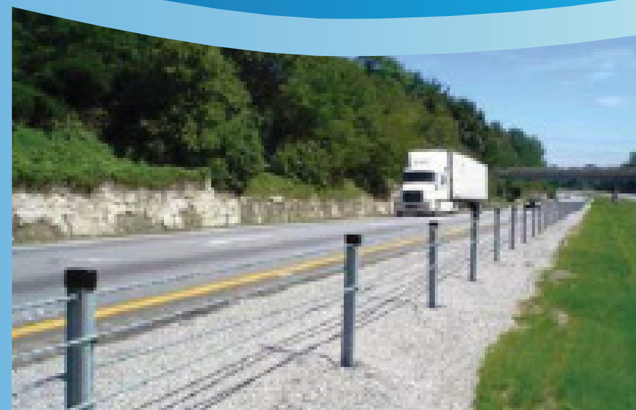
Countermeasure Service Life Guide



FHWA Safety Program

U.S. Department of Transportation
Federal Highway Administration

ZERO IS OUR GOAL
A SAFE SYSTEM IS HOW WE GET THERE

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FOREWORD

Many agencies use benefit-cost analysis to conduct economic appraisal of various alternatives or to prioritize projects for implementation. A thorough understanding of the time period for which a countermeasure may have a measurable impact is critical to establishing the cost effectiveness of the countermeasure relative to the installation and ongoing maintenance and operational costs. This time period is the countermeasure service life.

The Countermeasure Service Life Guide builds upon the Synthesis of Countermeasure Service Life and Crash Severity Costs User Guide and presents typical service life values for a wide range of countermeasures. The Guide also provides background information on factors that can impact countermeasure service life and analytical considerations when conducting benefit-cost analysis for multiple countermeasures or alternatives with differing service life. Further, this Guide discusses the benefits to standardizing countermeasure service life application throughout an agency.

Transportation practitioners use typical countermeasure service lives to make consistent, data-driven decisions for analyzing and prioritizing safety countermeasures. The results of this analysis allow agencies to target investments with more confidence and reduce fatalities and serious injuries on our nation's roadways.

Dana Gigliotti, Director Dana Gigliotti

Office of Safety Programs

Notice

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16. Abstract

The purpose of the Countermeasure Service Life Guide is to provide transportation practitioners with the necessary information to make consistent, data-driven decisions for evaluating and prioritizing safety countermeasures using prescribed countermeasure service lives. The target audience includes transportation professionals implementing safety strategies or countermeasures for safety projects or programs. This Guide provides typical service lives for a wide range of safety countermeasures. Further, this guide demonstrates the benefits to standardizing countermeasure service life application throughout an agency. This Guide provides background information on factors that can impact countermeasure service life and analytical considerations when conducting benefit-cost analysis for multiple countermeasures or alternatives with differing service life. Examples demonstrate the application of service life and analytical considerations in various scenarios. A thorough understanding of the time period for which a countermeasure may have a measurable impact is critical to establishing the cost effectiveness of the countermeasure relative to the installation and ongoing maintenance and operational costs. Reliable and consistent approaches are key to inform decisions and improve safety investments.

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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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ACRONYMS

BCA	Benefit-cost analysis
BCR	Benefit-cost ratio
CMF	Crash modification factor
CRF	Crash reduction factor
DOT	Department of Transportation
FHWA	Federal Highway Administration
HSIP	Highway Safety Improvement Program
HSM	Highway Safety Manual
ICWS	Intersection Conflict Warning System
ITS	Intelligent transportation systems
MaineDOT	Maine Department of Transportation
MoDOT	Missouri Department of Transportation
NCHRP	National Cooperative Highway Research Program
PVB	Present value benefits
PVC	Present value costs

EXECUTIVE SUMMARY

The Countermeasure Service Life Guide (Guide) provides transportation practitioners with the necessary information to make consistent, data-driven decisions for evaluating and prioritizing safety countermeasures using prescribed countermeasure service lives. This Guide focuses on safety strategies and countermeasures for which an agency may apply for safety funding. This Guide does not cover general maintenance concerns for which safety funding would not be eligible (e.g., a service life for improving sight distance by trimming vegetation).

This Guide also provides practitioners with definitions and methods or factors to consider for determining service life, relationships between service life and maintenance/rehabilitation activities, reasons for agencies to consider adopting standardized service life values, factors that influence countermeasure service life, and analytical considerations when using service life as part of a benefit-cost analysis (BCA). Further, this guide provides examples of applications throughout, including situations where service life for a countermeasure may be unknown.

There are several benefits to developing a typical service life list and using standardized service life values in BCA:

- Standardized values improve consistent application throughout an agency regarding BCA on proposed projects.
- The standardized list may draw from agencywide experience with regard to common countermeasures or may draw from other agency experiences when considering new countermeasures. Since there are several factors that can impact service life, a standardized list compiles known information about each countermeasure for which individual practitioners may not be aware.
- Along with crash modification factors (CMFs), the standardized service life list can help practitioners communicate to decisionmakers the reasons for selecting a preferred countermeasure, especially if the countermeasure has not been commonly applied throughout the agency or within a specific region.

In summary, countermeasure service life is an integral part of the BCA process. A thorough understanding of the time period for which a countermeasure may have a measurable impact is critical to establishing the cost effectiveness of the countermeasure relative to the installation and ongoing maintenance and operational costs. The analysis methodology for countermeasures with differing service life impacts the outcome of the BCA and it is important for practitioners to use a consistent approach for comparing and prioritizing potential projects. Reliable and consistent approaches are key to inform decisions and improve safety investments.

CHAPTER 1—OVERVIEW OF GUIDE

1.1 INTRODUCTION AND PURPOSE

The Countermeasure Service Life Guide (Guide) provides transportation practitioners with the necessary information to make consistent, data-driven decisions for evaluating and prioritizing safety countermeasures through the use of prescribed countermeasure service lives. This Guide provides typical service lives for countermeasures grouped into the following categories:

- Access Management
- Advanced Technology and Intelligent Transportation Systems (ITS)
- Alignment
- Bicycle
- Delineation
- Highway Lighting
- Interchange Design
- Intersection Geometry
- Intersection Traffic Control
- Pedestrian
- Railroad Grade Crossings
- Resurfacing
- Roadside
- Roadway
- Shoulder Treatment
- Signs
- Structures
- Work Zone
- Other

This Guide focuses on safety strategies and countermeasures for which an agency may apply for safety funding. This Guide does not cover general maintenance concerns for which safety funding would not be eligible (e.g., service life for improving sight distance by trimming vegetation).

This Guide also provides practitioners with definitions and methods or factors to consider for determining service life, relationships between service life and maintenance/rehabilitation activities, reasons for agencies to consider adopting standardized service life values, factors that influence countermeasure service life, and analytical considerations when using service life as part of a benefit-cost analysis (BCA). Further, this guide provides examples using service life as part of a BCA, including situations where service life for a countermeasure may be unknown.

