are known high volumes of bicyclists or pedestrians, and the amount will be increased to $300,000 per year, for a total 10-year cost of $3 million.

3.3.2 The amount to conduct safety assessment reviews during the design phase is based on historical costs to conduct this type of reviews (MAG consultant services Task Orders). The amount dedicated to this effort will be $80,000 per year for a total 10-year cost of $800,000.

3.3.3 The amount to conduct Bicyclist Safety Assessments (BSAs) is based on historical costs to conduct these types of studies (MAG consultant services Task Orders). The amount dedicated to this effort will be $100,000 per year, for a total 10-year cost of $1 million.

3.4 There is no cost for MAG to implement this strategy.

3.5 The cost to implement systemic improvements across MAG is based on the amounts applied for the installation of Pedestrian Countdown Heads, EVP, and APS from existing projects currently being implemented in the MAG region on a per intersection basis. Low cost left-turn improvements would be to provide protected left turn heads on existing mast arms and high cost improvements would include reconstruction and signal upgrades for which the cost was assumed to be that for a new standard signal system at an intersection. The average cost for upgrades was estimated to be $46,000 per intersection. From the 2008-2012 ALISS data, 495 intersections in the MAG region had at least one fatal

intersection-related collision (and of those, 165 had five or more serious injury crashes). The total cost is based on implementing improvements at 495 intersections over 10 years.

3.6 The amount to develop Road Diet and Complete Streets implementation guidelines is based on historical costs to develop this type of document (MAG consultant services Task Orders).

3.7 The amount to prepare a "best practices" guide for design of pedestrian and bicycle accommodations at roundabouts is based on historical costs to develop this type of document (MAG consultant services Task Orders).

3.8 The amount to prepare a technical resource that summarizes regional and national research on the effectiveness of safety countermeasures for all E's is based on historical costs to conduct this type of study and prepare the document (MAG consultant services Task Orders).

3.9 The amount for targeted enforcement assumes an average of $18,000 per intersection based on information provided by GOHS of funds spent on Selective Enforcement for 10 projects, assumed to be 10 intersections in 8 MAG agencies. From the 2008-2012 ALISS data, 495 intersections in the MAG region had at least one fatal intersection-related collision (and of those, 165 had five or more serious injury crashes.) The total cost is based on providing the targeted enforcement at 495 intersections over 10 years.

3.10 The amount to utilize automated enforcement at high crash risk intersections is based on an amount spent by one local agency for automated enforcement recently at 39 locations ($3 million divided by 39) for a per-intersection cost of $77,000. The total 10-year cost is based on an assumption that approximately half of the 495 intersections may be appropriate locations to implement this type of automated enforcement where at least one fatal collision occurred (see 3.5), resulting in a total cost (240 locations x $77,000 per location) of $18,480,000.

3.11 There is no cost for MAG to implement this strategy.

3.12 The amount to develop and distribute educational materials related to intersection safety is based on historical costs to produce and distribute similar materials (MAG consultant services Task Orders).

3.13 There are no additional costs for MAG to implement this strategy which is already funded.

4.1 There is no cost for MAG to implement this strategy.

4.2 There is no cost for MAG to implement this strategy.

4.3 This amount for SRTS framework studies is presumed to be the entire annual allocation of TA non-infrastructure funds allocated to the MAG region.

4.4 There is no cost for MAG to implement this strategy.

4.5 The cost for installation of a Pedestrian Hybrid Beacon (PHB aka HAWK) is based on current MAG agency costs to install this treatment. ALISS data shows 37 locations with three or more fatal/serious pedestrian injury crashes. The total cost assumes that only 20 of these locations may meet the warrant for PHB installation.

4.6 The unit crossing island cost of $75,000 is based on a cost estimate from a recently completed bike master plan effort, and includes all construction. ALISS data from 2008 - 2012 shows 37 locations in the MAG region with three or more fatal/serious injury pedestrian crashes. The total cost assumes that only 20 of these locations may be appropriate for installation of a pedestrian crossing island.

4.7 The unit cost to install bicycle detection of $2,500 at an actuated traffic signal approach is based on a cost estimate from a recently completed bike master plan effort. ALISS data for 2008 - 2012 shows there are 35 locations in the MAG region with 2 or more total fatal/serious injury bicyclist crashes. The total 10-year cost assumes installation of bicycle detection on two approaches at 35 signalized locations ($5,000 x 35) is $175,000.

4.8 The amount to develop Complete Streets implementation guidelines to integrate safety into the design is based on historical costs to conduct this type of document (MAG consultant services Task Orders).

