Federal Highway
Administration

Urbanized and Nonurbanized Safety Target Setting Final Report

June 2015

U.S.Department of Transportation
Federal Highway Administration

Safe Roads for a Safer Future
Investment in roadway safety saves lives

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16. Abstract

This report reviews the role of transportation safety target setting in a performance management framework, summarizes the state of the practice in safety target setting, and presents a framework for developing urbanized and nonurbanized safety targets. Conclusions include that States will need to consider the quality of their location data before deciding on urbanized and nonurbanized target setting, particularly for serious injuries. Urbanized and nonurbanized target setting can help States prioritize their resources for the greatest impact and may help with stakeholder involvement, particularly with metropolitan planning organizations (MPO).

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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1.0 Introduction

The Federal transportation legislation, Moving Ahead for Progress in the 21st Century (MAP-21), requires the U.S. Department of Transportation (U.S. DOT) under 23 USC 150 to define a set of safety performance measures and States to set targets that reflect the measures. The measures identified in MAP-21 are serious injuries and fatalities per vehicle mile traveled (VMT) and the number of serious injuries and fatalities. MAP-21 also provides the option in 23 U.S.C. 150 for States to set safety targets for urbanized and nonurbanized areas. The purpose of this document is to provide information to States considering setting urbanized or nonurbanized safety targets. The report includes a review of the state of the practice in setting urbanized and nonurbanized safety targets and identifies methods for state Departments of Transportation (DOT) to consider if they decide to set urbanized or nonurbanized targets.

The Federal Highway Administration's (FHWA) definition of urbanized areas is those with a population of 50,000 or higher, for which boundaries can be adjusted by States. Further information on geography definitions is included in section 3.

Each State Highway Safety Office (SHSO) established under 23 USC 402 and administered by the National Highway Traffic Safety Administration (NHTSA) develops an annual Highway Safety Plan (HSP) and submits an annual evaluation report to NHTSA. Under MAP-21, HSPs were initially required to report on 14 safety performance measures, as defined in the report entitled *Traffic Safety Performance Measures for States and Federal Agencies.* Bicyclist fatalities was added as a requirement for fiscal year (FY) 2015 reporting, bringing the total up to 15. States are required to develop annual performance targets for 11 of the measures, and to report annual progress on all 15. The NHTSA document recommends that "States report both rural and urban fatalities/VMT, as well as total fatalities/VMT."

This report provides information on the state of the practice and potential methodologies for integrating urbanized and nonurbanized safety performance measures and targets into a performance-based safety program.

- Section 2 provides a literature review and describes the potential benefits of setting urbanized and nonurbanized targets;
- Section 3 defines the relevant geography;
- Section 4 provides information on the state of the practice for urbanized and nonurbanized safety target setting and an analysis of State fatality and serious injury data for urbanized and nonurbanized areas;
- Section 5 provides a framework for safety target setting;
- Section 6 offers information on safety target setting methods for urbanized and nonurbanized areas; and
- Section 7 summarizes key conclusions.

2.0 Background

2.1 Literature Review

Previous work has synthesized the state of the practice in safety target setting by States and regions. For the FHWA's *A Compendium of State and Regional Safety Target Setting Practices,*[1] the research team catalogued national and international safety targets and methods for setting safety targets.

Establishing road safety performance measures and setting targets are widely advocated practices in other parts of the world, particularly in Europe and Australia. The Organization for Economic Cooperation and Development (OECD) suggests setting targets can improve road safety by encouraging more realistic and efficient road safety programs, communicate the importance of road safety to people who can affect it, give direction to policy-makers, motivate stakeholders to act, and hold road transport system managers accountable. The effectiveness of setting road safety targets has been evaluated in only a few studies; however, the available evidence shows reductions in fatalities and fatality rates are associated with target setting.[2]

Numerous countries throughout the world (with the majority in Europe) have pursued and achieved safety targets over the years. While limited examples of well-described target setting methodologies are available, current practice involves a combination of top-down long-term goals and bottom-up interim targets of shorter duration. A few agencies are developing interim targets aligned to selected countermeasures, their estimated effectiveness, deployment of vehicle safety technologies, and the extent to which countermeasures are successfully/effectively implemented. Such a process requires defining the country's level of ambition for road safety, taking into account institutional arrangements, developing methods to measure the effectiveness of strategies needed to improve safety, and identifying available resources. This target setting approach combines an idealistic long-term goal with realistic short-term targets.[3]

The *Safety Target Setting Final Report*[4] catalogued the state of the practice in safety target setting by reviewing key safety documents and surveying safety practitioners. That work emphasized the importance of clearly defining the terms "goal" and "target." Goals provide a framework and focus for safety efforts. They may be aspirational, such as "zero fatalities"; or numerical, such as the number calculated to "halve fatalities by 2030." Most States establish measurable objectives in State Strategic Highway Safety Plans (SHSP), although this is not Federally required. Targets are quantitative;

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1 http://safety.fhwa.dot.gov/hsip/tpm/docs/compendium.pdf.

2 FHWA, Safety Target Setting Final Report, 2013.

3 FHWA, Performance Management Practices and Methodologies for Setting a National Safety Performance Target, 2011.

4 http://safety.fhwa.dot.gov/hsip/tpm/docs/safetyfinalrpt.pdf.

typically evidence based; and have shorter timeframes (i.e., up to five years). As noted previously, HSPs set targets and track performance measures for most countermeasure areas.

Some international safety performance measurement literature makes reference to tracking progress in urban and rural contexts separately, or addresses how safety programs may be implemented differently in urban and rural areas. Norway tracks fatality and injury trends in urbanized areas and notes in its *National Plan of Action for Road Traffic Safety 2010-2013* the proportion of fatalities and serious injuries in densely built-up areas has decreased from 35 to 40 percent in the early 1990s to 20 percent. In *Vision Zero on the Move*, the Swedish Road Administration notes highly developed areas require a speed limit of 30 kilometers per hour for pedestrians and cyclists to survive a collision. New Zealand's priority safety programs focus on high-risk urban intersections and high-risk rural roads.[5] However, the safety performance management literature provides little information about setting safety targets for urban or rural areas.

An NHTSA research study[6] evaluated the location of fatal crashes with respect to urban boundaries, and concluded 86 percent of all traffic fatalities in the nation occurred in urban areas or in rural areas within 10 miles of the urban boundaries.[7] Therefore, it is important to understand that, while a large proportion of crashes are classified as rural, most occur close to the urban boundary. States will want to understand whether "rural" crashes are located in areas far from urbanized areas or clustered around the fringes to tailor appropriate countermeasures.

2.2 Benefits of Setting Urbanized/Nonurbanized Safety Targets

Under MAP-21, each State is required to set statewide safety targets that reflect the measures cited in the legislation: fatalities, fatality rate, serious injuries, and serious injury rate. The legislation also provides an option for States to establish targets for urbanized and nonurbanized areas. The Safety Performance Management Notice of Proposed Rulemaking[8] (Safety PM NPRM) proposed this option to allow one statewide target for each measure for the aggregate urbanized area and the aggregate nonurbanized area. Another option is to set safety targets for individual urbanized areas. In this case, States could set targets for one, several, or all urbanized areas in the State and one target for the nonurbanized area. Therefore, States could choose to set a large number of urbanized safety targets.

States considering the option to set urbanized and nonurbanized area targets will want to consider the benefit of setting these additional targets. They may decide to set targets separately for urbanized and nonurbanized areas for a variety of reasons. Some States have more evolved performance management programs and experience setting targets. They may wish to set targets for urbanized and nonurbanized areas because they see the benefits of performance management to track trends and use targets to motivate improvement. Additionally, some metropolitan areas are establishing aggressive safety

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5 Safer Journeys: New Zealand's Road Safety Strategy 2010-2020.

6 Subramanian, R., 2009, Geospatial Analysis of Rural Motor Vehicle Traffic Fatalities, NHTSA.

7 The study used data from the Fatality Analysis Reporting System (FARS), which codes the functional classification of land use as urban or rural, as defined by the U.S. Census Bureau.

8 Released March 11, 2015.

programs (i.e., New York, Los Angeles, and San Francisco have all established Vision Zero as an overarching goal). Therefore, States might wish to establish targets for the urbanized areas in which these cities are located to support the emphasis on safety in these areas.

States vary significantly in the amount of urbanized and nonurbanized areas, and the proportion of fatalities and serious injuries in the urbanized and nonurbanized areas may vary substantially. The first step when considering setting urbanized and nonurbanized area targets is for States to track safety trends separately for urbanized and nonurbanized areas to understand the safety performance in the different geographies. Agencies can determine if they are achieving safety progress in both urbanized and nonurbanized areas equally or having greater success in one area or the other. Setting urbanized or nonurbanized safety targets also may drive increased focus on how safety programs are developed for and resources allocated to urbanized and nonurbanized areas.

As part of this research effort, a Peer Exchange with representatives from eight State DOTs was conducted in September 2014 to discuss urbanized and nonurbanized safety target setting. Additional benefits for urbanized/nonurbanized safety target setting were identified through those discussions.

1. DOT-established urbanized and/or nonurbanized area targets may increase collaboration with SHSOs, which are encouraged to track progress in urban and rural areas.

2. DOT establishment of urbanized and/or nonurbanized area targets may increase collaboration with metropolitan planning organizations (MPO) and improve understanding of safety trends in urbanized areas, conducting safety planning in these areas, and coordinating on statewide and individual urbanized area targets.

3. Long-term consideration of urbanized/nonurbanized area geography would help States track expenditure distributions in these areas. The impending Model Inventory of Roadway Elements (MIRE) requirement for fundamental data elements under MAP-21 (23 U.S.C. 148(e)(2)(A)) and other data improvements may help optimize resource distribution.

4. Setting a target for urbanized areas might stimulate more collaboration between MPOs, counties, and local jurisdictions on safety strategies.

5. Agencies might find benefit in using urbanized and nonurbanized area performance measures to track statewide and emphasis area progress. If States find they are not meeting emphasis area goals, analysis of the emphasis areas by urbanized/nonurbanized areas could help identify where future focus is needed and provide a reason for reassessing their safety practices.

6. Examining safety data through an urbanized/nonurbanized area lens could draw attention to the need for increased outreach with certain safety partners (i.e., counties or local agencies).

3.0 Geography Definitions

A clear and consistent definition of the terms “urbanized,” “nonurbanized,” “urban,” and “rural” is needed to conduct target setting for urbanized and nonurbanized areas. This section provides information on a range of designations and describes how areas are defined. The area of interest for target setting is the *urbanized area*.

3.1 Urban Areas

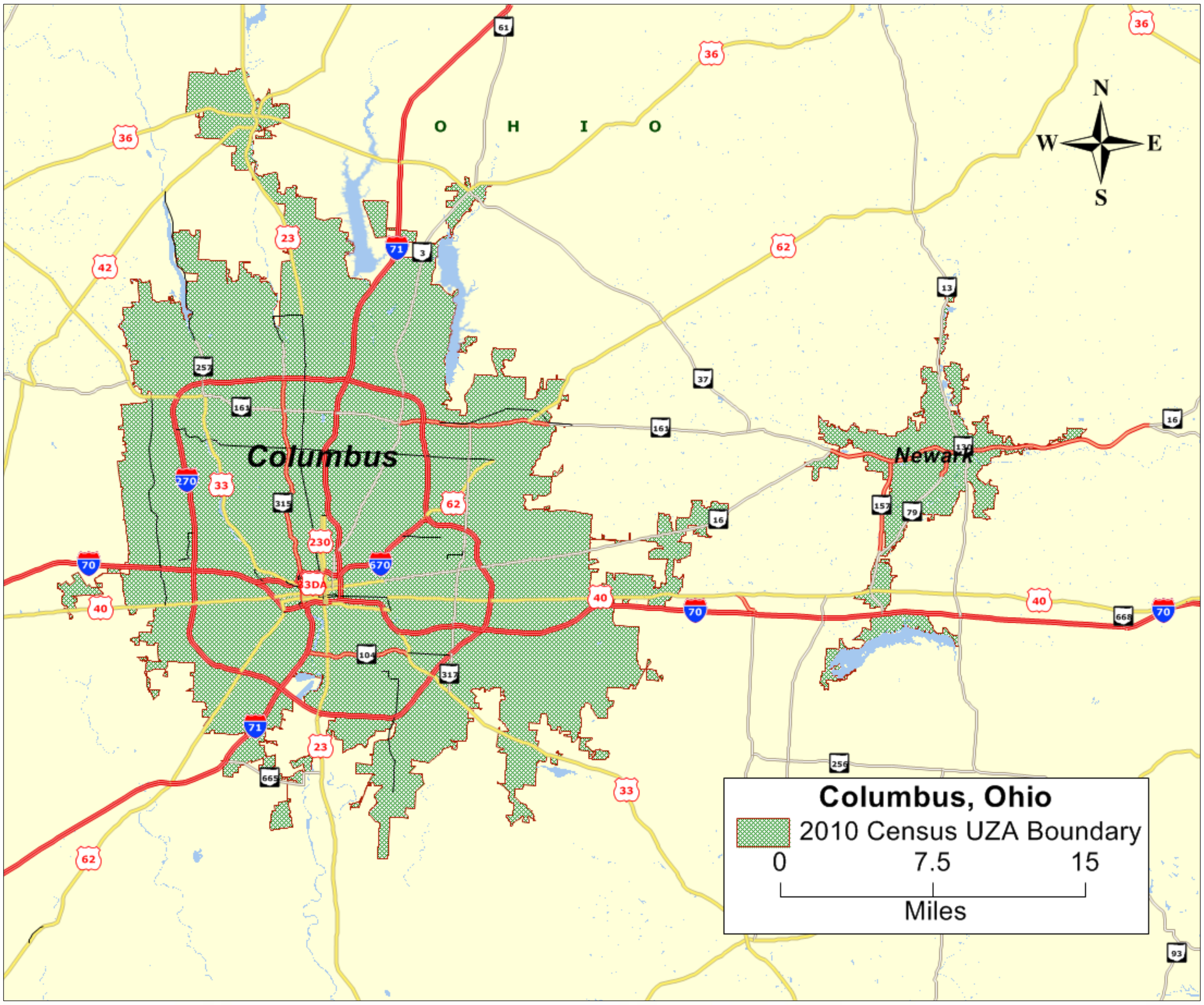
The U.S. Census Bureau defines and delineates the geographic boundaries for urban areas based on residential population after each decennial Census. Census-defined urban areas are used to summarize and report data collected by most Federal agencies. The Census definition of urban area includes urbanized areas of 50,000 or more population and urban clusters of at least 2,500 and less than 50,000 population.

Beginning with the 2000 decennial Census, the Census Bureau has used a geographic information system (GIS) methodology to identify and construct the boundaries for urban areas based on aggregations of Census Blocks. Each urban area is built outward from a core of Census Blocks that meets an initial population density threshold; new blocks are added until the population density falls below a specified threshold, or until the urban area bumps against an adjacent urban area.

Figure 3-1 shows the 2010 urban area boundary for Columbus, Ohio. As shown, urban area boundaries defined by this process tend to be highly irregular in shape and often containing elongated “fingers” that follow major highways, as well as indentations and “holes” that represent areas with little or no residential population (e.g., urban parkland or industrial areas).

Census defined urban area boundaries may not coincide with the jurisdictional boundaries of incorporated cities or towns, counties, or even States. Parts of a particular urban area (e.g., Washington, D.C. or Philadelphia, Pennsylvania) can exist in two or more States.

Figure 3-1 2010 Census Urban Area Boundaries in Columbus
Ohio



Source: Census.

3.2 FHWA Adjusted Urbanized Area Boundaries

While the above described urban areas, the focus is on urbanized areas, which is the geography to be used for target setting. FHWA and the Census Bureau differ in defining and describing urban and rural areas. The Census Bureau defines urban areas solely for the purpose of tabulating and presenting Census Bureau statistical data. A number of Federal agency programs uses the Census definitions as the starting point (if not the basis) for implementing and determining eligibility for a variety of funding programs.

Federal transportation legislation allows for the outward adjustment of Census Bureau-defined urbanized boundaries as the basis for development of adjusted urbanized area boundaries for transportation planning purposes. By Federal rule, these adjusted urbanized area boundaries must encompass the entire Census-designated urbanized area (and are subject to approval by the Secretary of Transportation (23 USC 101(a) (34) and 49 USC 5302(a) (16)-(17)).[9]

States may adopt the Census boundaries as is, or adjust them for transportation planning purposes. The FHWA does not require Census urbanized area boundary adjustments. The only official requirement is adjusted boundaries must include the original urbanized area boundary defined by the Census Bureau in its entirety. In other words, any adjustment must expand, not contract, the Census Bureau urbanized area boundary. The adjusted urbanized area boundaries also can include other areas that are "urban" in character, but do not meet the Census Bureau's population threshold (e.g., high-density industrial or commercial areas, urban parks, etc.). The adjusted boundaries also can be expanded to ensure roads do not alternate between urban and rural designations. This geography is called the "adjusted urbanized area" boundary.