1.2 TARGET AUDIENCE

The target audience for this Guide is transportation professionals implementing safety strategies or countermeasures for safety projects or programs, including traffic and safety engineers, designers, planners, and maintenance staff. This Guide assumes that these practitioners do not have formal expertise in economic evaluation or detailed knowledge on the expected service life of safety strategies and countermeasures.

1.3 STRUCTURE OF THE GUIDE

This Guide is organized into six chapters and one appendix. Chapter 2 provides an overview of service life, including the definition and methods or factors to consider for determining service life, as well as differentiates countermeasure service life from countermeasure maintenance and rehabilitation cycles. Chapter 2 introduces the need to standardize service life for BCA and provides examples of agencies that have developed standardized service life lists for BCA. Chapter 3 provides instructions on selecting countermeasure service life for BCA including analytical considerations and related resources. Chapter 4 introduces the organization, process for identifying, and typical service lives for countermeasures for BCA grouped by functional area. Chapter 5 presents BCA examples for single countermeasures where the service life is known and is unknown, and a project with multiple countermeasures and multiple sites. Chapter 6 presents a summary of this Guide with key takeaways. Appendix A details the review process for countermeasure service life values.

CHAPTER 2—OVERVIEW OF SERVICE LIFE

Service life is a key component of an economic analysis for determining the cost effectiveness of a safety strategy or countermeasure and for comparing the cost effectiveness of multiple alternatives. Transportation agencies should have reasonable and consistent agencywide estimates of service life for each countermeasure for uniform economic analysis that results in fair comparisons and project prioritization. This chapter introduces the fundamental concepts of service life, provides an overview of service life's role in BCA, discusses the need for standardized service life values, and identifies factors that agencies may consider when establishing or changing typical service lives.

Chapter 2 At-A-Glance

Chapter 2 is divided into eight sections:

- Section 2.1 defines service life.
- Section 2.2 provides background information to practitioners on how service life is determined.
- Section 2.3 introduces the role of service life in BCA.
- Section 2.4 characterizes the importance of standardizing service life for evaluations throughout an agency.
- Section 2.5 identifies factors that impact countermeasure service life.
- Section 2.6 differentiates service life from periodic maintenance and rehabilitation.
- Section 2.7 provides an overview of developing an agencywide service life list and presents several examples from State agencies.
- Section 2.8 provides a summary of the chapter.

2.1 WHAT IS SERVICE LIFE?

The Highway Safety Manual (HSM) defines countermeasure service life as "the number of years in which the countermeasure is expected to have a noticeable and quantifiable effect on the crash occurrence at the site."[1] Often, the service life is based on the physical presence and performance of the countermeasure; however, in other cases, changes in the surrounding land use or traffic operations will impact the long-term crash frequency at the site. The Missouri Department of Transportation's (MoDOT) Manual on Identification, Analysis, and Correction of High-Crash Locations defines service life as "the number of years during which the components of a project or the entire project can be expected to satisfactorily perform an intended function."[2] While the MoDOT definition focuses more on the asset management aspect of service life, both definitions of service life reflect the length of time roadway and traffic characteristics are expected to be consistent. If traffic flow changes over time, it is possible the countermeasure will not perform its intended function (e.g., traffic signal timing is periodically reassessed due to changing traffic flow characteristics over time).

Agencies have used several terms interchangeably with service life, including project life and expected life. Practitioners should be clear, however, when considering service life not to mistake service life with the analysis period if the service life is not directly used as the analysis period. As this Guide discusses in Section 3.2 Analytical Considerations, the analysis period may not coincide with the service life if a practitioner uses a horizon year analysis or if alternatives have differing service lives. Understanding the service life for each countermeasure allows the practitioner to account for appropriate costs and benefits if the practitioner uses an analysis period that is different from the service life.

2.2 HOW IS SERVICE LIFE DETERMINED?

There are many sources for countermeasure service lives, including Chapter 4 of this Guide. Additionally, several agencies have published service life lists as part of their Highway Safety Improvement Program (HSIP) Manual or as part of an economic evaluation tool. Section 2.7 provides several example State-agency countermeasure service life lists with varying levels of detail provided. Appendix A further summarizes agency service life lists identified through a review of agency-specific resources. Agencies use various methods and consider different factors for determining the service life values for these lists.

Most commonly, agencies rely on manufacturer warranties and in-service performance to assess the service life for a given countermeasure. Manufacturers may provide a warranty for specific components of a countermeasure, for example sign sheeting. In this case, every sign of that type is expected to last for the duration of the warranty. Several agencies have found through evaluation of in-service performance, that a service life longer than the warranty can be expected.[3] However, it is possible the environmental factors may contribute to a decrease in life expectancy in certain instances. More details can be found in Section 2.5 Factors Impacting Standard Service Life.

For existing countermeasures, agencies often use in-service performance evaluation to measure service life. In order to do so, agencies develop performance measures for a countermeasure based on a percentage of sites that have met the end-of-life criteria. Commonly, the median time to replacement is used to determine the service life (the duration at which 50 percent of sites have been replaced or considered to be at the end-of-life). More conservative estimates can be used if the agency is looking to achieve a service life prior to failure in the field. For example, the 5th or 10th percentile may be used as a conservative estimate of service life.

Table 1 provides an example of how an agency may track replacement age for an in-service countermeasure to determine average age at replacement. In this case, the average age is 15.57 years. For large samples, the agency may determine average service life by district to determine if differences exist.

Table 1. Sample Tracking Spreadsheet.

Countermeasure Identifier	District	Replacement Age (Years)	Deviation from Average	Square of Deviation
173254	1	17	1.43	2.05
283723	1	15	-0.57	0.33
029383	3	22	6.43	41.33
228769	2	15	-0.57	0.33
469278	3	8	-7.57	57.33
162533	3	17	1.43	2.04
263883	2	15	-0.57	0.33

The agency may be further interested in looking at the variability of in-service performance. To do so, Figure 1 shows the calculation for the standard deviation, a measure of variability.

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(a_i - \bar{a})^2}$$

Figure 1. Equation. Standard Deviation Calculation.

Where:

s = standard deviation.

N = sample size

a_i = replacement age for observation i.

¯ = average replacement age.

Assuming the distribution of service life for the countermeasure is normal, Figure 2 provides a graphical representation of the probability of replacement at any age (annual probability) and cumulative probability for replacement by year. The graphic shows the probability of replacement for any one year is highest between 15 and 16 years and, which is where the cumulative probability indicates 50 percent need replacement. Figure 2 also shows that approximately 10 percent of sites with the countermeasure need replacement at 10 years if the agency wants to use a conservative service life. Regression models may be used to determine more precise estimates, and to incorporate factors that may be associated with an increase or decrease in the in-service performance (for example annual average snowfall may be associated with a decrease in the in-service performance of pavement markings and markers).