4.9 The amount to prepare a "best practices" guide for high risk intersections and other crossings is based on historical costs to conduct this type of document (MAG consultant services Task Orders).

4.10 The amount to develop this short-range program to enhance transit stop safety is based

on historical costs to conduct this type of program (MAG consultant services Task Orders).

4.11 From information provided by GOHS on bicyclist and pedestrian enforcement, this cost assumes a goal of half of the MAG local agencies will conduct wrong-way riding enforcement annually, an increase of three times that was spent in previous years. $127,000 was spent by 6 MAG agencies, so the goal is (3 x $127,000) $381,000 per year for 10 years.

4.12 The amount to produce a white paper on wrong-way bicycle crashes and model ordinances to prevent these crashes is based on historical costs to produce this type of document (MAG consultant services Task Orders).

4.13 The amount to develop on-going training and public information bicycle and pedestrian safety campaign is based on historical costs to prepare these types of materials (MAG consultant services Task Orders).

4.14 There is no cost for MAG to implement this strategy.

4.15 This amount to support the annual regional training program is based on costs for the existing school crossing guard workshops hosted by MAG for the past 9 years ($4,000 per year).

4.16 The amount to develop and release a Smart Phone app to educate vulnerable road users is based on historical costs to develop similar applications.

5.1 The amount to identify best practices for promoting safe driving pledge campaigns is based on historical costs to conduct a similar type of effort (MAG consultant services Task Orders).

5.2 The amount to explore methods of educating young road users through mass media campaigns is based on historical costs to conduct this type of effort (MAG consultant services Task Orders).

5.3 The amount to deploy distracted driver safety campaigns is based on historical costs to conduct similar efforts including the production of materials.

6.1 There is no cost for MAG to implement this strategy.

6.2 The amount to conduct a study to enhance the regional transportation safety information management system is based on historical costs to conduct this type of effort (MAG consultant services Task Orders).

6.3 The amount to develop or purchase a comprehensive safety assessment tool based on HSM methodologies is based on historical costs to develop or purchase this type of product (MAG consultant services Task Orders).

6.4 The amount to develop a tool to conduct benefit-cost analyses and develop CRFs is based on historical costs to conduct this type of effort (MAG consultant services Task Orders).

6.5 The amount to develop local calibration factors for SPFs specific to the MAG region is based on historical costs to conduct this type of effort (MAG consultant services Task Orders).

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APPENDIX C

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MAG Strategic Transportation Safety Plan Technical Memorandum No. 1 – Transportation System Performance and Available Financial Resources from a Transportation Safety Perspective (September 30, 2013)

http://www.azmag.gov/Portals/0/Documents-Ext/Transportation/STSP-Tech-Memo-01_10.2.13_Final_Rev.pdf

Establish Regional Vision and Goals.....7

MAG Strategic Transportation Safety Plan Technical Memorandum No. 2 – Establish Regional Vision and Goals for Transportation Safety (October 3, 2013)

http://www.azmag.gov/Portals/0/Documents-Ext/Transportation/STSP-Tech-Memo-02_10.03.13_draft.pdf

Establish Action Areas and Performance Measures.....7

MAG Strategic Transportation Safety Plan Technical Memorandum No. 3 – Action Areas, Potential Strategies and Performance Measures (May 9, 2014)

http://www.azmag.gov/Portals/0/Documents-Ext/Transportation/STSP-Final-Tech-Memo-3.pdf

Review of the Current MAG Network Screening Methodology for Prioritization of Road Safety Needs7, 25

MAG Strategic Transportation Safety Plan Technical Memorandum No. 4 – Network Screening Methodologies for Prioritization of Road Safety Needs (April 8, 2014)

http://www.azmag.gov/Portals/0/Documents-Ext/Transportation/Technical-Memo-4-for-Network-Screening.pdf

Incorporating Safety in the Regional Transportation Plan 7

MAG Strategic Transportation Safety Plan Technical Memorandum No. 5 – Incorporating Safety into the Regional Transportation Plan (August 12, 2014)

http://www.azmag.gov/Portals/0/Documents-Ext/Transportation/STSP-Tech-Memo-05_Working Group_12.18.14_Final.pdf

Develop a Strategy to Incorporate Safety Enhancements in Road Infrastructure Projects..... 7, 24

MAG Strategic Transportation Safety Plan Technical Memorandum No. 6 – Develop a Strategy to Incorporate Safety Enhancements in Road Infrastructure Projects (July 31, 2014)

http://www.azmag.gov/Portals/0/Documents-Ext/Transportation/STSP-Tech-Memo-06-Final.pdf