Figure 3-2 shows the 2010 Census defined urbanized area boundary (light green) overlaid on the adjusted urbanized area boundary (brighter green) for Columbus, Ohio. The adjusted urbanized boundary fills in several areas throughout Ohio that are more industrial than residential, and aligns the adjusted boundaries with roads to minimize situations where a road alternates between an urban and rural designation.

As noted previously, the key geography used in this research is the FHWA *adjusted urbanized area* involving urbanized areas with a population of 50,000 or more. This is the geography proposed in the Safety PM NPRM with respect to urbanized and nonurbanized target setting. This definition is used by FHWA for any Federal reporting of urbanized areas in regulations or statistics, such as for the Urbanized Area Summaries on length and daily vehicle miles of travel (table HM-71) and selected characteristics (table HM-72) documented in the FHWA Highway Statistics Series.[10]

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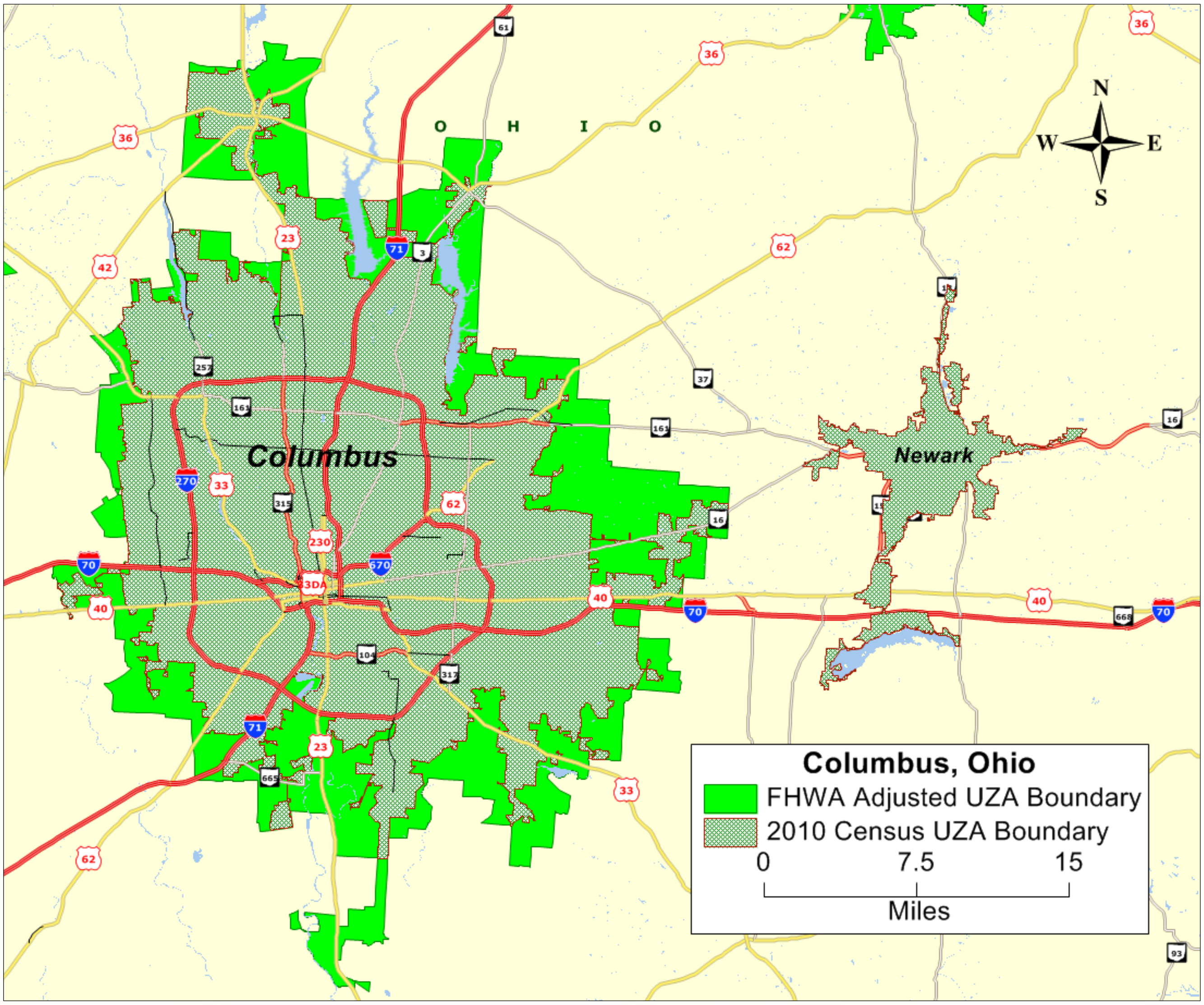
9 http://www.fhwa.dot.gov/planning/processes/statewide/related/highway_functional_classifications/. See section 6.

10 http://www.fhwa.dot.gov/policyinformation/statistics/2012/.

Figure 3-2 Adjusted Urbanized Area Boundaries in Columbus *Ohio*



Source: Census, FHWA.

Tables 3-1 and 3-2 summarize how Census and FHWA urban and urbanized areas are defined by population range and note FHWA urban area boundaries can be adjusted.

Table 3-1 U.S. Census Bureau Urban Area Types Defined by Population Range

Census Bureau Area Definition	Population Range
Urban Area	2,500+
Urban Clusters	2,500-49,999
Urbanized Area	50,000+

Source: FHWA Highway Functional Classification Concepts, Criteria and Procedures, 2013.

Table 3-2 FHWA Urban Area Types Defined by Population Range

FHWA Area Definition	Population Range	Allowed Urban Area Boundary Adjustments
Urban Area	5,000+	Yes
Small Urban Area (From Clusters)	5,000-49,999	Yes
Urbanized Area	50,000+	Yes

Source: FHWA Highway Functional Classification Concepts, Criteria and Procedures, 2013.

3.3 Other Urban and Rural Definitions

FARS definitions of urban and rural can vary from the urbanized area boundaries used by States. FARS uses the following definition for urban areas:[11]

> *An urban area is an area whose boundaries shall be those fixed by responsible State and local officials in cooperation with each other and approved by the FHWA, U.S. DOT. Such boundaries are established in accordance with the provisions of Title 23 of the USC. Urban area boundary information is available from State highway or transportation departments. In the event that boundaries have not been fixed as above for any urban place designated by the Bureau of the Census having a population of 5,000 or more, the area within boundaries fixed by the Bureau of the Census shall be an urban area.*

NHTSA produces annual fact sheets on urban and rural crashes using the urban and rural definitions that FARS analysts report from each State. However, as FARS data are geocoded, the number of fatalities falling within the urbanized area boundary can be calculated using GIS. For consistency, beginning in 2016, NHTSA will begin reporting data using the FHWA adjusted urbanized areas geography.

Most States also use other definitions for urban and rural. Common definitions include considering crashes occurring inside the boundaries of a municipality "urban", or defining urban areas as those over a certain population threshold. The urban/rural definitions used for crash reporting forms are likely different from Federal definitions, so that is not a reliable source for these computations.

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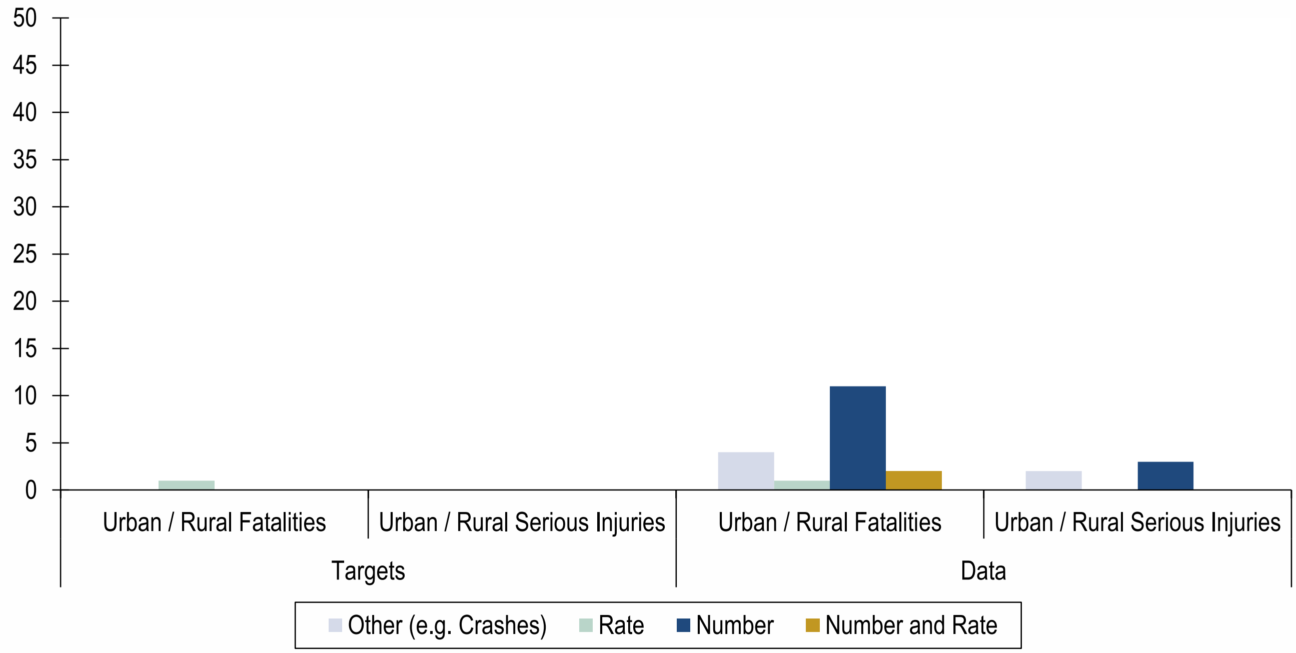
11 FARS Users Manual 1975-2012.

4.0 State of the Practice

In this section, because States currently do not necessarily track safety data by urbanized and nonurbanized area geographies, the terms urban and rural are used. Review of the most recent SHSPs, HSPs (FY 2014), and HSIP Annual Reports (FY 2013) in all 50 States revealed only one State (Georgia) set urban or rural targets in its SHSP (figure 4-1, left). A number of States include urban and rural fatality, serious injury, or crash data in their SHSPs to track overall trends (figure 4-1, right). Of those, some track the number of crashes within an SHSP emphasis area that are urban or rural.

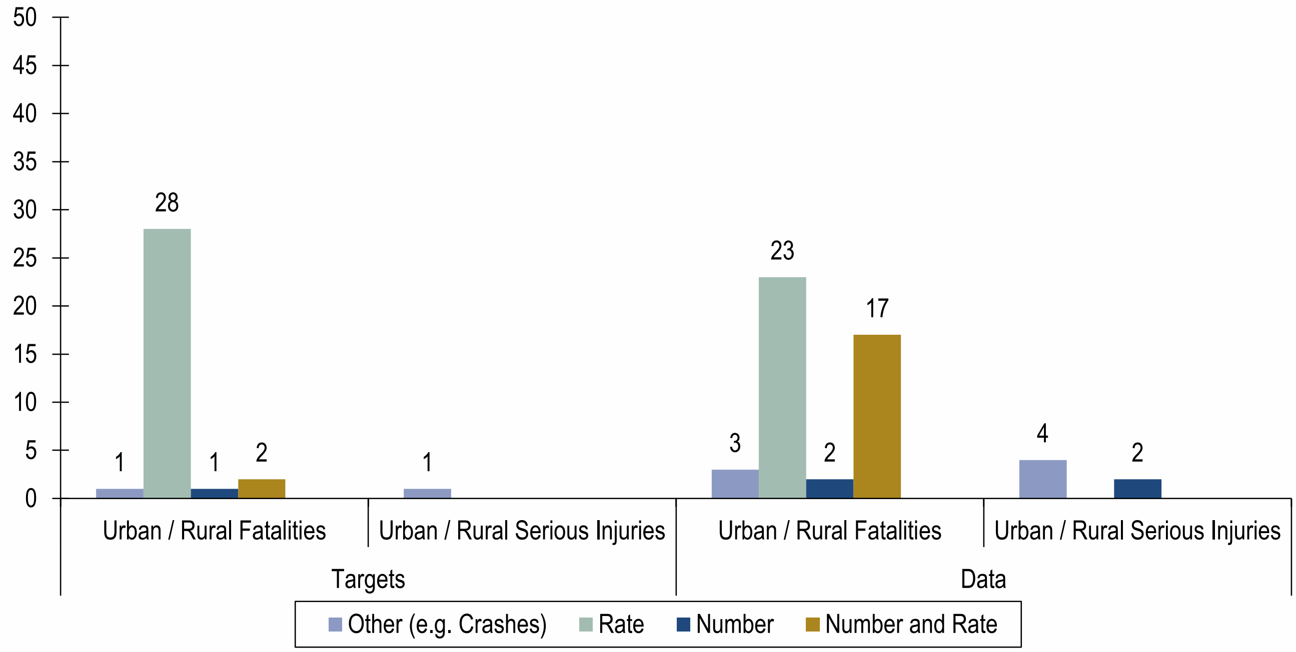
Figure 4-1 Existence of Urban and Rural Targets and Crash Data Analysis in SHSPs



Source: Cambridge Systematics, Inc.

States more commonly include safety targets for urban and rural areas in HSPs than in other State safety documents. This can be attributed to the 2008 *Traffic Safety Performance Measures for States and Federal Agencies* document which notes, "States should report both rural and urban fatalities/VMT as well as total fatalities/VMT." More than one-half of HSPs include urban fatality targets (figure 4-2, left), but only one includes an urban serious injury target. Nearly all HSPs track rates and/or numbers of urban and rural fatalities, but only a few States include urban and rural serious injury data (figure 4-2, right).

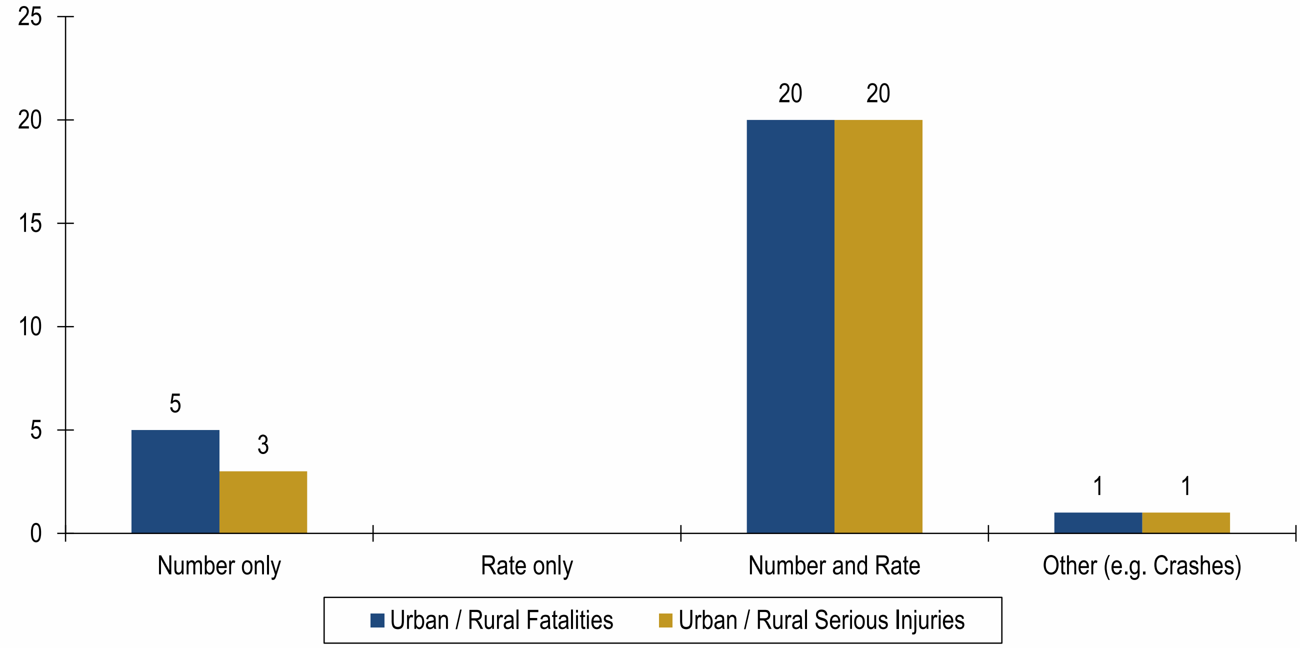
Figure 4-2 Existence of Urban and Rural Targets and Crash Data Analysis in HSPs



Source: Cambridge Systematics, Inc.