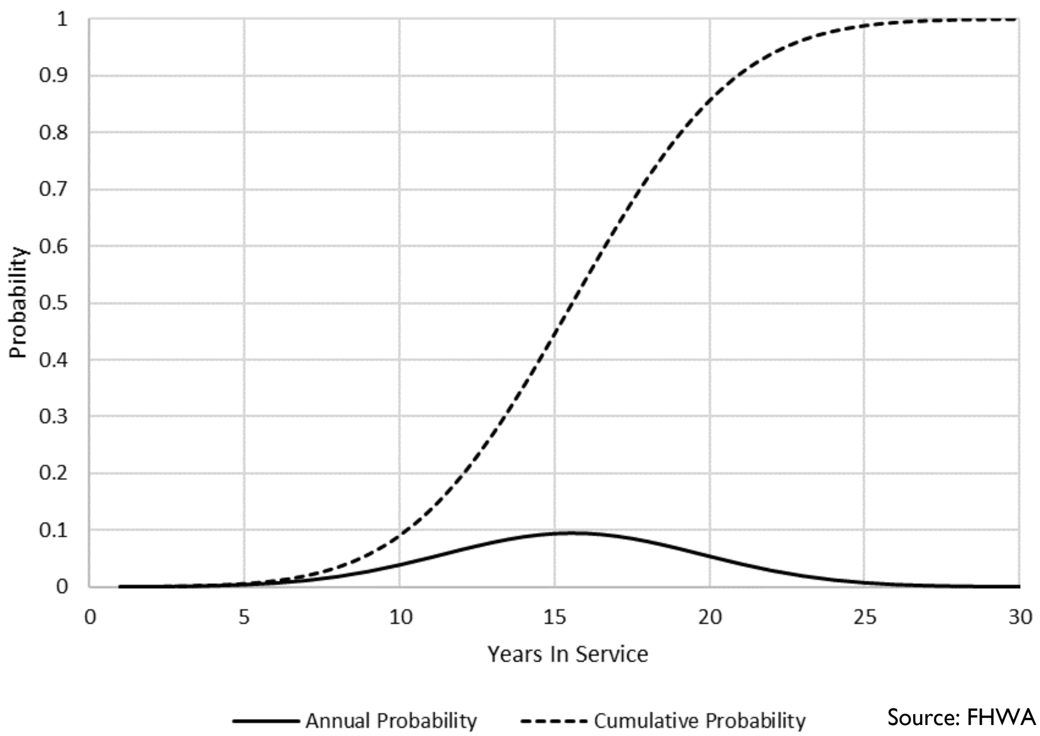

Figure 2. Graph. Probability Distributions for In-Service Performance Life.

In addition to evaluating the in-service performance of safety countermeasures, National Cooperative Highway Research Program (NCHRP) Report 713: Estimating Life Expectancies of Highway Assets, Volume 1: Guidebook, provides a methodology for estimating the life expectancies of major types of highway assets, including several safety countermeasures.[4] NCHRP Report 713 shows that service life is influenced by the end-of-life definition, material properties, temperature and precipitation, intervention possibilities (including no maintenance, local climate, repair and correction actions, and rehabilitation actions), timing of interventions (for example restoring or replacing an asset while already onsite for other work), inspection schedule and tracking data, and availability of deterioration models. NCHRP Report 713 provides further details on methods for determining countermeasure survivability and life expectancy for estimating countermeasure service life. This includes developing and applying life expectancy models, including regression and survival probability models for different types of assets.

Once the agency selects the appropriate measure for the end of life criteria (for example it is generally accepted that end of life occurs when 50 percent of signs would not meet retroreflectivity standards), expected service life may be further impacted by the agency's method for managing the countermeasure. In many cases, the agency may manage the countermeasure by expecting replacement at the end of service life. An alternative is that the agency may choose to provide blanket replacement for all countermeasures of a certain type and/or within a certain geographic area. When replacing individual countermeasures at the end of the service life, the age of the countermeasure must be known. When conducting blanket replacement, the age of individual countermeasures is not important, since they are all being replaced together (for example, all pavement markings may be replaced on a one-year cycle or all signs may be replaced on a 20-year cycle). The agency may further choose to stagger replacement based on available funding (for example an agency may replace five percent of all signs on an annual basis such that all signs are replaced by 20 years).

Agencies may choose to be precise with countermeasure service life, rounding to the nearest year. However, in doing so, there are potential drawbacks. The MoDOT High Crash Location Manual notes that the service life for an improvement project can be difficult to forecast for several reasons, for example quality of maintenance can be difficult to predict. Therefore, there may not be a benefit to estimating service life in an unusual number of years because it can complicate economic analysis. In some cases, it may be beneficial to round service life to five-year increments for ease of comparison. Except for standard paint marking and work zone countermeasures, this Guide groups countermeasure service lives into five-year groupings for nationwide estimates. However, if agencies have data supporting more specific values of service life, rounding service life may introduce error by over- or under-estimating the life of a given countermeasure. In these cases, using the more precise values can lead to more fair and realistic comparisons.

2.3 SERVICE LIFE AND BENEFIT-COST ANALYSIS (BCA)

A BCA is a systematic process for calculating and comparing the benefits and costs of project alternatives.(5) The BCA identifies all project benefits and compares those to the costs to achieve them, regardless to whom realizes the benefits or costs.(6) Practitioners compare the present value costs and benefits for an analysis period to identify economically-efficient alternatives. Figure 3 shows that the benefit-cost ratio (BCR) is the ratio of present value benefits (PVB) to present value costs (PVC). A BCR greater than 1.0 indicates the benefits exceed the costs, and the project is economically justified. The Federal Highway Administration

(FHWA) Highway Safety Benefit-Cost Analysis Guide provides more details on computing the BCR to compare the cost effectiveness of alternatives.[6]

$$BCR = \frac{PVB}{PVC}$$

Figure 3. Equation. Benefit-cost ratio.

Project benefits can include both direct and indirect safety benefits. Direct safety benefits include reductions in crash frequency and severity while indirect safety benefits include reductions in travel time, vehicle operating cost, and emissions. Practitioners may quantify direct safety benefits through application of crash modification factors (CMFs) or predictive modeling, such as the HSM Part C. The practitioner can then use locally derived, or national, comprehensive crash costs to monetize the value of the benefits. Refer to the FHWA guide, Crash Costs for Highway Safety Analysis, for further details.[7] The preferred approach to estimate net safety benefits is to apply CMFs and crash costs by individual severity level and aggregate the results. The FHWA Highway Safety Benefit-Cost Analysis Guide provides further details on monetizing indirect safety benefits.[6]

Project costs include those for initial capital cost and those for maintaining and/or operating the project alternative.[6] Initial capital costs include planning, design, construction/installation, and equipment costs. Maintenance and operational costs include any additional utility costs (such as power or communications) and routine maintenance costs. Rehabilitation costs include repairs and improvements beyond those that are routine maintenance.

The next step is to determine the present value for future benefits and costs. This includes applying a discount rate for objective comparison. Figure 4 provides the formula for discounting a benefit or cost. This formula can be applied for one year for a one-time cost, or each year for an annual benefit or cost.

$$PV = \left(\frac{1}{(1+r)^t}\right) A_t$$

Figure 4. Equation. Formula for discounting benefits and costs.

where:

PV = present value in the base year.

r = discount rate.

t = time (years).