Improve Safety via Traffic Operations and ITS Solutions 7

MAG Strategic Transportation Safety Plan Technical Memorandum No. 7 – Improving Safety via Traffic Engineering and Technology Solutions (August 29, 2014)

http://www.azmag.gov/Portals/0/Documents-Ext/Transportation/STSP-Tech-Memo-7_12.17.14_Final.pdf

Monitoring and Reporting on System Performance and Program Effectiveness..... 7

MAG Strategic Transportation Safety Plan Technical Memorandum No. 8 – Monitoring and Reporting on Performance and Program Effectiveness (December 3, 2014)

http://www.azmag.gov/Portals/0/Documents-Ext/Transportation/STSP-Tech-Memo-8_012115.pdf

Implementation Plan 7

MAG Strategic Transportation Safety Plan Technical Memorandum No. 9 – Implementation Plan

http://www.azmag.gov/Portals/0/Documents-Ext/Transportation/STSP-Tech-Memo-9_01.02.15_Draft.pdf

stsp.azmag.gov 7

MAG Strategic Transportation Safety Plan. (2014). Retrieved January 25, 2015, from Maricopa Association of Governments: *http://www.azmag.gov/Programs/Transportation/Road-Safety-and-Technology/MAG-Strategic-Transportation-Safety-Plan*

www.azdot.gov/shsp 8

Arizona Department of Transportation. (2014). Arizona Strategic Highway Safety Plan. Retrieved January 25, 2015, from Transportation Safety: *http://azdot.gov/about/transportation-safety/arizona-strategic-highway-safety-plan*

NCHRP Report 500 20

Neuman, T.R., Pfefer, R., Slack, K. L., Hardy, K. K., Raub, R., Lucke, R. & Wark, R. (2003) *Guidance for Implementation of the AASHTO Strategic Highway Safety Plan Volume 1: A Guide for Addressing Aggressive-Driving Collisions.* National Cooperative Highway Research Program. Washington, D.C.: Transportation Research Board. Retrieved January 25, 2015, from *http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_500v1.pdf*

MAP-21 21

https://www.fhwa.dot.gov/map21/legislation.cfm

Section 260 22

Section 260 Photo Enforcement on State Highways. (November 2013). In *ADOT Traffic Engineering Policies, Guidelines, and Procedures*. Arizona Department of Transportation. Retrieved from *https://www.azdot.gov/docs/default-source/traffic-library/tgp0260-2018-01.pdf?sfvrsn=2*

NCHRP 500 Volume 12: A Guide for Reducing Collisions at Signalized Intersections 23

Antonucci, N., Hardy, K. K., Slack, K. L., Pfefer, R., & Neuman, T. R. (2004). *Guidance for Implementation of the AASHTO Strategic Highway Safety Plan Volume 12: A Guide for Reducing Collisions at Signalized Intersections*. National Cooperative Highway Research Program. Washington, D.C.: Transportation Research Board. Retrieved January 25, 2015, from *http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_500v12.pdf*

MAG Complete Streets guide 27

Maricopa Association of Governments. (2010, December). Complete Streets Guide. Arizona, United States: Maricopa County. Retrieved January 25, 2015, from *http://www.azmag.gov/Portals/0/Documents/BaP_2011-01-25_MAG-Complete-Streets-Guide-December-2010.pdf*

FHWA 27, 30, 31

Furst, T. (2012, January 12). *Safety Memorandum.* Retrieved January 25, 2015, from Federal Highway Administration: *http://safety.fhwa.dot.gov/provencountermeasures/pc_memo.cfm*

NCHRP Report 672 26

Rodegerdts, L., Bansen, J., Tiesler, C., Knudsen, J., Myers, E., Johnson, M., . . . O'Brien, A. (2010). *NCHRP Report 672 - Roundabouts: An Informational Guide Second Edition.* Washington, D.C.: National Cooperative Highway Research Program. Retrieved from *http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_672.pdf*

NCHRP Report 572 26

Rodegerdts, L., Blogg, M., Wemple, E., Myers, E., Kyte, M., Dixon, M., . . . Carter, D. (2007). *NCHRP Report 572 Roundabouts in the United States.* Washington, D.C.: National Cooperative Highway Research Program. Retrieved from *http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_572.pdf*

NCHRP Report 674 26

Schroeder, B., Hughes, R., Rouphail, N., Cunningham, C., Salamati, K., Long, R., . . . Myers, E. (2011). *NCHRP Report 674 Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities.* Washington, D.C.: National Cooperative Highway Research Program. Retrieved from *http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_674.pdf*