As there is no current requirement, no States report urban or rural safety targets in Highway Safety Improvement Plan (HSIP) Annual Reports. Some HSIP annual reports include data on urban and rural crashes, as shown in figure 4-3. Moving forward, it is expected States will begin to report safety targets in these documents, as proposed in the Safety PM NPRM.

Figure 4-3 Existence of Urban and Rural Crash Data Analysis in HSIP Annual Reports



Source: Cambridge Systematics, Inc.

The research team analyzed FARS data using GIS to calculate the proportion of fatalities in urbanized and nonurbanized areas according to the FHWA adjusted urbanized area geography using the most recent boundary data available for all States (2000). Table 4-1 summarizes the annual average number and percent of statewide fatalities located in urbanized and nonurbanized areas over a five-year period (2007 to 2011). In those cases where the sum of urbanized and nonurbanized area fatalities is less than the total, some fatalities were not able to be geolocated (e.g., location data were incorrect or missing), and these are indicated in table 4-1 as "annual average nonlocatable fatalities". As noted previously, the FHWA *adjusted urbanized area*[12] boundary includes only areas with population more than 50,000. There is wide variation across States in the percentage of fatalities that occur in urbanized areas, ranging from 6 percent for North Dakota to 84 percent in Massachusetts, which is a reflection of the extent to which the land area is urbanized in a State. On a national level, 41 percent of fatalities occur in urbanized areas and 59 percent in nonurbanized areas. The percentages of urbanized and nonurbanized area fatalities in table 4-1 are calculated after removing nonlocatable fatalities.

[12] When the term FHWA adjusted *urban* boundary is used in other contexts, this includes areas with population above 5,000.

Table 4-1 Annual Average Fatalities in Urbanized and Nonurbanized Areas
2007 to 2011

State	Total Annual Average Fatalities	Annual Average Nonlocatable Fatalities	FHWA 2000 Urbanized Area Fatalities	Percent Urbanized Area Fatalities	FHWA 2000 Nonurbanized Area Fatalities	Percent Nonurbanized Fatalities
Alabama	936	1	292	31%	643	69%
Alaska	67	0	20	29%	47	70%
Arizona	870	35	382	44%	453	56%
Arkansas	593	1	107	18%	485	82%
California	3,206	2	1,929	60%	1,275	40%
Colorado	493	0	196	40%	297	60%
Connecticut	272	4	203	74%	65	25%
Delaware	111	0	45	40%	66	60%
Florida	2,719	76	1,724	64%	919	37%
Georgia	1,355	59	501	37%	795	63%
Hawaii	113	4	40	36%	69	64%
Idaho	217	0	28	13%	190	87%
Illinois	1,009	0	517	51%	493	49%
Indiana	779	11	244	31%	524	69%
Iowa	396	1	70	18%	325	82%
Kansas	401	1	81	20%	319	80%
Kentucky	792	1	139	18%	652	82%
Louisiana	826	2	268	32%	556	68%
Maine	159	1	20	13%	138	87%
Maryland	546	5	330	60%	211	40%
Massachusetts	364	9	307	84%	48	16%
Michigan	954	0	435	46%	519	54%
Minnesota	433	0	111	26%	322	74%
Mississippi	727	0	96	13%	631	87%
Missouri	887	1	262	30%	624	70%
Montana	225	0	19	9%	206	91%
Nebraska	212	0	31	15%	181	85%
Nevada	289	1	160	55%	128	44%
New Hampshire	119	0	34	28%	85	72%
New Jersey	616	7	453	74%	156	26%
New Mexico	368	0	77	21%	292	79%

State	Total Annual Average Fatalities	Annual Average Nonlocatable Fatalities	FHWA 2000 Urbanized Area Fatalities	Percent Urbanized Area Fatalities	FHWA 2000 Nonurbanized Area Fatalities	Percent Nonurbanized Fatalities
New York	1,199	110	727	61%	362	39%
North Carolina	1,381	75	394	29%	912	71%
North Dakota	122	1	7	6%	114	94%
Ohio	1,113	1	465	42%	647	58%
Oklahoma	723	14	155	21%	554	79%
Oregon	379	1	86	23%	292	77%
Pennsylvania	1,365	3	552	41%	810	60%
Rhode Island	70	0	55	79%	15	21%
South Carolina	906	1	240	27%	665	73%
South Dakota	130	0	9	7%	121	93%
Tennessee	1,044	1	364	35%	679	65%
Texas	3,215	46	1,378	43%	1791	57%
Utah	262	0	115	44%	147	56%
Vermont	68	1	6	10%	61	91%
Virginia	823	46	304	37%	473	63%
Washington	499	3	206	41%	290	59%
West Virginia	364	1	54	15%	309	85%
Wisconsin	615	0	150	24%	466	76%
Wyoming	146	1	12	9%	133	91%
Total	35,476	2	14,402	41%	21,074	59%

Source: Cambridge Systematics, Inc.

To calculate fatality rates for adjusted urbanized areas, it was necessary to obtain VMT data from FHWA. Currently, VMT data are provided for urbanized areas on the FHWA Highway Statistics web site, but data are provided in the aggregate for urbanized areas spanning multiple States. Therefore, FHWA provided calculations for urbanized area VMT by State for use in this report. Each State must calculate VMT for its annual submission to the Highway Performance Monitoring System (HPMS) maintained by FHWA and should be in possession of its urbanized area VMT.

Table 4-2 shows average annual fatality rates using 2007 to 2011 FARS data and 2009 to 2011 VMT data. Ideally, a five-year average of VMT data would be used with five-year average fatalities, but for this study only select years of urbanized area VMT data by State were available. In every State, the nonurbanized fatality rate was higher than the urbanized fatality rate and statewide fatality rate. Statewide fatality rates range from 0.70 in Massachusetts to 2.03 in Montana. Urbanized area fatality rates are between 0.42 for Minnesota and 1.49 in Nevada, and nonurbanized fatality rates range from 1.08 in Minnesota to 2.95 in Nevada.

Table 4-2 FHWA 2000 Adjusted Urbanized Area Fatality Rates

State	Statewide Fatality Rate	Urbanized Area Fatality Rate	Nonurbanized Area Fatality Rate
Alabama	1.48	1.15	1.69
Alaska	1.46	1.22	1.59
Arizona	1.45	1.00	2.27
Arkansas	1.79	0.98	2.18
California	1.01	0.78	1.83
Colorado	1.06	0.70	1.61
Connecticut	0.89	0.79	1.41
Delaware	1.28	0.90	1.79
Florida	1.40	1.14	2.31
Georgia	1.30	0.83	1.93
Hawaii	1.20	0.80	1.65
Idaho	1.41	0.54	1.84
Illinois	0.99	0.74	1.56
Indiana	1.08	0.65	1.54
Iowa	1.29	0.77	1.51
Kansas	1.34	0.67	1.80
Kentucky	1.68	0.93	2.04
Louisiana	1.83	1.25	2.35
Maine	1.12	0.69	1.23
Maryland	1.00	0.84	1.37
Massachusetts	0.70	0.65	1.12
Michigan	1.01	0.76	1.42
Minnesota	0.77	0.42	1.08
Mississippi	1.88	0.98	2.19
Missouri	1.33	0.81	1.81
Montana	2.03	1.30	2.14
Nebraska	1.12	0.49	1.43
Nevada	1.91	1.49	2.95
New Hampshire	0.92	0.61	1.16
New Jersey	0.88	0.73	2.17
New Mexico	1.47	1.01	1.67
New York	0.95	0.83	1.24
North Carolina	1.34	0.76	1.92

State	Statewide Fatality Rate	Urbanized Area Fatality Rate	Nonurbanized Area Fatality Rate
North Dakota	1.45	0.47	1.68
Ohio	1.00	0.69	1.46
Oklahoma	1.53	0.79	2.05
Oregon	1.15	0.58	1.61
Pennsylvania	1.39	0.99	1.89
Rhode Island	0.87	0.79	1.39
South Carolina	1.87	1.18	2.38
South Dakota	1.46	0.53	1.67
Tennessee	1.53	1.07	1.99
Texas	1.41	0.94	2.27
Utah	1.05	0.72	1.62
Vermont	1.26	0.82	1.34
Virginia	1.03	0.64	1.60
Washington	0.90	0.56	1.54
West Virginia	1.91	1.00	2.27
Wisconsin	1.06	0.63	1.37
Wyoming	1.58	1.19	1.63
Total	1.23	0.84	1.80

Source: Fatality rate based on annual average 2007 to 2011 FARS and 2009 to 2011 VMT provided by FHWA.

As shown in table 4-2, the nonurbanized fatality rate nationally is 1.8, and the urbanized area fatality rate is 0.84.

When comparing two States using fatality rates, one State may appear to be safer than another based on a comparison of their statewide fatality rates; however, the other State could look safer based on a comparison of urbanized fatality rates. Simpson's Paradox represents the statistical phenomenon of stratifying aggregate data into two or more groups, and finding that analysis of the smaller groups results in opposing conclusions. It illustrates how the safety profile of a State is affected by the proportion of urbanized and nonurbanized VMT in the calculation.

Table 4-3 shows California has a lower statewide fatality rate than South Dakota; therefore, California roads appear safer. However, the fatality rates for urbanized and nonurbanized areas are both lower in South Dakota than in California.

Table 4-3 Simpson's Paradox Illustration

State	Percent Urbanized Area VMT	Percent Nonurbanized Area VMT	Statewide Fatality Rate	Urbanized Area Fatality Rate	Nonurbanized Area Fatality Rate
California	78%	22%	1.01	0.78	1.83
South Dakota	19%	81%	1.46	0.53	1.67

Source: Fatality rate based on annual average 2007 to 2011 FARS and 2009 VMT provided by FHWA.

A national dataset does not exist with comprehensive, high quality injury crash data like the FARS database for fatal crashes. To conduct GIS analysis of crash locations and determine the proportion of urbanized and nonurbanized serious injury crashes, locations of all serious injury crashes on all public roads are needed for at least one if not multiple five-year periods. To analyze the proportion of urbanized versus nonurbanized serious injuries, the study team collected data on serious injuries maintained in State crash records systems from all 50 States.

The study team ultimately obtained usable data for 20 States, which is presented in table 4-4. Usable data was defined as data for which crashes on all public roads were geolocated, and for which data on serious injuries was clearly identified separately from other levels of injury severity. For each State, five years of data were used, but not all time periods were consistent, as noted in the columns to the right. The percentage of serious injuries in urbanized areas is higher than for fatalities. Crashes in urbanized areas differ from those in nonurbanized areas (e.g., there are more bicycle, pedestrian, and intersection crashes in urbanized areas). To calculate the proportion of serious injuries in urbanized versus nonurbanized areas, the 2000 map of adjusted urbanized areas was used, which was the last year for which GIS data were available for all States.

Table 4-4 Serious Injury Numbers for Select States

State	Percent of Urbanized	Percent of Nonurbanized	Number of Serious Injuries	Number of Urbanized Serious Injuries	Number of Nonurbanized Serious Injuries	Start Year	End Year
Alaska	51.6%	48.4%	435	225	211	2006	2010
Arizona	67.1%	32.9%	5,020	3,367	1,652	2008	2012
Colorado	49.2%	50.8%	4,128	2,033	2,096	2008	2012
Iowa	30.7%	69.3%	1,694	520	1,175	2008	2012
Illinois	66.5%	33.5%	9,704	6,456	3,248	2008	2012
Louisiana	43.2%	56.8%	1,424	616	808	2008	2012
Maine	27.7%	72.3%	636	176	460	2008	2012
Michigan	50.6%	49.4%	6,116	3,093	3,022	2008	2012
Minnesota	22.3%	77.7%	1,268	283	984	2008	2012
Missouri	39.3%	60.7%	6,143	2,416	3,727	2008	2012
Montana	13.4%	86.6%	1,094	147	947	2008	2012
Nebraska	33.8%	66.2%	1,721	582	1,139	2007	2011
New Jersey	64.1%	35.9%	1,532	982	550	2008	2012
New York	68.9%	31.1%	12,932	8,912	4,019	2008	2012
Ohio	52.1%	47.9%	9,720	5,061	4,659	2008	2012
Oklahoma	39.4%	60.6%	3,663	1,445	2,218	2008	2012
Oregon	43.3%	56.7%	1,537	666	871	2008	2012
Pennsylvania	46.5%	53.5%	2,871	1,335	1,537	2008	2012
South Dakota	21.7%	78.3%	837	182	655	2008	2012
Texas	50.7%	49.3%	15,459	7,839	7,621	2009	2013

Source: Cambridge Systematics, Inc., and State crash databases.

Table 4-5 presents serious injury rates, which are significantly higher than fatality rates, given the numbers of serious injury crashes are higher than fatal crashes. The table presents annual average data for a five-year period, but not all time periods are consistent, as noted by the columns indicating the years included in the analysis.

Table 4-5 Serious Injury Rates for Selected States

State	Annual Average Number of Serious Injuries	Statewide Serious Injury Rate (per 100 MVMT)	Urbanized Area Serious Injury Rate (per 100 MVMT	Nonurbanized Serious Injury Rate	Start Year	End Year
Alaska	435	9.4	13.7	7.1	2006	2010
Arizona	5,020	8.4	8.8	7.7	2008	2012
Colorado	4,128	8.9	7.2	11.4	2008	2012
Iowa	1,694	5.5	5.7	5.5	2008	2012
Illinois	9,704	9.5	9.2	10.3	2008	2012
Louisiana	1,424	3.2	2.9	3.4	2008	2012
Maine	636	4.5	6.1	4.1	2008	2012
Michigan	6,116	6.5	5.4	8.3	2008	2012
Minnesota	1,268	2.3	1.1	3.3	2008	2012
Missouri	6,143	9.2	7.4	10.8	2008	2012
Montana	1,094	9.9	10.0	9.8	2008	2012
Nebraska	1,721	9.1	9.2	9.0	2007	2011
New Jersey	1,532	2.2	1.6	7.3	2008	2012
New York	12,932	10.3	10.1	10.6	2008	2012
Ohio	9,720	8.7	7.5	10.5	2008	2012
Oklahoma	3,663	7.7	7.3	8.0	2008	2012
Oregon	1,537	4.7	4.5	4.8	2008	2012
Pennsylvania	2,871	2.9	2.4	3.6	2008	2012
South Dakota	837	9.4	10.8	9.1	2008	2012
Texas	15,459	6.8	5.3	9.4	2009	2013

Source: Cambridge Systematics, Inc., State crash databases, VMT data for 2009 to 2011 provided by FHWA.

5.0 Safety Target Setting Framework

5.1 What is Evidence-Based Target Setting?

MAP-21's performance management orientation has increased attention to performance measures and target setting. The policy in USC 23 (150) states:

> *Performance management will transform the Federal-aid highway program and provide a means to the most efficient investment of Federal transportation funds by refocusing on national transportation goals, increasing the accountability and transparency of the Federal-aid highway program, and improving project decision-making through performance-based planning and programming.*

The Safety PM NPRM provided an indication of potential Federal guidance on target setting implementation and presented the option for urbanized and nonurbanized area target setting. As with any management framework, understanding the semantics of the elements of the framework is important to effectively implement the approach. This section presents an approach to evidence-based target setting. The NHTSA Interim Final Rule calls for evidence-based target setting. It states:[13]

> *"State HSPs must now provide for performance measures and targets that are evidence-based…. The State process for setting targets in the HSP must be based on an analysis of data trends and a resource allocation assessment."*

There are two basic ways to think about target setting, one of which is evidence based:

- **Aspirational or vision-based targets.** Sometimes, agencies will use "target" to refer to a long-term vision for future performance—the ultimate goal. Many transportation agencies are setting vision-based targets for zero fatalities (i.e., Vision Zero, Toward Zero Deaths); and interim targets for progress towards this vision (i.e., reduce fatalities by one-half within 20 years).
- **Evidence or investment-based targets.** Evidence-based target setting is a narrower approach to target setting—focused specifically on what can be achieved within the context of a set of investments, policies, and strategies defined within a shorter timeframe when future trends can be forecasted with more accuracy based on available data.

In the context of MAP-21, HSIP[14] annual reports will have to include targets and explain how fatalities and serious injuries will be reduced. This is evidence-based target setting, examining how a specific set of actions contributes to improved performance over a specific time horizon. In addition, when a performance measure, such as the number of urbanized area fatalities, is used by multiple agencies (e.g., State DOT and SHSO), the targets will need to be aligned.

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[13] http://www.gpo.gov/fdsys/pkg/FR-2013-01-23/html/2013-00682.htm.