A_t = Benefit or cost in year t.

The service life for the countermeasure(s) under evaluation determines the time t in Figure 4. Since the benefits are typically estimated in terms of annual future values and costs are present value for both initial construction cost and annual values for operational and maintenance costs, the service life is imperative for determining the time/period over which to capture the benefits and costs. If service life differs among countermeasures, the practitioner may choose an appropriate value for t based on the analysis methodology selected in Section 3.2.2 Alternatives Analysis for Multiple Countermeasures. Once the practitioner determines the analysis period, the practitioner can calculate PVB, PVC, and the BCR. Chapter 5 presents several example applications of BCA through the selection and application of service life for countermeasure selection and alternatives analysis under different scenarios.

2.4 STANDARDIZING SERVICE LIFE FOR EVALUATIONS

Agencies may consider developing a standardized service life list for countermeasures for use on all safety projects considered for safety funding. Similar to an agency-specific CMF list, it can be a short list for the most commonly used countermeasures, or it can be a more comprehensive list, providing a consistent service life for all countermeasures installed by the agency.(8) The standardized service life list, like the CMF list provides the following benefits:

- Consistent application.(8) Standardized values improve consistent application within an agency regarding BCA on proposed projects. A practitioner from one district may decide to use a rounded service life value for a proposed countermeasure while a practitioner from another district may choose to go with a more specific value, based on his or her experience with the proposed countermeasure.
- Leveraging experience.(8) The standardized list may draw from agencywide experience with regard to common countermeasures or may draw from other agency experiences when new countermeasures are considered. As indicated in Section 2.5, there are several factors that can impact service life. The standardized list compiles known information about each countermeasure for which individual practitioners may not be aware.
- Improved documentation and justification.(8) Along with CMFs, the standardized service life list can help practitioners communicate to decisionmakers the reasons for selecting a preferred countermeasure, especially if the countermeasure has not been commonly applied throughout the agency or within a specific region.

As an example, practitioners in two districts may both consider installing oversized chevron signs as a horizontal curve countermeasure to correct an issue with nighttime crashes on similar curves with similar crash histories. The practitioner in district 1 may choose to use a CMF of 0.731 (CMF ID 8980 from FHWA's CMF Clearinghouse) and a service life of 10 years to estimate the expected safety benefits. The practitioner in district 2 may choose to use a CMF of 0.56 (CMF ID 8982 from FHWA's CMF Clearinghouse) and a service life of 15 years to estimate the expected safety benefits. The BCA for the district 2 application would indicate a better BCR than the BCA for the district 1 application, even though the conditions and countermeasures are the same. Standardized values would allow the practitioners to conduct similar BCAs for a fairer comparison of the proposed projects.

2.5 FACTORS IMPACTING SERVICE LIFE

While Chapter 4 of this guide provides values that represent typical, nationwide service lives for countermeasures by category, agencies should consider countermeasure service lives that are appropriate for their jurisdiction when possible. There are many reasons why an agency may choose to use a different service life for a countermeasure, and it is possible that different jurisdictions/regions within a State could adopt different service lives based on in-service performance or if the expected service life differs based on factors provided in this section. However, it is important for agencies to understand the implications and to document the reasons for adopting jurisdiction-specific values.

There are several factors that influence countermeasure service life. While this list is not meant to be exhaustive, several factors known to influence countermeasure service life include the following:

- **Environment**. It is generally accepted that the effects of plowing and salting operations can shorten the service life of countermeasures in regions that receive snowfall. Regions with more snowfall are likely to have a greater impact. However, other environmental factors, such as the duration and intensity of sunshine may impact service life, particularly for signs. While the research has not converged on whether south facing signs degrade at a faster rate, south-facing red signs have a higher variation in retroreflectivity, meaning they may be more susceptible to degradation than other sign colors.[9] Additionally, north facing signs may be more susceptible for the need for cleaning (adding annual maintenance costs).

- **Maintenance and rehabilitation activities**. Maintenance and rehabilitation activities can help to extend the service life of a countermeasure, while a lack of maintenance can shorten the service life. Section 2.6 provides several examples of routine maintenance, repair or corrective actions, and rehabilitation activities that can impact service life. Agencies can document maintenance activities and estimate their impact on service life through summary spreadsheets or deterioration models such as those highlighted in Section 2.2 and detailed in NCHRP Report 713.[4]

- **Replacement cycles**. If the agency has a routine schedule for countermeasure replacement, such as restriping longitudinal markings on a two-year basis, the schedule may dictate the service life. Another example includes traffic sign replacement. If using the blanket replacement method, the service life for the sign should align with the blanket replacement schedule.

- **Operational and design context**. The HSM notes that changes to surrounding land use occurring over time may influence safety performance for sites designed for operations that no longer exist.[1] The service life for the countermeasure should reflect a reasonable period for which the roadway characteristics and traffic patterns are expected to remain relatively consistent. The service life for traffic signals are generally based on the average length of time for which timing changes are needed rather than based on the average lifespan of system components. Based on changing demographics, values for certain countermeasures may need to be reconsidered across an agency or within specific jurisdictions of any agency.

- **Manufacturer specifications and warranties**. Manufacturers may provide a warranty identifying an expected service life for countermeasures or components. The warranty is based on the materials and components used and may vary from manufacturer to manufacturer. Table 2 provides an example of common warranties for signs based on sheeting type.[3] As sheeting type increases, the warranty number of years generally increases.

Table 2. Example warranties for signs based on sheeting type.[3]

ASTM D4956 Type	Years of Warranty*
I and II	7
III and IV	10
VII, VIII, IX, X	12
* May be different for fluorescent sheeting materials	

While these factors all may impact the selected service life for an agency, it is important for agencies to take an active role in asset management and determine if adjustments to the service lives are necessary. For example, studies have shown that expected life for signs is greater than the warranty provided, with an expected life of 12 to 20 years for beaded sheeting and 15 to 30 years for prismatic sheeting.[9] Agencies can track their asset life cycle to develop a data driven method for estimating service life, such as those presented in Section 2.2 (i.e., in-service performance evaluation).

2.6 MAINTENANCE AND REHABILITATION ACTIVITIES

Maintenance and rehabilitation activities are designed to extend the service life of a countermeasure. Maintenance and rehabilitation activities are a necessary consideration in a BCA but can sometimes be difficult to separate from the service life for an individual countermeasure. In general, the service life is defined by the replacement of the countermeasure itself; however, complex systems, such as traffic signals, may have component replacements that may influence the service life but typically do not justify the end of the service life for the countermeasure.

In general, there are three activities that agencies conduct to extend service life, which would be considered within a BCA, but would not bound the service life of the countermeasure.[(4)] These include the following:

- Routine maintenance activities. These activities are conducted often and are often considered to be preventive. Examples include washing signs, painting structures, and sealing cracks in roadway surfaces. Street cleaning in urban areas is used to improve the visibility of pavement markings.