FHWA-HRT-05-080 26

Inman, V. W., Davis, G. W., & Sauerburger, D. (2006). *Pedestrian Access to Roundabouts: Assessment of Motorists' Yielding to Visually Impaired Pedestrians and Potential Treatments To Improve Access.* McLean: Office of Safety Research and Development Federal Highway Administration. Retrieved from *https://www.fhwa.dot.gov/publications/research/safety/pedbike/05080/05080.pdf*

Safety in Geometric Design Standards 27

Hauer, E. (1999). *Safety in Geometric Design Standards.* Toronto: University of Toronto, Department of Civil Engineering. Retrieved from *https://www.researchgate.net/ publication/228903642_Safety_in_geometric_design_standards*

A Case for Evidence Based Road Safety Delivery 27

Hauer, E. (2007). *A case or evidence-based road-safety delivery.* AAA Foundation for Traffic Safety. Retrieved from *http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.170.2678&rep=rep1&type=pdf*

TRB Special Report 300 27

Morris, J. R. (2011, January-February). Achieving Traffic Safety Goals in the United States: Lessons from Other Nations. *TR News 272*, pp. 30-33. Retrieved from *http://onlinepubs.trb.org/onlinepubs/trnews/trnews272SR300.pdf*

Fact Sheets 27

SWOV Institute for Road Safety Research. (2015, February 28). *Fact sheets ordered by keyword*. Retrieved from *https://www.swov.nl/UK/Research/factsheets.htm*

Young Drivers: The Road to Safety..... 27

Organisation for Economic Co-Operation and Development. (2006). *YOUNG DRIVERS The Road to Safety.* Paris: OECD Publishing. Retrieved from *http://www.oecd.org/itf/37556934.pdf*

Traffic Safety for School Areas Guidelines 2006 33

Arizona Department of Transportation. (2006). *Traffic Safety for School Areas Guidelines.* Retrieved January 25, 2015, from *http://www.saferoutespartnership.org/sites/default/files/pdf/Lib_of_Res/SRTS_State_Program_School Safety_120106.pdf*

application..... 34

Metro Trains Melbourne. (2014, August 18). Dumb Ways to Die. Melbourne, Australia: Metro Trains. Retrieved from *http://bobcm.net/2014/03/22/metro-trains-melbourne-dumb-ways-to-die/*

reported 34

Cauchi, S. (2013, February 14). *No dumb luck: Metro claims safety success.* Retrieved from The Age Victoria: *http://www.theage.com.au/victoria/no-dumb-luck-metro-claims-safety-success-20130214-2eelt.html*

USDOT report 35

Institute for Research in Public Safety. (1973). *Tri-Level Study of the Causes of Traffic Accidents: Interim Report 1.* Indiana University, Institute for Research in Public Safety. Washington, D.C.: U.S. Department of Transportation. Retrieved from *https://rosap.ntl.bts.gov/view/dot/1087*

Crash Reduction Analysis Safety Hub (CRASH) 37

Fitzgerald, R. (2012). Crash Reduction Analysis System Hub (CRASH) Information Guide. FDOT State Safety Office. State of Florida Department of Transportation. Retrieved January 23, 2015, from *http://www.dot.state.fl.us/rddesign/QA/Tools/CRFGuide.pdf*

2009 FHWA Low-Cost Safety Enhancements for Stop-Controlled and Signalized Intersections..... 40

Federal Highway Administration. (2009). Low-Cost Safety Enhancements for Stop-Controlled and Signalized Intersections. U.S. Department of Transportation. Retried from *http://safety.fhwa.dot.gov/intersection/resources/fhwasa09020/fhwasa09020.pdf*

2013 FHWA Costs for Pedestrian and Bicyclist Infrastructure Improvements..... 40

Bushnell, M. A., Poole, B. W., Zeeger, C. V., & Rodriguez, D. A. (2013). Costs for Pedestrian and Bicyclist Infrastructure Improvements. UNC, Highway Safety Research Center, Chapel Hill. Retrieved from *http://www.pedbikeinfo.org/cms/downloads/Countermeasure%20Costs_Report_Nov2013.pdf*

BIKESAFE: Bicycle Safety Guide and Countermeasure Selection System 40

Sundstrom, C., & Nabors, D. (2014, September). *Bicycle Safety Guide and Countermeasure Selection System.* (Federal Highway Administration) Retrieved from Bikesafe: *http://pedbikesafe.org/BIKESAFE/index.cfm*

PEDSAFE: Pedestrian Safety Guide and Countermeasure Selection System 40

Zeeger, C. V., Nabors, D. & Lagerwey, P. (2013, August) *Pedestrian Safety Guide and Countermeasure Selection System.* (Federal Highway Administration) Retrieved from Pedsafe: *http://pedbikesafe.org/PEDSAFE/index.cfm*