[14] The HSIP is the safety program through which infrastructure-oriented safety projects are prioritized and programmed. The projects identified in the HSIP also are included in the State Transportation Improvement Program (STIP).

While these two approaches are distinct, they are not necessarily in conflict. A zero-based vision or target is useful for galvanizing support around a planning effort, and for ensuring successful strategies are considered and/or implemented while keeping the focus on a clear long-term goal.

Evidence-based targets, in contrast, promote accountability and encourage agencies to consider the tradeoffs of their investments across different program areas. Being able to demonstrate the benefits of different levels of investment in safety (and other programs) helps decision-makers better understand the implications of investment in various program areas. Target setting with this approach is derived from considering the tradeoffs among investment levels.

5.2 How to Conduct Evidence-Based Target Setting

The basic concept for evidence-based target setting is to link investments and policy decisions to performance. Typically, this is done by reviewing the achievements resulting from previous investments and applying that knowledge to estimate the expected improvement in safety outcomes likely to be achieved given varying levels of investment in the future.

As agencies begin setting evidence-based targets, the approaches outlined below should be considered. The steps for using countermeasure data in target setting are relatively simple, although implementation may be complex:

1. Use trend analysis.

2. Consider exogenous factors (i.e., population, distribution between urbanized and nonurbanized areas, anticipated policies).

3. Forecast fatality reductions based on planned implementation of proven countermeasures:

    a. Identify potential for application of countermeasures (through SHSP, HSP, HSIP, or other planning processes);

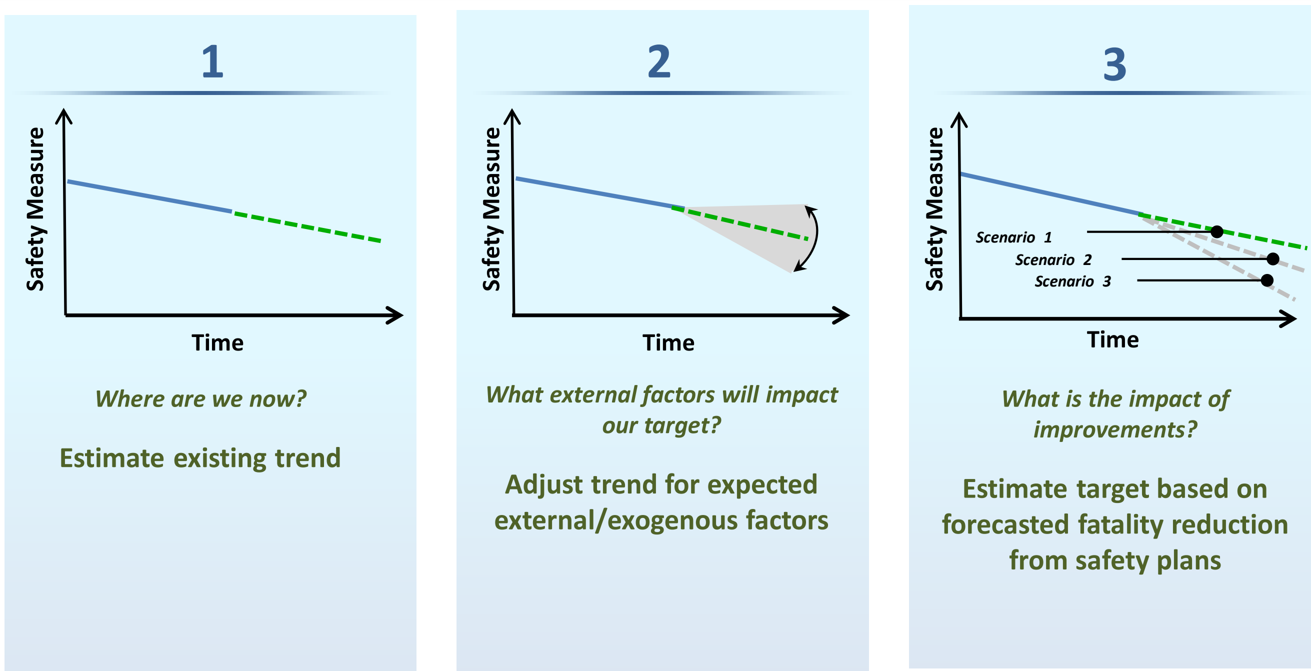
    b. Identify data on expected countermeasure or legislation impact;

    c. Develop constrained list of countermeasures based on expected effectiveness and available resources (i.e., expected lives saved per dollar of investment); and

    d. Estimate system, region, or State benefits based on the aggregation of expected countermeasures, discounting for potential overlap among emphasis areas.

Once the trend line forecast is developed, consideration of exogenous factors and forecasted fatality reductions will help quantitatively estimate how aggressive the target can be. Agencies may wish to include countermeasures not previously implemented. For those projects or programs without known effectiveness data, evaluation should be included as a component of the project. Figure 5-1 shows how these steps can be used to develop an evidence-based fatality target and what questions are being answered at each phase.

Figure 5-1 Target Setting Steps



Source: Cambridge Systematics, Inc.

The appropriate combination of the steps described above will depend on the factors and issues in each State or region. While these steps are quite general, they point to a direction agencies can pursue, and some illustrative examples are provided in this report. In the short term, agencies will have to consider multiple pieces of information to set a meaningful, evidence-based target. Safety analysis tools currently available are described below, as well as an overview of each of the analytical approaches. Details on data and methodologies are provided in section 6.

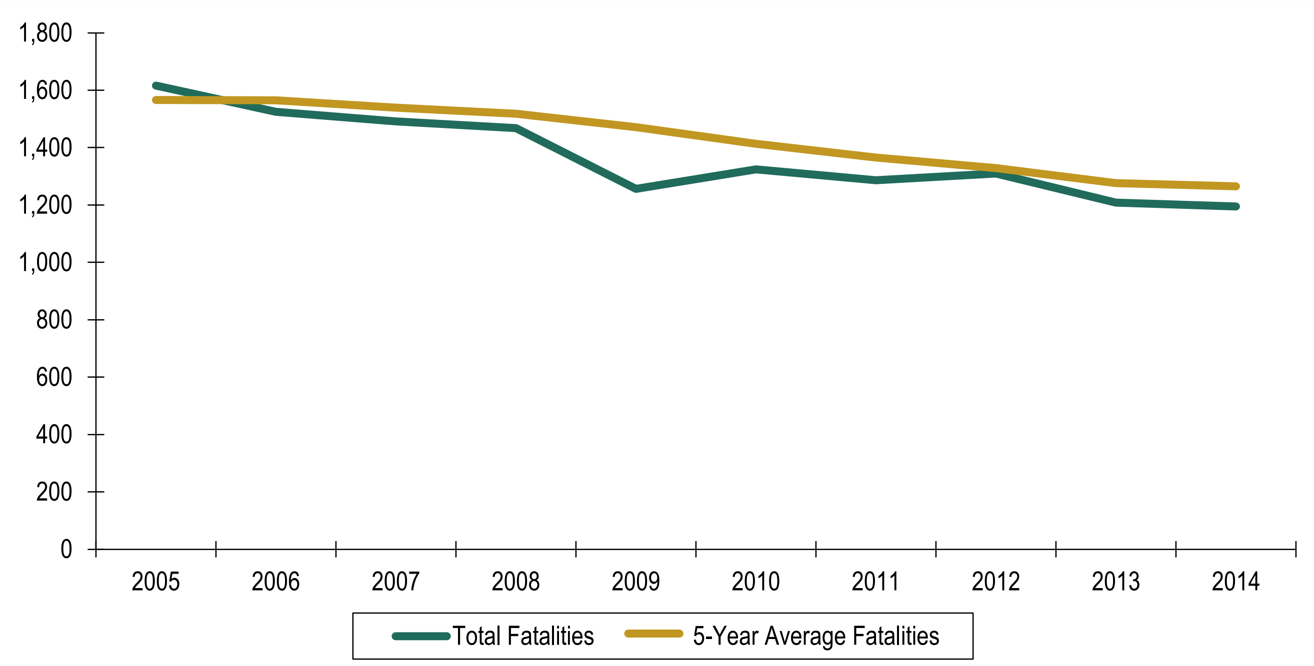
Using Trend Analysis

Examining fatality trends is a simple approach. It is generally the first step States take in understanding safety performance and potential future safety gains. Given the potential variation in crashes and severity each year, it is common for States to look at a rolling average of multiple years, as well as single-year results. American Association of State Highway and Transportation Officials' (AASHTO) Standing Committee on Performance Management (SCOPM) recommends in its *SCOPM Task Force Findings on MAP-21 Performance Measure Target-Setting*[15] that States use five-year moving averages to evaluate trends.

[15] *SCOPM Task Force Findings on MAP-21 Performance Measure Target-Setting*, http://scopm.transportation.org/Documents/SCOPM%20Task%20Force%20Findings%20on%20Performance%20Measure%20Target-Setting%20FINAL%20v2%20(3-25-2013).pdf, page 13.

Figure 5-2 is a graphical example of trend analysis showing both a multiyear average and individual year data. As shown, multiyear averages smooth the variation in the data year to year. More detail on calculating trends and projections is provided in section 6.9 on Projection Methods.

Figure 5-2 Pennsylvania Roadway Fatality Trend



Source: *Pennsylvania Highway Safety Plan*, Cambridge Systematics, Inc.

Consideration of Exogenous Factors

Agencies will likely want to consider the impact of exogenous factors, those which are outside the safety field but affect safety, in defining their targets. Because demographic and technological factors play a significant role in safety, it is important to consider how these trends impact target setting.

Technology is likely to play a major role in helping the U.S. and other nations reduce fatalities, serious injuries, and crashes. Recently, in-vehicle technology, such as curtain airbags or rearview cameras, has been one of the largest contributors to improved roadway safety. New technologies, such as vehicles that “read the road” (e.g., can identify lane markings and help reduce lane departure) and self-driving vehicles, will have major safety implications. Because many of these technologies are immature, the task in the short term is to determine how much can be achieved with currently available technologies and other nontechnology-oriented strategies.

Demographics are one factor explaining variation in fatalities. Population is increasingly shifting into urban areas. The nation's urban population increased by 12.1 percent from 2000 to 2010, outpacing the nation's overall growth rate of 9.7 percent for the same period, according to the U.S. Census Bureau.[16]

Another consideration is how involvement in fatal crashes varies greatly based on age and gender. For example, the crash rate for drivers age 16 to 19 is 4.6 crashes per 100 million VMT (100 MVMT), compared to 1.2 crashes per 100 MVMT for ages 30 to 69.[17] Within these age groups, crash rates are higher for males than females. Taking into account forecasted demographic trends can help States develop better targets.

It is often useful to leverage the experience of other States when evaluating the impact of exogenous factors. States or regions that have undergone similar transitions can provide helpful insights about expected safety impacts.

Impact of Legislative Changes

Implementation of key safety legislation can have a significant impact on traffic safety. As shown in figure 5-3, at a national level, legislative changes resulting from Federal transportation bills are correlated with reductions in the number of fatalities and the fatality rate.

Evidence at the State level suggests enacting legislation, such as primary seatbelt laws, motorcycle helmet laws, and strengthened graduated driver licensing (GDL) requirements, reduces fatalities.[18] However, the degree of fatality reduction is tied to the level of resources applied to implementation and enforcement. Information about calculating performance of planned improvements is provided in section 6.7.

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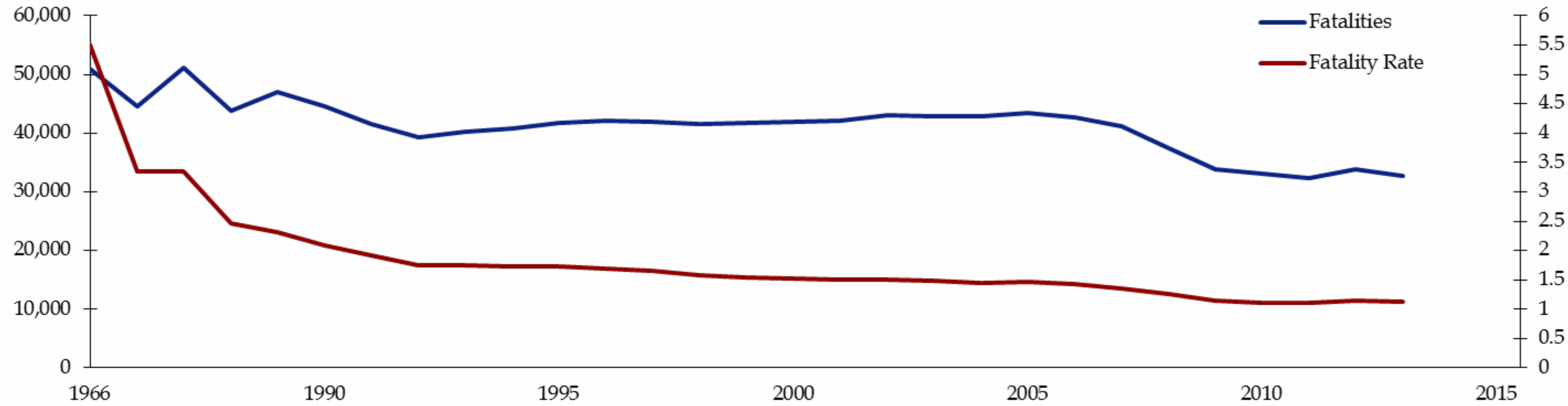
16 https://www.census.gov/newsroom/releases/archives/2010_census/cb12-50.html.

17 http://www.iihs.org/iihs/topics/t/teenagers/fatalityfacts/teenagers.

18 Countermeasures that Work, 2013, NHTSA.

Figure 5-3 National Legislative History and Fatality Trends



1966

National Traffic and Motor Vehicle Safety Act

- Federal Motor Vehicle Safety Standards (FMVSS)
- Research and Development
- National Driver Register

Highway Safety Act

- Highway Safety Grant Program
- Federal/State Partnership

1973

Highway Safety Act

- High-crash locations, benefit-cost analysis, project prioritization
- Categorical funding (e.g., highway-rail grade crossing)

1991

ISTEA

- Safety Management Systems (SMS)
- MPO authority
- More flexible

1998

TEA-21

- Safety and security planning factor

1999

Motor Carrier Safety Improvement Act

- Federal Motor Carrier Safety Administration (FMCSA)

2005

SAFETEA-LU

- Safety as a standalone planning factor
- HSIP as a core funding program
- SHSP requirement

2012

MAP-21

- Performance management and performance-based planning
- Streamlining funding

ISTEA—Intermodal Surface Transportation Efficiency Act of 1991; TEA-21—Transportation Equity Act for the 21st Century; and SAFETEA-LU—Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users.

Source: Cambridge Systematics, Inc.

Forecasting Reductions Based on Planned Implementation of Proven Countermeasures

Agencies can use performance analysis to understand what is likely to be achieved by a planned safety program, which can then inform the evidence-based target setting process. This approach builds on existing efforts by State DOTs to understand effectiveness of countermeasures implemented in their State. State DOTs, FHWA, and other national research organizations examine countermeasure effectiveness on an ongoing basis.

Particularly for infrastructure improvements, forecasts of safety impacts resulting from implementation of proven countermeasures can be made using crash modification factors (CMF). Agencies can draw upon nationally developed CMFs, such as those provided in the Highway Safety Manual (HSM) or the CMF Clearinghouse, as well as the knowledge they already have about the effectiveness of projects implemented in their State or region. Results from implemented projects that address the unique conditions of the State or region are likely the most useful. A target is evidence based if it incorporates the expected results of a set of improvements in a plan.

Traditional benefit-cost analysis estimates the value of potential crash reduction based on CMFs for a given treatment. States can also look at the impact of a broader set of investments on fatalities by comparing historical investment trends against the associated impact on targeted crashes to determine what types of investments are most effective in reducing fatalities. This will help provide a sense of the level of investment required to reduce fatalities in one emphasis area compared to another.

Under MAP-21, States are required to report to the U.S. DOT Secretary on progress made implementing highway safety improvements, the effectiveness of those improvements, and the extent to which fatalities and serious injuries on all public roads have been reduced, including a breakdown by functional classification and ownership to the maximum extent practicable.[19] As part of this reporting process, States have to describe the effectiveness of HSIP-funded projects. States also should determine the benefits and costs of not only infrastructure programs, but also behavioral, enforcement, Emergency Medical Services (EMS), and other programs. This type of evaluation should be incorporated into as many projects as possible for which good effectiveness data do not yet exist to develop new CMFs.