- Repair and corrective actions. These actions are often completed after an inspection or in response to damage. Examples include replacing corroded components, loose connections, non-functioning components, damaged wiring and insulation, or removing accumulated debris in traffic signals.

- Rehabilitation actions. These actions replace degraded materials or restore a countermeasure to full functionality (or to stop damage progression). An example includes a complete replacement of a wearing surface for shoulder pavement.

Agencies should include the cost of each of these corrective actions in the BCA. Some may be annual or reoccurring costs while others may be larger, one-time expenditures. However, since the purpose of the maintenance, repair, or rehabilitation action is to extend the service life of the countermeasure, the cost of the actions should continue to provide an expected benefit greater than the cost.

Table 3 provides a comparison of life cycle costs for a countermeasure based on no corrective action or varying levels of corrective action. Based on the actions taken, the overall service life for the countermeasure can vary. However, the costs associated with each maintenance/rehabilitation alternative is a consideration in the BCA. Since the objective of these activities is to extend the life of the countermeasure, each alternative does that. Note that this serves only as an example for consideration; the optimal approach may differ based on the specific circumstances of a contemplated countermeasure. Additionally, as an agency has maintenance and rehabilitation policies in place, in general, only one alternative would be considered for the countermeasure. The agency would use the service life associated with the appropriate maintenance and rehabilitation schedule (along with associated costs) in the BCA.

For the countermeasure in Table 3, the expected service life is 5 years. There are no costs in addition to the initial installation cost of $50,000. If conducting annual maintenance, the annual cost is $500 per year. This approach is expected to extend the service life by two years (note that the annual cost is discounted assuming a discount rate of 3.0 percent and present values are shown in each row. The present value cost for extending the service life by 2 years through routine annual maintenance is $3,510. Additionally, $10,000 repair and corrective actions taken in year 5 may extend the life of the countermeasure to 10 years. The present value cost for this approach adds $12,891 to the original installation cost. Alternatively, the agency may choose to conduct a $15,000 rehabilitation in year 5 only (no annual maintenance), extending the service life to 10 years. The rehabilitation action adds $12,939 in present value cost to the original installation cost. However, extending the service life through maintenance and rehabilitation actions appears to be more cost effective than simply replacing the countermeasure at the end of the original service life.

Table 3. Comparison of Life Cycle Costs and Service Life for Example Countermeasure.

Years After Construction	No Activities	Annual Maintenance	Corrective Actions	Rehabilitation Actions
Initial Cost (0)	$50,000	$50,000	$50,000	$50,000
1	$0	$485	$485	$0
2	$0	$471	$471	$0
3	$0	$458	$458	$0
4	$0	$444	$444	$0
5	$0	$431	$9,057	$12,939
6	--	$419	$419	$0
7	--	$407	$407	$0
8	--	--	$395	$0
9	--	--	$383	$0
10	--	--	372	$0
Total	$50,000	$53,510	$62,891	$62,939

2.7 DEVELOPING AN AGENCYWIDE SERVICE LIFE LIST

As indicated in Section 2.4 Standardizing Service Life for Evaluations, there are several benefits to standardizing service lives for countermeasures throughout an agency. Having considered the Factors Impacting Service Life in Section 2.5, agencies can make specific recommendations for each countermeasure in an agencywide service life list, ensuring consistent application. Agencies have taken several approaches for adopting typical service lives, including the following:

- Providing a specific countermeasure list focused only on service life.
- Adding the typical service life into an agencywide CMF list. These lists often include additional information, such as estimated initial project costs and ongoing maintenance and operational costs.
- Including typical service life into an agency-specific BCA tool.

In each of these cases, the countermeasures are often grouped in categories based on similar applicability. For example, intersection countermeasures are often grouped together.

Table 4 provides an example service life list from the Arizona HSIP Manual.[10] In this case, the list is a separate appendix to the manual providing service life for each listed countermeasure.

Table 4. Arizona HSIP Manual project service life list.[10]

Project Category	Project Description	Service Life (Years)
INTERSECTION PROJECTS	Channelization, left-turn bay	10
	Traffic signals	10
	Combination of 10 and 11	10
	Sight distance improvement	10
	Other intersection improvements, except structures	10
CROSS SECTION PROJECTS	Pavement widening, no lanes added	20
	Lanes added without new median	20
	Highway divided, new median added	20
	Shoulder widening or improvement	20
	Combination of 20 – 23	20
	Skid treatment – grooving	10
	Skid treatment – overlay	10
	Flattening, clearing side slopes	20
STRUCTURES	Widening bridge or major structure	20
	Replace bridge or major structure	30
	New bridge or major structure (except 34 and 51)	30
	Minor structure	20
	Pedestrian over- or under-crossing	30

Table 5 provides an example service life list for improvements from the Texas HSIP Guidelines.[11] The service life list in this case provides further definition of each improvement, the associated crash reduction factor (CRF), service life, annual maintenance cost, and codes for improvement target crash types. In this case, the CRF is applicable to the crash types listed under preventable crashes. The work codes provided under preventable crashes directly link to the Texas crash data for target crash identification.

Table 5. Work codes for Texas HSIP Guidelines.[11]

Work Code	Measure	Detail
101: Install Warning/ Guide Signs	Definition:	Provide advance signing for unusual or unexpected roadway features where no signing existed previously.
	Reduction Factor (%):	20
	Service Life (Years):	6
	Maintenance Cost:	N/A
	Preventable Crash:	(Vehicle Movements/Manner of Collision = 20 – 22 or 30) OR (Roadway Related = 2, 3 or 4)
105: Install Intersection Flashing Beacon	Definition:	Provide a flashing beacon at an intersection where a beacon did not exist previously.
	Reduction Factor (%):	35
	Service Life (Years):	10
	Maintenance Cost:	$2,100 (overhead) $1,300 (roadside mounted)
	Preventable Crash:	Intersection Related = 1 or 2
106: Modernize Intersection Flashing Beacon	Definition:	Improve an existing overhead flashing beacon, located at an intersection, to current design standards. Refer to W.C. 104 for non-intersection flashing beacon.
	Reduction Factor (%):	10
	Service Life (Years):	10
	Maintenance Cost:	N/A
	Preventable Crash:	Intersection Related = 1 or 2
107: Install Traffic Signal	Definition:	Provide a traffic signal where none existed previously.
	Reduction Factor (%):	35
	Service Life (Years):	10
	Maintenance Cost:	$3,400 (Isolated) $3,900 (Interconnected) $5,400 (Diamond Interchange)
	Preventable Crash:	[(Intersection Related = 1 or 2) AND (Vehicle Movements/Manner of Collision = 10-39)] OR (First Harmful Event = 1 or 5)

Table 6 presents an example CRF list, including service life, from the North Carolina Department of Transportation.[12] This worksheet provides comprehensive details necessary to conduct a BCA for proposed countermeasures. This worksheet provides details on the target crash type(s) for each countermeasure, details on specific CRFs by crash outcomes impacted, and a notation on which CRFs can be considered together.