Behavioral programs are impacted by the manner of implementation, and a State's culture and effectiveness data are less likely to be available; therefore, it is even more beneficial for States to study program effectiveness on behavioral countermeasures. This will enable States to know which programs are delivering results and are most cost-effective. Moving forward, this State-specific safety effectiveness information will help determine which programs to replicate and expand, and which to modify or discontinue. The results can be used to forecast the outcomes of a safety plan and support the target setting process. For example, on average, States that pass primary seat belt laws can expect to increase seat belt use by eight-percentage points. Depending on the level of high-visibility enforcement that they employ, however, far greater results are possible. One study found that

[19] http://www.fhwa.dot.gov/map21/factsheets/hsip.cfm.

passenger vehicle driver death rates dropped by seven percent when States changed from secondary to primary enforcement.[20]

Safety Analysis Tools

In recent years, a number of safety analysis tools have become available that can aid in forecasting fatality and injury reductions associated with countermeasures. Estimating the impact of safety projects supports the development and refinement of evidence-based safety targets. Tools include the following:

- **Highway Safety Manual (HSM)** provides practitioners with information and tools to consider safety when making decisions related to design and operation of roadways. The HSM assists practitioners in selecting countermeasures and prioritizing projects, comparing alternatives, and quantifying and predicting the safety performance of roadway elements considered in planning, design, construction, maintenance, and operation.
- **Interactive Highway Safety Design Model (IHSDM)** is a suite of software analysis tools for evaluating safety and operational effects of geometric design decisions on highways. IHSDM is a decision support tool that provides estimates of existing or proposed highway designs' expected safety and operational performance, and checks designs against relevant design policy values.
- ***SafetyAnalyst*** provides a set of software tools used by State and local highway agencies for highway safety management. It incorporates state-of-the-art safety management approaches into computerized analytical tools for guiding the decision-making process to identify safety improvement needs and develop a systemwide program of site-specific improvement projects.
- **HSIP Manual** provides an overview of the HSIP and presents State and local agencies with tools and resources to implement the HSIP. The manual provides information related to planning, implementation, and evaluation of State and local HSIPs and projects.
- **CMF Clearinghouse** provides a regularly updated on-line repository of CMFs, which are used to forecast the impact of a countermeasure on crash frequency and severity. The Clearinghouse also provides a mechanism for sharing newly developed CMFs and educational information on the proper application of CMFs.
- **Countermeasures That Work** is a resource, updated annually by NHTSA, which documents the effectiveness of safety countermeasures for noninfrastructure-oriented major highway safety problem areas (e.g., behaviors, population groups, and vulnerable user types). Calculating effectiveness of noninfrastructure strategies is more challenging than that for infrastructure-oriented approaches. Nevertheless, this resource provides evidence-based information that can inform project result forecasts and safety target setting.

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[20] NHTSA, *Countermeasures that Work: A Highway Safety Countermeasure Guide for State Highway Safety Offices*, Seventh Edition, 2013.

6.0 Data and Methods for Evidence-Based Urbanized and Nonurbanized Targets

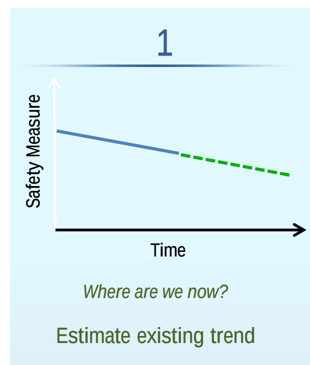
Safety analysis is a data-driven process. For performance measures to be useful, relevant data must exist. Realistic targets also require the existence of appropriate data. This section outlines the core data needed for fatality and serious injury target setting and identifies other data useful for further refining safety targets. The information is grouped into three categories: 1) trend data; 2) data on exogenous factors; and 3) countermeasure impact data.

The following sections walk through the technical analysis aspects of methods and data requirements for setting urbanized and nonurbanized safety targets.

6.1 Step 1. Identifying Trends

Fatality and Serious Injury Data

A core data element States must collect for trend analysis is fatalities. Fatal crash data are high quality as they are standardized among States and available in the national FARS database. Each State has one or more FARS analysts who review crash reports and correct errors. All fatal crashes include detailed location data and can be mapped in GIS, which is necessary to enable analysis of data and target setting for urbanized or nonurbanized areas. FARS contains comprehensive information on factors involved in each crash, which enables understanding the distribution of crash types between urbanized and nonurbanized areas. Therefore, analyzing trends for fatalities and fatality rates by urbanized versus nonurbanized areas is feasible for all States. It is useful to observe actual annual data trends, as well as five-year moving average trends, as will be required for Federal safety performance monitoring.



Source: Cambridge Systematics, Inc.

Serious injury data is less straightforward. The primary challenge for setting serious injury targets is the quality of injury data, which are maintained individually by States in their own crash databases. The quality of injury data varies greatly. Key aspects of injury data that affect the ability to set urbanized and nonurbanized area targets are crash location, injury severity, years of data available, and data completeness, which are described in more detail below.

Crash Location Information

To categorize crashes as urbanized or nonurbanized, accurate information on crash location is needed. Ideally, datasets include latitude and longitude coordinates so the exact point location of a crash can be identified. Many States use Geographic Positioning System (GPS) data as part of the crash reporting process, so latitude and longitude are part of each crash record. With point location data such as these, crashes can easily be mapped in GIS and determined to be inside or outside the FHWA-adjusted urbanized area boundary. One concern related to the use of GPS coordinate data is that the law enforcement officer must take the GPS reading at the exact crash location, which is not always possible. Map-based location methods are becoming increasingly common, which should improve the accuracy of crash location data. With this approach, the law enforcement officer locates the crash on an electronic map, clicks on the map, and coordinates and other location information are automatically entered into the crash record.

Another approach to location of crashes is the use of a State's linear referencing system (LRS). Linear referencing is used by many State DOTs to associate features (e.g., signs, guardrail, etc.) or events with the roadway network. The LRS is associated with the State's roadway infrastructure file, so crashes can be located with respect to mileposts or other roadway location information. This approach to locating crashes is generally quite good, although location information may have a margin of error. For example, if a State has mileposts only every mile, a responder to the crash scene will note the closest milepost on the crash report, but the actual crash location could be some distance of less than a mile away from that milepost. Most States are working toward development of a high-quality LRS, but some currently do not have a fully functional system in operation.

A number of States have location data only for crashes on the State highway system and are missing this information on nonstate-owned facilities. This is frequently the case because State law enforcement agencies usually have the ability to input crash reports electronically in their vehicles, possibly with the assistance of GPS for crash locations, but local law enforcement agencies may not.

In the absence of precise location data described above, some location data for serious injury crashes may be available, such as an address, zip code, or the jurisdiction in which a crash occurred (e.g., city name). These data can be useful in determining whether injuries have occurred within or outside the FHWA-adjusted urbanized area, especially if entire zones (i.e., city or zip code) are known to be contained within a boundary. Some assumptions would need to be made, however, in the event the FHWA urbanized area boundary bisects one or more zones.

Injury Severity

A second facet of working with data to calculate serious injury numbers or rates is knowing the severity of injury crashes. To calculate a serious injury number or rate, it is necessary to separate severe injury crashes from other injury crashes.

The Safety PM NPRM proposes to define serious injuries in a manner that would provide for a uniform definition for national reporting in this performance area. The NPRM proposes States adopt the latest edition Model Minimum Uniform Crash Criteria (MMUCC) definition and attribute for ''Suspected Serious Injury (A).''

The MMUCC is a voluntary and collaborative effort to generate uniform, accurate, reliable, and credible crash data for data-driven highway safety decisions within a State, between States, and at the national level. These guidelines suggest a manner for classifying all data associated with a crash in a State's crash database, including injury severity. Each State, however, maintains its own crash form and only periodically updates the crash form because doing so requires financial and staff resources, and makes it difficult to compare data across years. Over time, States are modifying crash data and increasingly following the MMUCC; however, significant variation still occurs among terms used in each State. The NPRM proposes a requirement to use the latest version of the MMUCC (currently Version 4), which means some States need to change crash report forms. Injury severity classification often varies by State; States may use the KABCO scale shown in table 6-1, or record injury severity using other categories. Category A below is the code used for calculating numbers or rates of suspected serious injuries.

Table 6-1 KABCO Injury Classification

Classification	Definition
O	Property Damage Only
C	Possible Injury
B	Suspected Minor Injury
A	Suspected Serious Injury
K	Fatal Injury
U	Unknown

Source: MMUCC, Version 4.

To calculate the number of serious injuries or a serious injury rate, the data required is the number of people experiencing injuries. In some cases, crash databases are oriented around the crash and do not reliably report the number of persons injured and the level of injury severity sustained by each person. For the purpose of developing a serious injury target, it must be possible to isolate only those people sustaining serious injuries and information about those crashes. In the event information is available only for the crash severity, but not for the number of injuries or severity of injuries, it is possible to make assumptions about the number of severe injuries resulting from each crash type, but this will not be as accurate as if the data were reported directly. States could use the information on the probability that a crash of unknown severity (e.g., table, 6-2, right two columns) will result in a certain level of severity on the Abbreviated Injury Scale (AIS). For example, if a person were in a nonfatal crash and injury data were unknown (far right column), an analyst could assume a 4.8 percent probability of AIS injury Level 3, or serious injury. These conversions could be applied to all injuries for which the severity is unknown or nonfatal crashes to estimate the number of serious injuries occurring.

Table 6-2 KABCO/Unknown AIS Data Conversion Matrix

AIS	O No injury	C Possible Injury	B Nonincapacity Injury	A Incapacity Injury	K Killed	U Injured Severity Unknown	Nonfatal Accidents Unknown if Injured
0	0.92534	0.23437	0.08347	0.03437	0.00000	0.21538	0.43676
1	0.074257	0.68946	0.76843	0.55449	0.00000	0.62728	0.41739
2	0.00198	0.06391	0.10898	0.20908	0.00000	0.10400	0.08872
3	0.00008	0.01071	0.03191	0.14437	0.00000	0.03858	0.04817
4	0.00000	0.00142	0.00620	0.03986	0.0000	0.00442	0.00617
5	0.00003	0.000013	0.00101	0.01783	0.00000	0.01034	0.00279
Fatality	0.00000	0.00000	0.00000	0.00000	1.00000	0.00000	0.00000
Sum (Prob)	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Source: NHTSA, July 2011, as published in the Transportation Investment Generating Economic Recovery (TIGER) Benefit-Cost Analysis Resource Guide, updated May 3, 2013.

Table 6-3 shows how the KABCO scale compares to the AIS scale.

Table 6-3 Comparison of Injury Severity Scales
KABCO and AIS

Reported Accidents (KABCO or Number of Accidents Reported)		Reported Accidents (AIS)	
O	No injury	0	No injury
C	Possible injury	1	Minor
B	Nonincapacitating	2	Moderate
A	Incapacitating	3	Serious
K	Killed	4	Severe
U unknown)	Injury (severity	5	Critical
Number of Accidents Reported	Unknown if injured	6	Unsurvivable

Source: NHTSA, July 2011, as published in the TIGER Benefit-Cost Analysis Resource Guide updated May 3, 2013.

Vehicle Miles Traveled

The second core set of safety performance measures are fatality and serious injury rate (the number of fatalities or serious injuries as a function of VMT). Historical data from FHWA, State, and regional sources, as well as forecasts from a travel demand model are needed to calculate fatality rate trends and forecast future fatality rates. VMT data are needed for the geographic area for which the fatality rate is being calculated. These data are needed to understand underlying travel demand (total fatalities may be decreasing simply due to less travel) and to normalize fatalities into fatality rates. At a State level this is fairly straightforward, because each State reports VMT annually via the Highway Performance Monitoring System (HPMS).

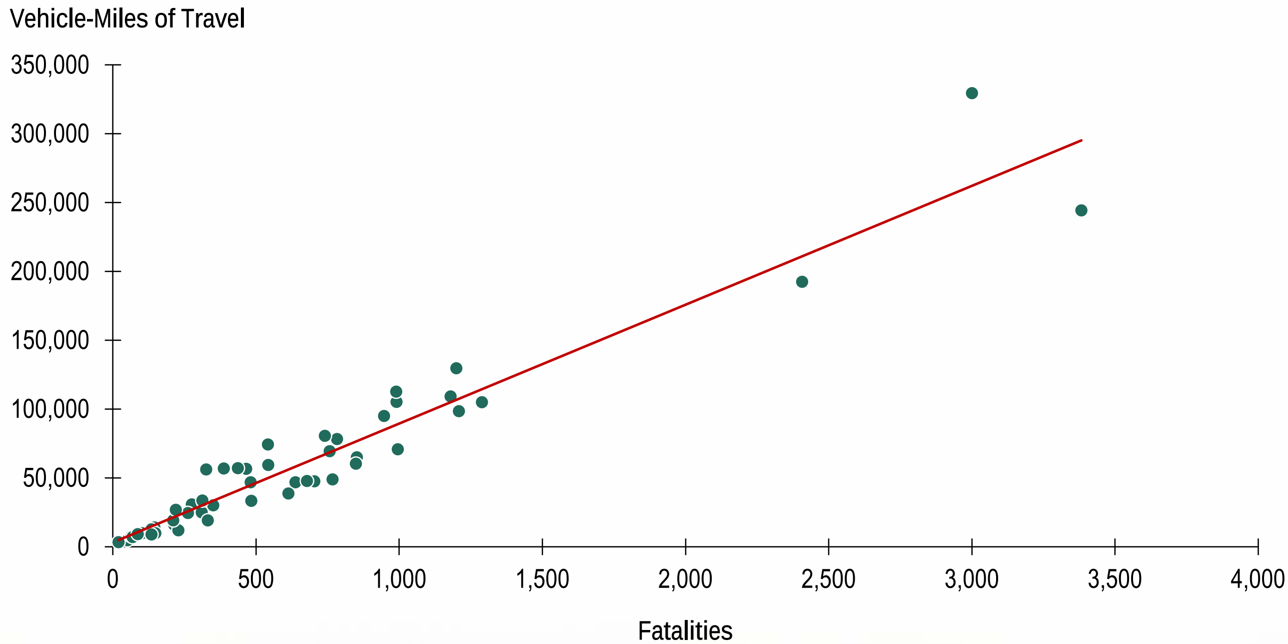
To calculate urbanized and nonurbanized crash rates, VMT data must be available for urbanized and nonurbanized areas. Safety analysts will need to know whether the State has formally approved its adjusted urbanized area boundaries and reported them to FHWA, and obtain VMT for that same geographic area. Given the typical lag time between the decennial Census and State definition of adjusted urbanized area boundaries, and that the adjustment of boundaries is not mandatory, it will be important to obtain clarity on the State's policies and process for establishing and finalizing these boundaries. The State should be submitting VMT data to FHWA for the urbanized area geography so these data should be readily available via the Highway Statistics Series published by U.S. DOT[21] (tables HM-71 and HM-72). FHWA will be refining these data to provide VMT by urbanized area by State in the future so these data will be more easily accessible in future years.

[21] http://www.fhwa.dot.gov/policyinformation/statistics.cfm.

The VMT data used in the rate calculations should be from the same years as the data used to calculate the fatality or serious injury number performance measures. Additionally, when establishing targets, it will be useful to understand forecasted VMT growth rates in urbanized and nonurbanized areas.

Figure 6-1 shows the linear relationship between statewide annual average VMT and the number of fatalities in 2013 at the aggregate level—the more exposure to risk in terms of more miles traveled, the higher the number of fatalities. However, each State should consider evaluating its own trends as significant variation exists across States. For example, several States, such as Utah and Washington, have experienced increasing population and VMT concurrent with decreasing fatalities, due at least in part to effective safety programs. In addition, given other trends such as declining vehicle licensure among younger drivers, it is useful to carefully monitor VMT trends and the relationship to safety results.

Figure 6-1 Relationship between VMT and Fatalities
By State



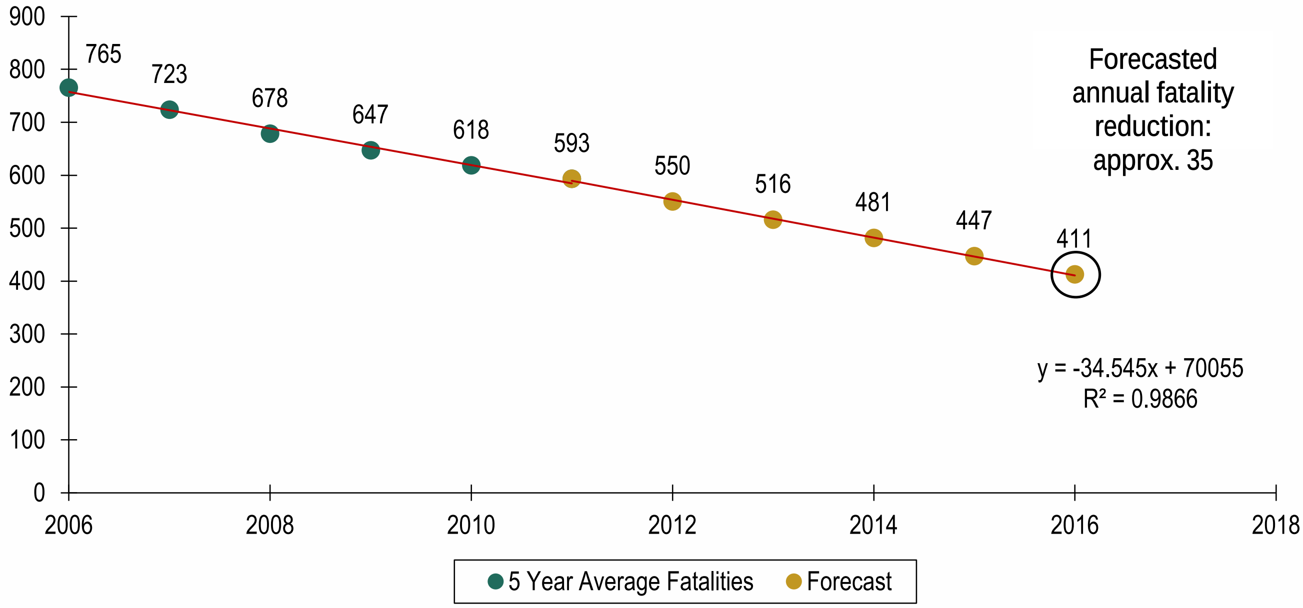
Source: Cambridge Systematics, FARS 2013.

6.2 Step 1—Trend Example

The first step in setting urbanized and nonurbanized targets is to evaluate statewide fatality and serious injury trends broken down by urbanized and nonurbanized areas. A good practice is to use a 5-year moving average for 10 years of data, resulting in six data points. States will need to take into account the target set for statewide fatalities or serious injuries and ensure targets for urbanized and nonurbanized areas ultimately add up to the total reduction target.

Figures 6-2, 6-3, and 6-4 show sample State trend data for total, urbanized, and nonurbanized area fatalities using five-year moving averages, which also are forecast out five years into the future using linear regression. The green circles represent historical sample data, and the gold circles are forecasted data based on the historical data. Therefore, if the State anticipated continuing this trend, it could set a target of 411 fatalities by 2012 to 2016, which represents a statewide reduction of approximately 35 fatalities per year.

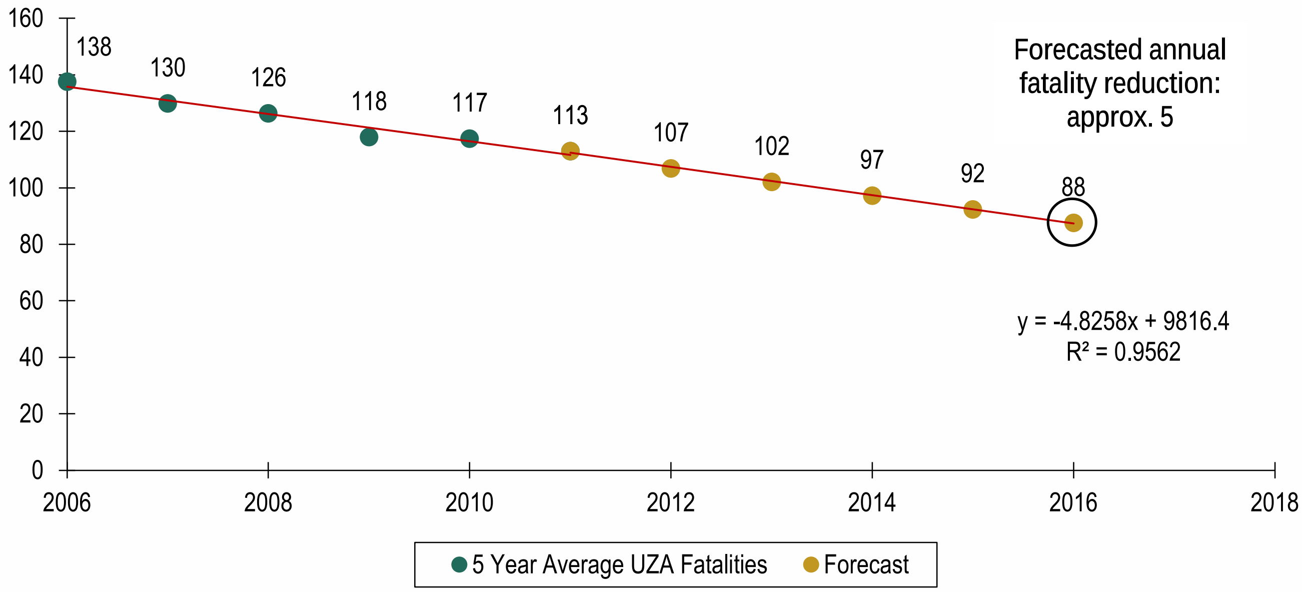
Figure 6-2 Sample State Total Fatality Trend



Source: Cambridge Systematics, Inc.

Figure 6-3 shows sample historical trend data for fatality reduction in urbanized areas (green circles), and a forecast if that same rate of reduction were to continue into the future (gold circles). The urbanized area fatality target could be set for an average of 88 fatalities in 2012 to 2016 based on continuing the existing trend.

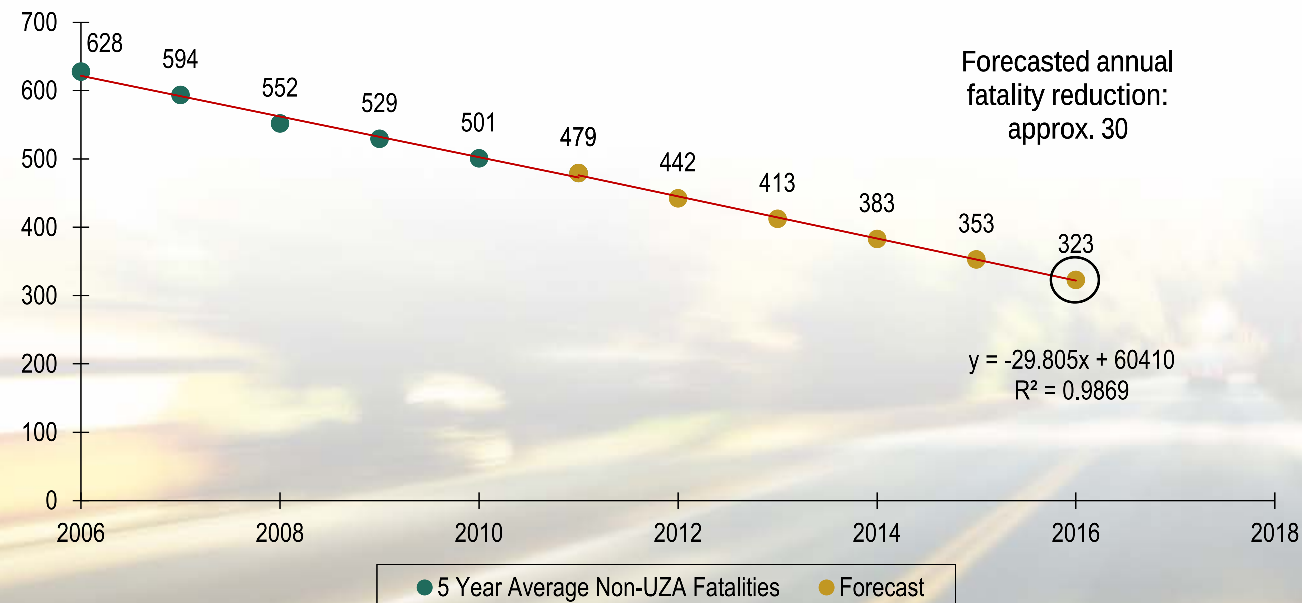
Figure 6-3 Urbanized Area Fatality Trend



Source: Cambridge Systematics, Inc.

Similarly, a linear regression was calculated in nonurbanized areas (figure 6-4) to forecast a target if the existing trend were to continue. For nonurbanized areas, a reduction of 30 fatalities per year and a target of 323 fatalities in nonurbanized areas could be set for 2012 to 2016 based on the historical trend. Of course, the urbanized and nonurbanized area forecasts need to add up to the total statewide fatality forecast.

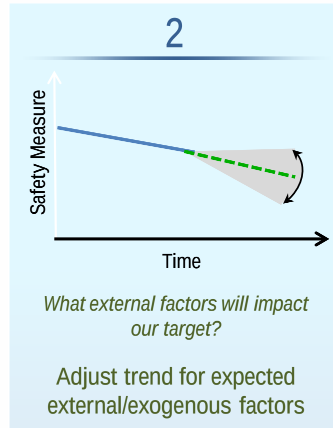
Figure 6-4 Nonurbanized Fatality Trend



Source: Cambridge Systematics, Inc.

6.3 Exogenous Factors

Population



Source: Cambridge Systematics, Inc.

Changes in population are outside the control of safety planners, yet impact the number of fatalities as population growth typically results in VMT increases and increased exposure to safety risk. Historical and forecasted population data can help with target setting.

Urbanization of Development

When considering either an aggregated urbanized area target for the State, or individual urbanized area targets, it is important to consider development trends in urbanized and nonurbanized areas. A State may want to consider the extent to which policies are in place encouraging infill development within urbanized areas, or whether development is occurring mostly in nonurbanized areas. To understand recent development trends, a State can obtain Census data on population density trends over the past decade. MPO planning areas are always larger than adjusted urbanized areas,[22] as shown in figure 6-5, so MPO data also can inform decisions about urbanized area target setting.

Additionally, MPOs regularly develop forecasts of future population and employment and distribution throughout the planning area. While data are prepared for long-term forecasts (i.e., 20 years in the future), interim forecasts (i.e., 5 years) also should be available to inform near-term target setting. Understanding where growth is anticipated related to the urbanized area boundaries will provide additional insight into where VMT growth is expected and how that may impact safety in urbanized or nonurbanized areas.

States also may isolate the proportion of the current population under age 25 and those over age 65 in urbanized and nonurbanized areas. These age groups tend to have higher fatality rates and are disproportionately affected by certain contributing crash factors; therefore, certain strategies are more effective if targeted to these groups. Given the high incidence of crashes and fatalities among younger drivers, analysts should break them down into smaller age groups (such as 16 to 17, 18 to 20, and 21 to 24) for greater precision. States and regions should review recent demographic trends and available forecasts for population distribution by age for the target year. The change in proportions among these age groups over time can impact changes in fatalities over time, even without implementing any safety strategies. As shown in figure 6-6, the rate of fatalities among drivers ages 16 to 24 is higher per 100,000 population than the rate overall, although it has declined significantly over the last 15 years. Therefore, if a State anticipates a larger cohort of younger or older drivers in its target year, the State may choose to adjust its target accordingly.

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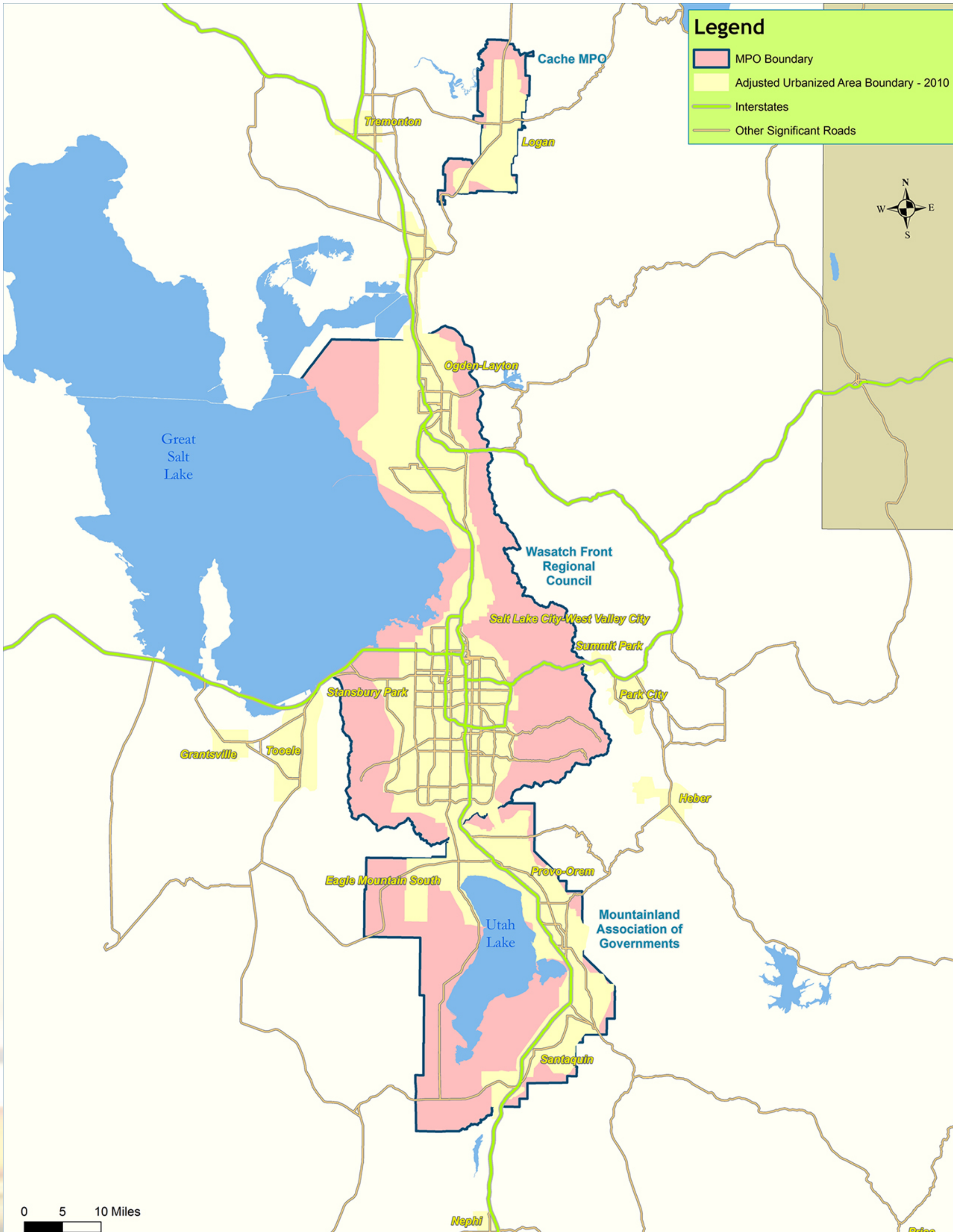
[22] By definition the MPO Metropolitan Planning Area must include at least the urbanized area and the contiguous area expected to become urbanized within 20 years 23 USC 134(e)(2).

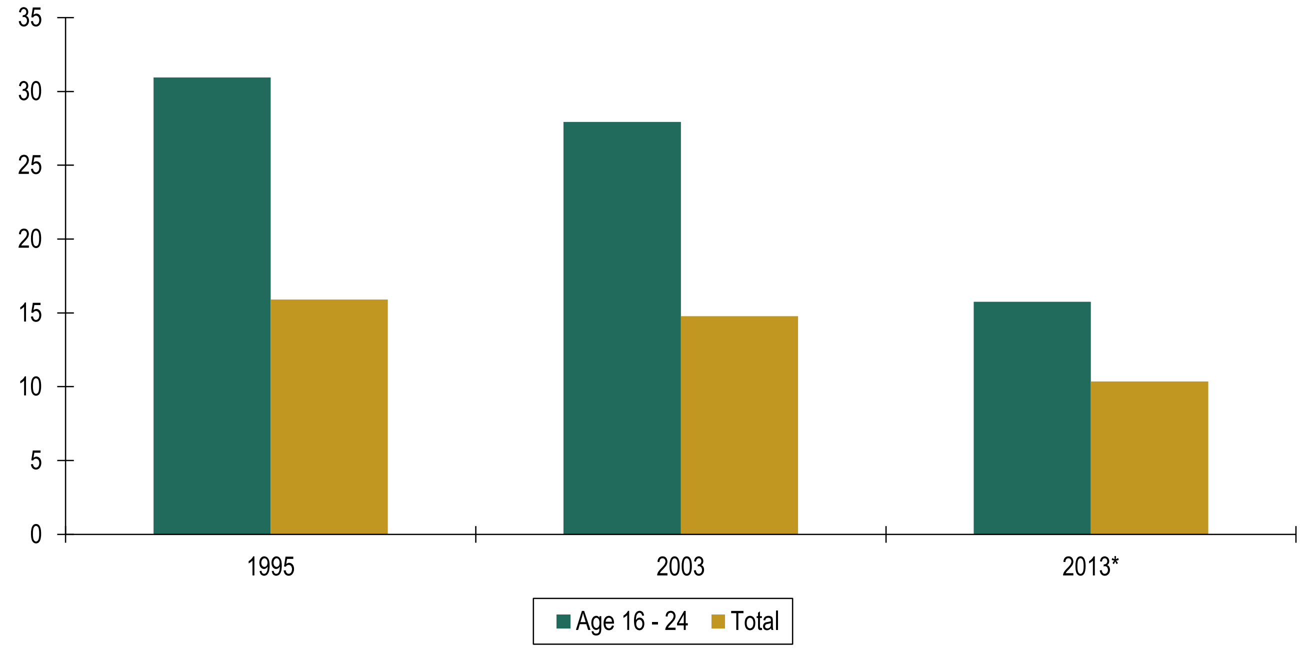
Figure 6-5 Adjusted Urbanized Areas and MPO Areas for Three Utah MPOs



Source: FHWA

State records on licensed drivers may help an agency understand the proportion of at-risk drivers. Changes in automobile ownership and driving rates may impact future safety targets as much as countermeasure selection. In 2011, the percentage of 16 to 24 year olds with driver's licenses dipped to 67 percent—the lowest percentage since at least 1963.[23] This seems to indicate that younger drivers may be choosing to delay or not pursue licensure, which reduces their in-vehicle crash exposure. However, they are likely taking transit, which has almost zero risk; or they may be walking or riding a bicycle more often and, therefore, be more exposed to the risks associated with those modes.