The remaining columns include additional details necessary to complete the BCA other than the initial project cost. This includes the service life, annual maintenance cost, and annual operating cost. Moreover, the CRF spreadsheet includes the crash costs for use in determining the project benefits, separately for fatal and serious injury, moderate and minor injury, and property damage only crashes.

Table 41 in Appendix A provides additional examples of State service life lists.

Table 6. North Carolina CRF sheet.[12]

Countermeasure	Site Type Specification	Crash Pattern Affected	CRF	Service Life (Years)	Annual Maintenance Cost	Utility Cost	Crash Costs K+A	Crash Costs B+C	Crash Costs PDO
1.1 New Traffic Signal	3-leg Urban	Angle Injury	34	10	$2,700	$475	$3,403,000	$161,000	$12,400
	3-leg Urban	Rear End Injury	-50	10	$2,700	$475	$2,571,000	$139,000	$12,400
	4-leg Urban	Angle Injury	67	10	$2,700	$475	$3,403,000	$161,000	$12,400
	4-leg Urban	Rear End Injury	-38	10	$2,700	$475	$2,571,000	$139,000	$12,400
1.2 Upgrade Traffic Signal	All	Total	14	10	--	--	$3,121,000	$139,000	$12,400
1.3 Change to Protected Left Turn	Urban	Left Turn	99	10	--	--	$3,403,000	$161,000	$12,400
	Not Specified	Left Turn	70	10	--	--	$3,403,000	$161,000	$12,400
1.4 Convert Signal to Mast Arm	All	Angle	5	50	$400	--	$3,403,000	$161,000	$12,400
1.5 Install Near Side Signal Head	All	Target Frontal Impact	30	10	--	--	$3,403,000	$161,000	$12,400
1.6 Pretimed to Actuated Signal	Not Specified	Angle	10	10	--	--	$3,403,000	$161,000	$12,400
1.7 Closed Loop Signal System	Not Specified	Total	15	10	$1,000 per Signal	$480	$3,121,000	$139,000	$12,400
1.8 Improve Signal Timing	Not Specified	Total	15	10	--	--	$3,121,000	$139,000	$12,400
1.9 Replace 8-in. to 12-in. Signal Head	Urban	Angle	42	10	--	--	$3,403,000	$161,000	$12,400
1.10 Add Long Vehicle Detection	All	Total	10	10	$250	--	$3,121,000	$139,000	$12,400

2.8 CHAPTER SUMMARY

Chapter 2 introduces the fundamental concepts of service life, provides details on how service life can be determined, and how annual maintenance and rehabilitation impact service life. Further, Chapter 2 provides an overview of service life's role in BCA, discusses the need for standardized service life, and identifies factors that agencies may consider when establishing or changing typical service lives.

Key Takeaways from Chapter 2:

- Service life is the number of years in which a countermeasure is expected to have a noticeable and quantifiable effect on the crash occurrence at a site.
- There are many sources of service life including manufacturer warranties, published research, in-service performance evaluations, and survival analysis.
- Annual maintenance and rehabilitation activities can extend the service life for safety countermeasures and should be accounted for in BCA.
- Since countermeasure benefits and ongoing maintenance and operational costs are typically estimated in terms of annual future values, the service life is imperative for determining the time/period over which to capture the benefits and costs.
- Using standardized values of service life provides consistent application across agency BCA, leverages agency experiences, and provides improved documentation and justification.
- Many factors can impact countermeasure service life including environmental conditions, maintenance and rehabilitation activities, replacement cycles, operational and design context, and manufacturer specifications and warranties.
- Agency-specific service life lists may be combined with CMF, project cost, and project benefit values to provide consistent agencywide application in BCA.

CHAPTER 3—SERVICE LIFE SELECTION AND CONSIDERATIONS

Chapter 3 provides an overview of countermeasure service life selection and analysis considerations.

Chapter 3 At-A-Glance

Chapter 3 is divided into three sections:

- Section 3.1 provides instructions on selecting countermeasure service life for BCA.
- Section 3.2 provides specific details to practitioners on considerations when using countermeasure service life as part of a BCA. This includes estimating countermeasure service life when there is no documented service life available.
- Section 3.3 presents related resources and documentation helpful for using service life as part of a BCA.
- Section 3.4 provides a summary of the chapter.

3.1 SELECTION OF SERVICE LIVES FOR COUNTERMEASURES

This Guide provides typical service lives for individual countermeasures. Often, multiple countermeasures are implemented together, for example adding shoulder rumble strips while widening shoulders. Section 3.2.1 addresses service life considerations for BCA of multiple countermeasures. However, there can still be difficulty in determining the appropriate service life for individual countermeasures when the following scenarios occur:

- **Project elements are part of routine maintenance**. For example, while improving intersection sight distance would be a safety countermeasure, doing so through clearing vegetation would not necessarily impact service life. Vegetation clearing would fall under periodic maintenance and can be addressed through maintenance cost, not service life. Changes to intersection sight distance would impact service life if the agency applied for and used safety funds to make physical changes to the roadway or roadside environment (such as removing objects, moving side slopes, or through pavement widening).
- **A countermeasure impacts other features associated with safety**. An example would be restriping existing paint markings as part of a roadway widening project. In this case, the cost of the markings could be included in the initial project cost only. Since the pavement markings are restriped on an ongoing basis, future restriping efforts would have been conducted anyway. Therefore, restriping markings

would not need to be considered as a maintenance expense and service life would not need to be considered as part of the BCA.

- **The function of a countermeasure may differ from the physical properties defining the countermeasure**. For example, agencies may use standard waterborne paint markings to create a median. The practitioner may have to choose the service life for installing a median (in this Guide this would be a 20-year service life) versus installing standard paint markings in this Guide this would be a 1-year service life). Since the pavement markings used to define the median are not a part of the standard longitudinal markings, the service life in this case would be defined by the replacement of the median paint markings. When possible, this Guide provides this distinction in Chapter 4 (this includes installing a median through standard paint markings, as well as installing right-turn channelization through standard paint markings); however, not all scenarios are covered in this Guide. The practitioner should exercise judgment when selecting the service life in these cases.

3.2 ANALYSIS CONSIDERATIONS

The section provides details to practitioners on considerations that can be made when using countermeasure service life as part of BCA. Section 3.2.1 provides details on selecting service life for countermeasure packages, Section 3.2.2 provides details on alternatives analysis for multiple options including countermeasure packages, and Section 3.2.3 provides options for practitioners when no service life is available for a countermeasure of interest.

3.2.1 Service Life for Countermeasure Packages

While this Guide provides service lives for individual countermeasures, there are many instances where multiple countermeasures may be installed at the same time for the following reasons:

- The combined safety effect of multiple countermeasures justifies implementing more than one at a location. The different countermeasures may target different crash types and severities or may both target the same crash type and severity, depending on the nature of the problems at the site.
- There is a reduced cost to implementing a specific countermeasure when an improvement is already under construction at a location. For example, rumble strips are commonly installed when widening shoulders on rural, two-lane highways.