Figure 6-6 National Fatalities per 100,000 Population
Young Drivers versus Total



Source: Cambridge Systematics, Inc.; FARS; and U.S. Bureau of the Census.

Note: 2013 data are preliminary.

6.4 Modal Trends

Another facet of understanding potential future safety performance is considering the transportation landscape where growth is anticipated. A major consideration is whether transit is available and trends in transit use. If transit is available, the State will want to understand the transit mode share in a State's urbanized areas. MPOs will be an important resource as they can provide this information for both current conditions and future forecasts from their travel demand models. These forecasts should take into account anticipated investments in transit, pedestrian and bicycle transportation and the extent to which mode shift is anticipated. In general, transit is very safe, so a shift from auto trips to transit will benefit safety. If more people are biking and walking, they will be reducing their risk for crashes in a

[23] http://www.uspirg.org/sites/pirg/files/reports/A%20New%20Direction%20vUS.pdf.

vehicle, but they may be more vulnerable to crashes depending on the state of bicycle and pedestrian infrastructure (i.e., existence of continuous sidewalks or protected bicycle lanes). It will be important to consider mode shift, but if the result of lower VMT growth is more serious crashes involving nonauto modes, safety may not improve overall. It is important to make sure that any changes to the mode share also take into account the share of crashes by mode.

6.5 Safety Culture

An important question to consider for the urbanized areas in a State is the extent to which they have a strong transportation safety culture. To assess this, it is useful to understand the extent to which the MPOs are conducting proactive safety planning, which will have an influence on how safety is considered in regional transportation investments and how aggressive targets should be. A resource for understanding how to consider the extent of safety integration into planning is the *Framework for Institutionalizing Safety in the Transportation Planning Process*.[24] Questions the State can ask regarding MPO safety planning include the following:

- Do MPOs have dedicated safety committees that place a sustained focus on improving safety?
- Have any MPOs developed dedicated safety plans? If so, are they actively implementing them?
- How well is safety integrated into the planning process for the long-range plan, corridor plans, or modal plans:
  - Is safety explicit in plan goals and objectives?
  - Has the MPO conducted regional analysis of safety problems, such as network screening or identification of safety hot spots?
  - Have MPOs developed regional safety targets?[25] How aggressive are they? As noted, some metropolitan areas, including New York, Chicago, San Francisco, and Los Angeles, have recently established a high level of commitment to transportation safety as evidenced by their adoption of Vision Zero goals.
  - Do the MPOs effectively use safety as a criterion for prioritizing transportation investments? Is safety given sufficient weight relative to other transportation priorities?
  - Do MPOs monitor and evaluate performance of the transportation system in terms of safety and reallocate resources as needed?
  - Is the region undertaking education and enforcement campaigns to change behaviors and culture related to transportation safety?

If regions are fairly proactive on safety, then a more aggressive urbanized area target might make sense.

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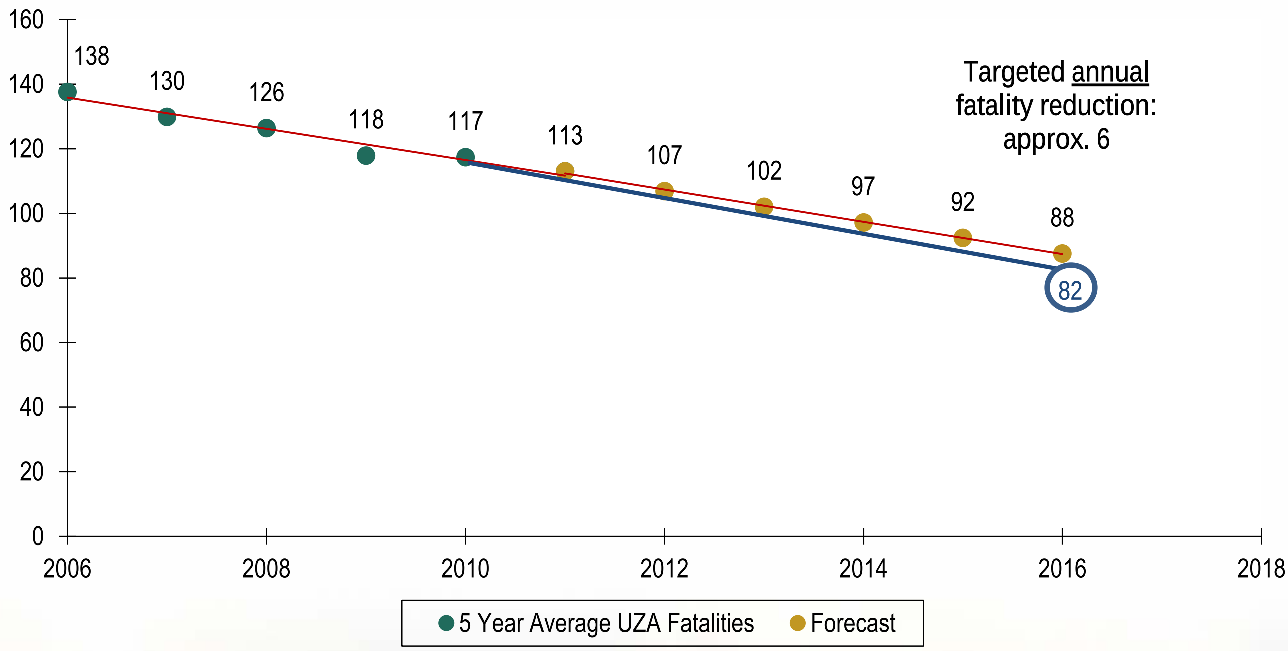
[24] http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP08-76_PhaseI-FR.pdf.

[25] Under MAP-21, States are required to coordinate with MPOs on development of State targets. MPOs will be required to set safety targets or adopt the State safety target.

6.6 Step 2—Exogenous Factors Example

Now, we will carry the example into the second step of the framework. In Step 1 the statewide target for urbanized areas was 88 fatalities and 323 fatalities for nonurbanized areas. The example State's analysis shows it should expect more future development in nonurbanized areas than in urbanized areas and, therefore, more nonurbanized VMT, as well as an increasing proportion of drivers over age 65 in nonurbanized areas. As a result, it may be more difficult to make progress on reducing severe crashes in nonurbanized areas. Therefore, the State might want to adjust the target so it is more aggressive in urbanized areas and less aggressive in nonurbanized areas. In this example, the urbanized area target was shifted from a reduction in fatalities of about five annually calculated in Step 1 (red line/gold dots) to a reduction of about six fatalities annually (blue line), so the target is now 82 fatalities by 2012 to 2016 in urbanized areas, as shown in figure 6-7.

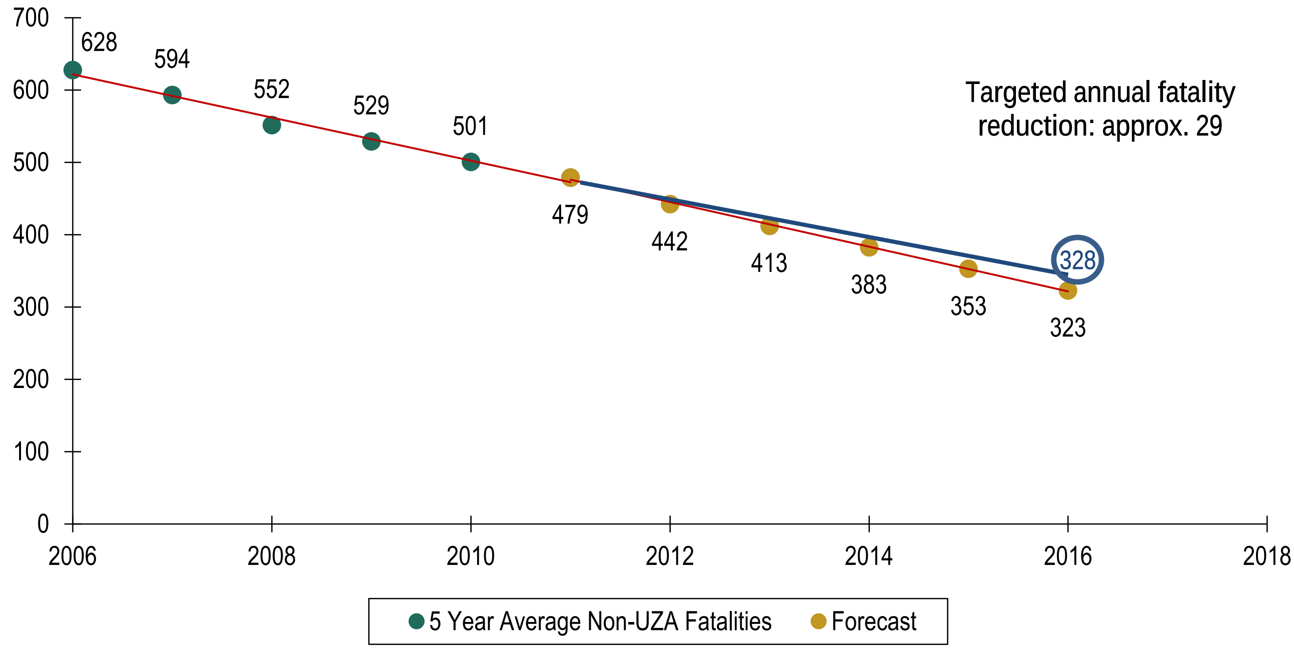
Figure 6-7 Sample Step 2—Consideration of Exogenous Factors
Urbanized Areas



Source: Cambridge Systematics, Inc.

The target in nonurbanized areas would then be less aggressive, for a decrease in annual fatality reduction from 30 to 29, and the target would be increased from 323 fatalities per year by 2012 to 2016, calculated in step 1 (red line/gold circle) to 328 fatalities per year by 2016, as shown in figure 6-8.

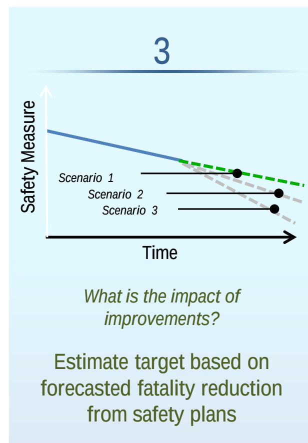
Figure 6-8 Sample Step 2—Consideration of Exogenous Factors
Nonurbanized Areas



Source: Cambridge Systematics, Inc.

6.7 Countermeasure Impact Data

State Data on Countermeasure Effectiveness



Source: Cambridge Systematics, Inc.

States should use the safety analysis tools listed in section 5 to adjust targets. Program and project evaluations help agencies determine which countermeasures are most effective in saving lives and reducing injuries. Agencies should determine which countermeasures have not demonstrated the expected effectiveness and reconsider or modify them in the future. The results of all such evaluations should be captured in a knowledge base to improve future estimates of effectiveness and for consideration in future decision-making and planning. This information is a critical input into evidence-based safety target setting. When a State sets or updates a safety target, it should draw upon its body of knowledge of project effectiveness for use in forecasting future fatality reductions given a set level of resources. This information will help the State develop the most effective safety program possible, and also ensure its fatality targets are realistic.

To understand the extent to which a particular measure is working, the State should conduct an evaluation. A range of methods is available for evaluating countermeasures, depending on the available data and resources. Section 6 of the HSIP Manual describes options for conducting project and program evaluation, including before/after analysis. It is critical for the purpose of target setting to continue to improve this information and use it to forecast fatality reductions anticipated from planned safety programs.

Both individual State DOT and FHWA research have examined countermeasure effectiveness for many years. The CMF Clearinghouse database is a continually updated source for effectiveness data for infrastructure-oriented safety countermeasures. For certain projects, a State may pursue high-quality evaluation that is of the caliber to develop a CMF about the countermeasure. FHWA's *A Guide to Developing Quality Crash Modification Factors* is a useful resource. Given the limited number of CMFs currently available, States are encouraged to develop CMFs to contribute to this knowledge base so that fatality reduction forecasts can be continuously improved. This will help States improve the accuracy of target setting. Understanding the urban or rural context of countermeasure implementation also is important.

Data on the effectiveness of behavioral programs is limited and varies according to the scale and type of implementation. For these programs, the best resource is a State's own evaluation of how the project or program worked on its roadway system. Therefore, States should evaluate projects without known effectiveness data to ensure they are implementing effective programs, and they are getting the most safety improvement possible with the resources available. In-house evaluation generates confidence in the validity of the results and fosters their use in future fatality forecasts and target setting.

Emphasis Area Plans

Through the use of efficacy data (either national CMFs or State-developed information) for multiple projects, a State can develop a detailed emphasis area plan and create reasonable fatality reduction forecasts, provided all countermeasures are implemented. The combination of evidence-based data with a State's planned safety program will help generate a realistic fatality target, given anticipated resources. Understanding the share of investment planned in urbanized and nonurbanized areas will help with targets for these geographies.

Emphasis area plans should use CMFs or other data on anticipated fatality reductions to forecast the safety benefits of the investment and inform target setting. Two approaches for incorporating CMFs into target setting are: 1) CMFs can be used in individual locations to calculate the forecasted fatality or injury reduction of a specific improvement; and 2) on a systemic level, improvements can be identified throughout a State or area with a history of or high potential for crashes based on identified characteristics. CMFs can be used to forecast the overall reduction in severe crashes within the countermeasure implementation area. The Oregon DOT, in cooperation with the FHWA Resource Center, recently conducted a study that shows how an emphasis area plan can estimate the expected fatality reduction that can be used in target setting, which is described in the following example.

Oregon DOT Roadway Departure Safety Implementation Plan

In its Roadway Departure Safety Implementation Plan, Oregon established a roadway departure goal to reduce the seven-year average (2002 to 2008) of 307 roadway departure fatalities by approximately 20 percent by 2016. Achieving this goal will prevent approximately 65 roadway departure deaths from occurring each year.

Oregon combined traditional location-specific strategies with systemic application of large numbers of cost-effective, low-cost countermeasures at locations experiencing specific crash types above a specified frequency level. On some corridors, targeted education and enforcement initiatives were implemented.

Table 6-4 shows a sample of the calculations in the plan, including the number of crashes, as well as the number of annual severe injuries and fatalities the countermeasure was expected to reduce. By dividing the cost of the project by the number of fatalities it is expected to reduce, an estimate is developed of the cost required to save one life per year. This type of analysis is useful in prioritizing projects to ensure the greatest number of fatalities is reduced, given a fixed level of safety investment and in setting targets.

Table 6-4 Oregon Roadway Departure Safety Implementation Plan Countermeasures (Sample)

Countermeasure	Approach	Number of Sections	Associated Costs ($ Million)	Annual Targeted Crash Reduction	Annual Estimated Incapacitating Injury Reduction	Annual Estimated Fatality Reduction	Required to Save One Annual Life (Million Dollars)
State Roads							
Enhanced Curve Sign and Marking Countermeasures—State Rural Roads	Systematic	750	$3.7	112	14.71	7.56	0.49
Enhanced Curve Sign and Marking Countermeasures Plus Flashing Beacons—State Rural Roads	Systematic	20	$0.14	6	0.78	0.41	0.34
Enhanced Curve Sign and Marking Countermeasures—State Urban Roads	Systematic	19	$0.09	8	0.66	0.34	0.26
Enforcement and Education: Alcohol Related—State Roads	Education & Enforcement	36	$1.3 (annual costs)	5	1.11	1.04	6.25
Local Roads							
Enhanced Curve Sign and Marking Countermeasures—Local Rural Roads	Systematic	442	$4.42	143	15.29	7.39	0.60
Centerline Rumble Stripes—Local Rural Roads	Systematic	88	$3.52	28	1.39	3.17	1.11
Edge Line Rumble Stripes—Local Rural Roads	Systematic	38	$2.30	46	4.63	2.12	1.08

Benefit-Cost Analysis

Benefit-cost analysis is a useful approach for providing a relative sense of the fatality reduction results expected for a specific investment. Development of project-specific benefit-cost ratios will help prioritize safety investments for an emphasis area plan. If the projects with the best benefit-cost ratio in a specific emphasis area are chosen for implementation, a State will know it has developed the most effective program possible with defined resources. Once emphasis area plans, including fatality reduction forecasts are developed, they can be used to inform development of a fatality target. The use of benefit-cost analysis, in combination with emphasis area plan development, will help a State know how aggressive the target can be while ensuring it is realistic. Guidance on how to conduct benefit-cost analysis is available in the HSIP Manual.

Urbanized and Nonurbanized Distribution of Safety Problem within Emphasis Areas

An important facet of understanding crash trends and identifying countermeasures to reduce fatalities is knowledge of the most prevalent emphasis areas in urbanized and nonurbanized areas. A few States conduct analysis of the share of the safety problem within an emphasis area in urban and rural areas. This can inform the extent to which countermeasures addressing crashes in that emphasis area are targeted to be urbanized versus nonurbanized areas. If States decide to set urbanized or nonurbanized targets, they will likely want to pay even closer attention to this distribution as they set targets and implement programs.

The study team analyzed FARS data for 2007 to 2011 to determine the proportion of fatalities in each geography by key emphasis areas, which are summarized in table 6-5. At a national level, some emphasis areas for which fatalities occur primarily in urbanized areas include pedestrians (71 percent), bicycles (68 percent), and intersections (68 percent). Emphasis areas dominant in nonurbanized areas include: animal involved (91 percent), unlicensed driver (76 percent), fatigued/asleep (82 percent), and roadway departure (68 percent).

To forecast the extent of anticipated safety progress in urbanized as compared with nonurbanized areas, it is necessary to estimate the level of investment in the two geographies. One way to do this at a broad level is to review the share of fatalities and serious injuries in urbanized and nonurbanized areas within each of the emphasis areas as defined in the SHSP. If future investments are required to align with SHSP emphasis areas, progress should be anticipated in those areas. The State will want to understand whether the future investments are likely to provide more benefit to urbanized or nonurbanized area crashes.

Table 6-5 Fatalities by Crash Type in Urbanized and Nonurbanized Areas

	National Fatalities (Annual Average 2007-2011)	Urbanized Area Fatalities	Percent Urbanized Area Fatalities	Nonurbanized Area Fatalities	Percent Nonurbanized Area Fatalities
Alcohol/Drug Impaired	11,461	4,616	40%	6,846	60%
Seatbelt/Helmet Not Used/ Misused	18,472	7,137	39%	11,335	61%
Distracted/Inattentive Driver	4,886	1,769	36%	3,117	64%
Fatigued/Asleep	870	159	18%	711	82%
Aggressive	225	103	46%	122	54%
Speed Related	10,316	4,162	40%	6,154	60%
Pedestrian Killed	4,373	3,109	71%	1,265	29%
Bicyclist Killed	668	455	68%	213	32%
Motorcyclist Killed	4,840	2,349	49%	2,492	51%
Large Truck Involved	1,306	489	37%	817	63%
Train Involved	178	59	33%	119	67%
Intersection	8,412	4,930	59%	3,481	41%
Roadway Departure	20,710	6,726	32%	13,984	68%
Work Zone Location	678	319	47%	358	53%
Animal Involved	218	19	9%	199	91%
Unlicensed Driver	12,429	3,044	24%	9,385	76%
Young Driver	5,896	2,309	39%	3,587	61%
Older Driver	6,496	2,727	42%	3,769	58%
Total	35,371	14,402	41%	20,969	59%

Source: FARS, Cambridge Systematics, Inc.

Table 6-6 shows an example State's fatalities by emphasis area and the breakdown by urbanized and nonurbanized areas. The total exceeds the actual total of fatalities as each crash may have multiple factors and be represented in multiple emphasis areas. As shown in table 6-6, two-thirds of the fatalities addressed by the emphasis areas are located in nonurbanized areas. Therefore, planned expenditures should have a greater impact on nonurbanized fatality reduction, and the target for the nonurbanized areas should be more aggressive.

Table 6-6 Example State Fatalities and Serious Injuries by SHSP Emphasis Area

Emphasis Area	Number of Fatalities in Urbanized Area	Number of Fatalities in Nonurbanized Area	Emphasis Area in SHSP
Alcohol/Drug Related	45	55	Yes
Occupant Protection (Safety Belts, Helmets)	53	75	Yes
Distracted/Inattentive Driving Related	11	7	
Fatigued/asleep	4	17	
Aggressive	8	23	
Speed Related	12	55	Yes
Pedestrian Involved	5	0	
Bicycle Involved	6	1	
Motorcycle Involved	5	10	
Large Truck Involved	9	9	
Train Involved	1	0	
Intersection/Intersection Related (Signalized and Unsignalized)	62	29	Yes
Roadway Departure: Head-On, Roadside Objects (Trees, Utility Poles), Horizontal Curves	20	205	Yes
Work Zone	2	4	
Animal Related	2	0	
Unlicensed/Suspended/Revoked License	1	8	
Young Driver Involved	30	86	Yes
Older Driver Involved	38	16	
Share of Total Fatalities and Serious Injuries by Urbanized/Nonurbanized Area	370 (34%)	542 (66%)	
Share of Emphasis Area Fatalities and Serious Injuries Addressed by Urbanized/Nonurbanized Area	296 (31%)	431 (69%)	

Source: Cambridge Systematics, Inc.

Resource Allocation Data

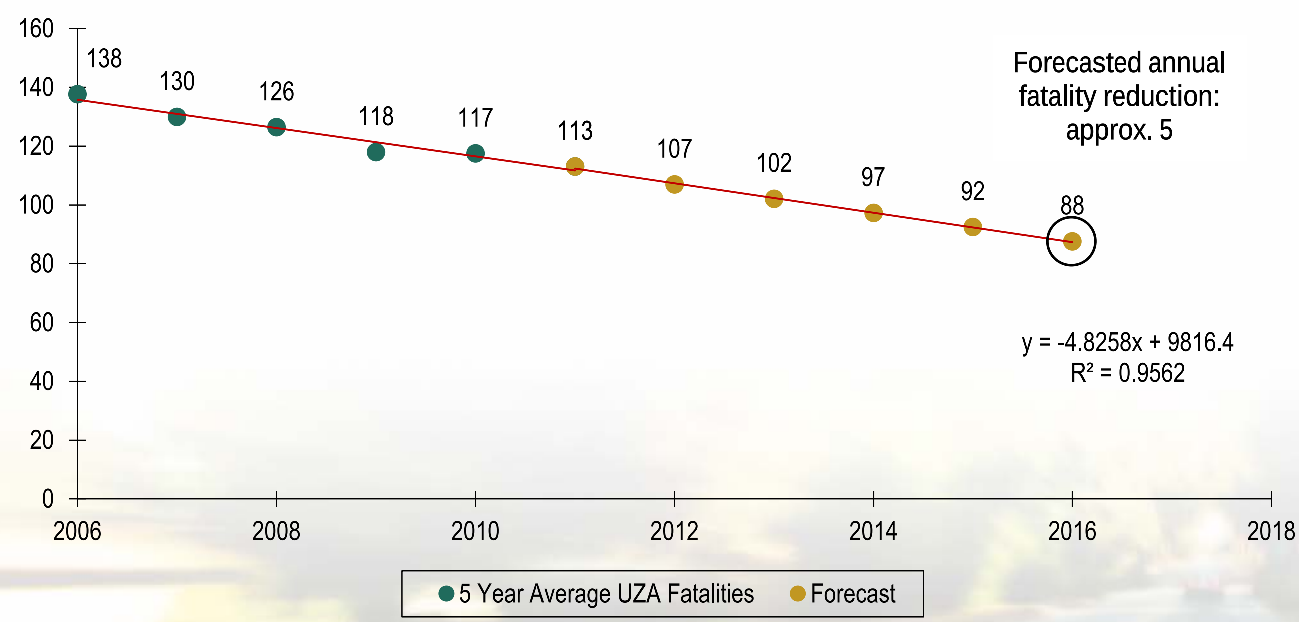
Resource allocation is a key element of the performance-based planning process. As progress toward achieving targets is made, agencies should engage in a continuous process of reevaluation and reallocation of resources based on where progress is being made and where problems still exist. To understand how investments are affecting progress in urbanized and nonurbanized areas, States should continuously track the level of investment in each of these geographies, as well as fatality and serious injury trends in each geography. Historically, States have not allocated resources to urbanized or nonurbanized areas strictly based on crash trends in these geographies. They have been more likely to invest based on the scale of a safety problem, as compared to the rest of the State or the benefit-cost analysis for an improvement. However, by tracking trends in urbanized and nonurbanized areas, States may learn that they need to reallocate resources to the geography where numbers or rates are experiencing lower levels of progress, or modify how they apply countermeasures in urbanized and nonurbanized areas. For example, if a State determines the majority of its unbelted fatalities and serious injuries are in nonurbanized areas, it will need to ensure that its education and enforcement programs are targeting drivers outside of the urbanized area.

Funding sources have traditionally been limited in their use, and organizational structures have been siloed with infrastructure-oriented funding and countermeasures handled by the State DOT, and behavioral funding and countermeasures handled by the SHSO. This arrangement has made it challenging to shift funding between programs. However, State DOTs now have flexibility to shift HSIP funds to noninfrastructure purposes. Therefore, resource allocation analysis may be even more useful in the future.

6.8 Step 3—Example

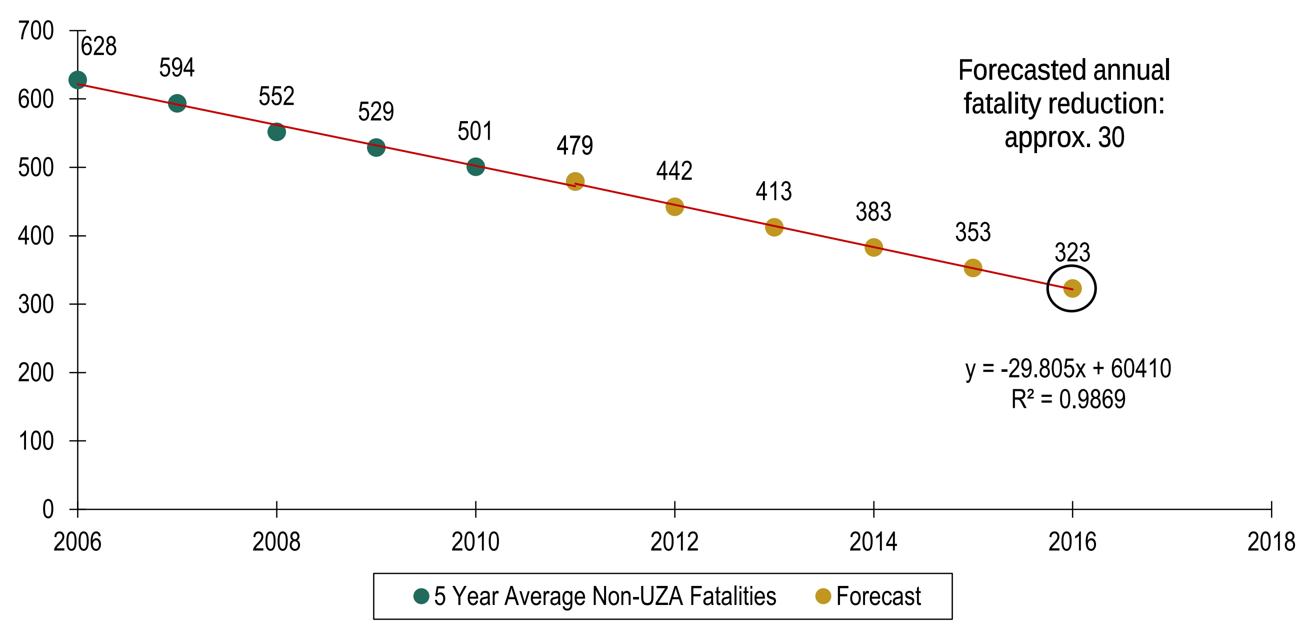
In the example, because the SHSP analysis to understand anticipated impact of future investments showed more benefit to nonurbanized areas, the State decides to readjust the nonurbanized target once again to make it more aggressive. Therefore, the end result is to go back to the original trend line shown in Step 1 with a target of 88 fatalities in urbanized areas (figure 6-9) and 323 fatalities in nonurbanized areas by 2012-2016 (figure 6-10).

Figure 6-9 Urbanized Area Fatalities



Source: Cambridge Systematics, Inc.

Figure 6-10 Nonurbanized Fatalities



Source: Cambridge Systematics, Inc.

6.9 Technical Methods

This section describes technical methods and factors to be considered as analysts calculate safety targets.

Selection of Baseline Method

The first consideration when setting a target is what will be used for a base year value against which the target will be compared. Rolling multiyear averages show long-term trends more clearly than annual counts. The longer the time period for which the average is used, however, the longer it will take for trends to show up in the data. If a multiyear average is used, a State or region also will likely track annual numbers.

Projection Methods

To compare fatality targets with fatality trends, a linear regression methodology (also known as a "line of best fit") is often used to project future fatality numbers and rates. Most spreadsheet software offers a "linear trend" function, which projects what the fatalities would be in the future if the trend were to continue. It is a good idea to review the "fit" of the linear regression. As each fatality becomes more challenging to reduce in the future, it will be more likely that the trend line flattens out as fewer fatalities are reduced per year. Therefore, States may want to segment the trend line to estimate separate linear trends for different time periods; or use nonlinear functions (e.g., exponential, logarithmic, polynomial, or power[26]) to improve the fit of the trend line with the data. By selecting the R-squared value (in the spreadsheet) to evaluate the fit, different approaches can be compared. The closer the R-squared is to one, the better the fit of the trend line to the historical data.

To adjust a projection further, other statistical methods such as exponential smoothing or averaging can be used. These techniques are helpful because data collected over time will inherently have some form of random variation. "Smoothing" techniques help reveal more clearly the underlying trend, as well as seasonal and cyclic components. More information about smoothing techniques is available in the Engineering Statistics Handbook by the National Institute of Standards and Technology.

Feasibility Assessment

While some targets are set for only one year, others are set for as many as 20 years into the future. A check on the level of ambition for a target is to calculate the annual rate of fatality reduction for both the historical trend and the future years, and to see how they compare. In the future, as the number of fatalities gets closer to zero, every fatality reduction will become more challenging. Therefore, a significantly larger annual reduction than has been achieved in the past may not be realistic. A Compendium of State and Regional Target Setting Practices[27] developed calculations of annual fatality reductions for each State where a target was available, and provides a reference for benchmarking. Once a potential target has been defined, agencies should overlay it on the forecasted trend based on past performance. This gives a sense of whether the target seems achievable.

[26] These methods are available in many off-the-shelf spreadsheet software applications.

[27] http://safety.fhwa.dot.gov/hsip/tpm/docs/compendium.pdf.

7.0 Conclusion

The framework for setting statewide safety targets is relevant for urbanized and nonurbanized target setting. However, more complexity is involved when manipulating the data for analysis by the separate urbanized and nonurbanized areas. Additionally, other considerations such as safety culture and urbanization trends must be taken into account when evaluating how aggressive targets should be.

States should consider the quality of their location data before deciding on urbanized and nonurbanized target setting, particularly for serious injuries. If States have lower confidence in accuracy of crash locations, they may want to wait to set urbanized and nonurbanized targets until they have higher confidence in crash locations both on and off the State system.

Urbanized and nonurbanized target setting can help States prioritize their resources for the greatest impact. With increased attention to the locations of crashes, States may be able to tailor implementation of countermeasures better to address the areas with the higher numbers of severe crashes.

Establishment of urbanized and nonurbanized targets may help bring more stakeholders to the process if they feel more of a stake in the targets for their area. Given urbanized areas are part of MPO planning areas, States may find urbanized area target setting improves coordination with MPOs or location jurisdictions.

In terms of evaluation, if the State is monitoring progress by individual urbanized area, it may be able to more quickly recognize when innovative projects and higher level of mode shift are resulting in improved safety outcomes. This could result in improved recognition of how best practices generate results at a regional scale.

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