If the countermeasures target different crash types and severities, the safety effects of each may be assessed independently from each other using the Additive method when quantifying project benefits. If the countermeasures target the same crash types and severities, there are several approaches to estimating the combined safety effect, including the following:

- The Dominant Effect method, which applies when both countermeasures completely overlap targeting the same crash types and severities.
- The Dominant Common Residuals method, which applies when there is some overlap in countermeasure effects.
- The Multiplicative method, which applies when both countermeasures result in an increase in a target crash type or severity, or when there is a counteractive effect.

The *FHWA Highway Safety Benefit Cost Analysis Guide* provides more details on each of these methods for combining safety effects for multiple countermeasures.(6) Additionally, NCHRP Report 17-63, *Guidance for the Development and Application of Crash Modification Factors*, provides a more reliable approach for estimating the benefits of multiple countermeasures.(13) Additionally, the CMF Clearinghouse contains instances of CMFs for combined countermeasures. Practitioners should prioritize CMFs specific to the countermeasure package when assessing combined safety effectiveness. When evaluating the methods for combining CMFs for safety effects, the analyst can evaluate if the methodology will have an impact on the combined service life.

In many instances, multiple countermeasures, when applied together, have the same service life. In this case, the combined service life determination is straightforward and is the same as the service life for each of the individual countermeasures. For example, the typical service life for both pavement resurfacing and installing center line rumble strips is 10 years. While the calculation of the combined safety effect may take consideration of target crash type, target crash severities, and estimated safety effectiveness of each individual countermeasure, the service life is readily assessed to be 10 years.

When the service life among countermeasures differ, there are several methods for normalizing the service life for BCA (or identifying the appropriate analysis period), including the following:

- **Least common multiple of service lives**. For example, if countermeasure 1 has a service life of 5 years and countermeasure 2 has a service life of 10 years, then the least common multiple is a service life of 10 years. In this case, the practitioner would estimate the initial cost for the both countermeasures and assume one replacement for countermeasure 1 at the end of the fifth year.

  When considering maintenance and rehabilitation, the least common multiple still applies. For example, the hardware for countermeasure A has an estimated 10-year service life, which requires maintenance every 2 years. Countermeasure B has an estimated 25-year service life, requiring repairs every 5 years. Using the least common multiple of service lives, the analysis period is 50 years. For the first countermeasure, this would include the initial cost and replacements at 10, 20, 30, and 40 years. For the second countermeasure this would include the initial cost and replacement at year 25. The service life for countermeasure A includes 24 maintenance activities and for countermeasure B includes 9 repairs.

- **Maximum service life**. In this case, the maximum service life from any of the multiple countermeasures is used as the service life for BCA. If the individual service lives are multiples of each other, then this is the same approach as the least common multiple method. When the service lives are not multiples of each other, this method fails to yield full benefit of one countermeasure's replacement. If the service life for countermeasure A is 10 years and the service life for countermeasure B is 25 years, then the combined service life, in this case, is 25 years. For the first countermeasure, this would include the initial cost and replacement at years 10 and 20. Note that the benefit of the replacement at year 20 is not fully realized. For the second countermeasure, this would include only the initial cost.

- **Horizon year**. In this case, a standard analysis period is used for all evaluations. For example, a horizon year analysis may consider a 10-year analysis period for all BCA evaluations. Agencies may select this approach for one or more of several reasons, including the following:

    - Constrained budgets. Agencies may use the horizon year approach for BCA to identify projects with short-term benefits.

    - Providing a common ground for comparing and prioritizing projects.

    - Supporting zero fatality program goals. For example, if the agency goal is zero fatalities by 2050, 2050 provides a common analysis period for comparison.

    - Service life for one or more countermeasures may not be known. Historically agencies have used this approach because no service lives have been available for individual countermeasures. This approach provides some standardization and agencies may consider separate horizon years for countermeasures by groupings. For example, Maine DOT (MaineDOT) uses present worth costs for either 10 or 20 years. MaineDOT uses 10 years for all projects except for construction projects resulting in a change in facility type (for example installing a roundabout). In this approach, MaineDOT uses project costs to help account for maintenance and replacement costs if the service life is known to be less than 10 years. The Wisconsin DOT uses 10 years for all resurfacing, restoration, and rehabilitation projects as well as for HSIP projects.

Example

An agency is considering installing two countermeasures on a 20-mile section of rural two-lane roadway, including paved shoulder widening and shoulder rumble strips. The service life for shoulder rumble strips is 10 years and the service life for widening the paved shoulder is 20 years. The CMF for the combined countermeasure application is 0.608 (CMF ID 6665) for total crashes. Table 7 provides estimated annual crashes for base conditions by crash severity, average crash cost by severity, and estimated annual monetary benefit from installing the combined countermeasures.

Table 7. Example application of crash costs by severity.

Crash Severity	Estimated Annual Crashes for Base Conditions	Applicable CMF	Estimated Annual Reduction in Crashes	Average Crash Cost by Severity	Estimated Annual Monetary Benefit
K	0.4	0.608	0.157	$11,637,900	$1,824,823
A	2.4	0.608	0.94	$674,400	$634,476
B	4.2	0.608	1.65	$204,100	$336,030
C	7.5	0.608	2.94	$129,000	$379,260
O	15.0	0.608	5.88	$12,100	$71,148
Total	29.5	--	11.56	--	$3,245,736

For identifying the service life-based analysis period for BCA, the least common multiple and maximum service life methods are the same value in this case (20 years). This example further compares the 20-year analysis period to a horizon year analysis of 10 years.

Table 8 provides the annualized benefits and costs for both analysis periods. The analysis includes a 3 percent discount rate, $100,000 per mile initial construction cost for shoulder widening, $3,000 per mile initial construction cost for shoulder rumble strips, and a rehabilitation cost of $25,000 per mile for the pavement resurfacing at the end of year 10. The initial construction cost is $100,000 × 20 miles + $3,000 × 20 miles = $2,060,000 for shoulder widening and rumble strip installation.

Table 8. Annualized benefits and costs.

Years After Construction	Maximum Service Life Safety Benefit	Maximum Service Life Project Cost	Horizon Year Safety Benefit	Horizon Year Project Cost
Initial (0)	--	2,060,000	--	2,060,000
1	$3,151,200	$0	$3,151,200	$0
2	$3,059,418	$0	$3,059,418	$0
3	$2,970,308	$0	$2,970,308	$0
4	$2,883,794	$0	$2,883,794	$0
5	$2,799,800	$0	$2,799,800	$0
6	$2,718,253	$0	$2,718,253	$0
7	$2,639,080	$0	$2,639,080	$0
8	$2,562,214	$0	$2,562,214	$0
9	$2,487,586	$0	$2,487,586	$0
10	$2,415,132	$0	$2,415,132	$0
11	$2,344,789	$404,556	--	--
12	$2,276,494	$0	--	--
13	$2,210,188	$0	--	--
14	$2,145,814	$0	--	--
15	$2,083,314	$0	--	--
16	$2,022,635	$0	--	--
17	$1,963,724	$0	--	--
18	$1,906,528	$0	--	--
19	$1,850,998	$0	--	--
20	$1,797,085	$0	--	--
Present Value	**$48,288,356**	**$2,464,556**	**$27,686,786**	**$2,060,000**

Figure 5 shows the equation to convert the annual safety benefit for a given year to a present value. In this case, the equation shows the conversion of annual safety benefits for year 1 [Note this is the first year after the one-year construction period.]

$$PV = \left(\frac{1}{(1+r)^t}\right) A_t = \left(\frac{1}{(1+0.03)^1}\right) \$3{,}245{,}736 = \$3{,}151{,}200$$

Figure 5. Equation. Example conversion of annual safety benefit to present value for year 1.

Figure 6 shows the equation to convert the rehabilitation cost in year 11 to a present value. [Note this is the pavement resurfacing cost and rumble strip installation cost in year 10 after the one-year construction period.]

$$PV = \left(\frac{1}{(1+r)^t}\right) A_t = \left(\frac{1}{(1+0.03)^{11}}\right) (\$25{,}000 \times 20 + \$3{,}000 \times 20) = \$404{,}556$$

Figure 6. Equation. Example conversion of rehabilitation cost to present value for year 11.

Figure 7 provides the equation for BCR calculation for the maximum service life/least common multiple of service lives analysis and Figure 8 provides the equation for BCR calculation for the horizon year analysis.

$$BCR = \frac{PVB}{PVC} = \frac{\$48{,}288{,}356}{\$2{,}464{,}556} = 19.6$$

Figure 7. Equation. Example BCR calculation for maximum service life/least common multiple of service lives analysis period.

$$BCR = \frac{PVB}{PVC} = \frac{\$27{,}686{,}786}{\$2{,}060{,}000} = 13.4$$

Figure 8. Equation. Example BCR calculation for horizon year analysis period.

The results of the maximum service life/least common multiple of service lives analysis indicates a BCR of 19.6 while the horizon year analysis indicates a BCR 13.4. As expected, the BCR is higher when considering at least the maximum service life, even with the rehabilitation cost. The horizon year analysis shows that a benefit is found even when the complete service life is not evaluated.

3.2.2 Alternatives Analysis for Multiple Countermeasures

Service life is also an important consideration when conducting BCA for alternatives analysis. When the service life is the same between two alternatives (or the only alternative is a no-build option), the service life can be used directly for the analysis period. However, if the service life differs between the alternatives, one of the approaches from Section 3.2.1 may be used to establish a common analysis period. The analysis period should include the initial construction and at least one subsequent rehabilitation action for each alternative.(14)

For comparing alternatives using BCA, the practitioner should calculate the present value costs and benefits for each alternative over the same analysis period. As indicated in Section 3.2.1, the analysis period includes the initial construction and all maintenance and rehabilitation costs associated with each countermeasure for each alternative. The practitioner may compute the results separately for each alternative and then summarize the results for each alternative in a single summary table. The summary table can include the PVC, PVB, analysis period, service lives for countermeasures, and BCR.

Example

An agency is considering improvements for a midblock pedestrian crossing. Alternative A includes installing a thermoplastic crosswalk, two advance pedestrian crossing signs, and two pedestrian signs with a diagonal downward point arrow plaque at the crossing. Alternative B includes the crosswalk and signage from Alternative A along with installing rectangular rapid flashing beacons (RRFBs). Table 9 provides a summary of project costs and service lives for each alternative countermeasure. Upon analysis of existing crash data, expected reductions in crash frequency, and associated crash costs, the analyst determined the project benefits for alternative A to be approximately $5,000 per year and for alternative B to be approximately $15,000 per year. The discount rate is 3 percent.

Table 9. Project costs for alternatives analysis example.

Project Costs	Crosswalk (Alternative A and B)	Signage (Alternative A and B)	RRFBs (Alternative B)
Service Life (Years)	5	15	10
Initial Cost	$1,000	$1,500	$10,000
Annual Maintenance Cost	0	$500	$2,000

The initial project cost for alternative A includes both the crosswalk and signage ($1,000 + $1,500 = $2,500). The initial project cost for alternative B includes the crosswalk, signage, and RRFB ($2,500 + $10,000 = $12,500).

Table 10 provides the annualized benefits and costs for each of the alternatives using the maximum service life analysis period. Table 10 includes reinstalling the crosswalks in years 6 and 11 and reinstalling the RRFB in year 11. All future costs and benefits are converted to present value.

Figure 9 shows the equation to convert the annual safety benefit for alternative A for a given year to a present value. In this case, the equation shows the conversion of annual safety benefits for year 15 [Note this is the benefit in year 15 after the one-year construction period.]

$$PV = \left(\frac{1}{(1+r)^t}\right) A_t = \left(\frac{1}{(1+0.03)^{15}}\right) \$5{,}000 = \$3{,}209$$

Figure 9. Equation. Example conversion of annual safety benefit to present value for year 15.

Table 10. Annualized benefits and costs for alternatives analysis example.

Years After Construction	Alternative A Safety Benefit	Alternative A Project Cost	Alternative B Safety Benefit	Alternative B Project Cost
Initial (0)	--	$2,500	--	$12,500
1	$4,854	$485	$14,563	$1,942
2	$4,713	$471	$14,139	$1,885
3	$4,576	$458	$13,727	$1,830
4	$4,442	$444	$13,327	$1,777
5	$4,313	$431	$12,939	$1,725
6	$4,187	$1,256	$12,562	$2,512
7	$4,065	$407	$12,196	$1,626
8	$3,947	$395	$11,841	$1,579
9	$3,832	$383	$11,496	$1,533
10	$3,720	$372	$11,161	$1,488
11	$3,612	$1,083	$10,836	$9,391
12	$3,507	$351	$10,521	$1,403
13	$3,405	$341	$10,214	$1,362
14	$3,306	$331	$9,917	$1,322
15	$3,209	$321	$9,628	$1,284
Present Value	**$59,690**	**$10,028**	**$179,069**	**$45,159**

Figure 10 shows the equation to convert the reinstallation cost for the crosswalk and RRFB plus maintenance cost in year 11 to a present value. [Note this is cost in year 11 after the one-year construction period.] This calculation approach is used for reinstallation and maintenance costs in alternatives A and B.

$$PV = \left(\frac{1}{(1+r)^t}\right) A_t = \left(\frac{1}{(1+0.03)^{11}}\right)(\$10{,}000 + \$1{,}000 + \$2{,}000) = \$9{,}391$$

Figure 10. Equation. Example conversion of rehabilitation cost to present value for year 11.

Figure 11 provides the equation for BCR calculation for alternative A and Figure 12 provides the equation for BCR calculation for alternative B.

$$BCR = \frac{PVB}{PVC} = \frac{\$59{,}690}{\$10{,}028} = 6.0$$

Figure 11. Equation. Example BCR for alternative A.

$$BCR = \frac{PVB}{PVC} = \frac{\$179{,}069}{\$45{,}159} = 4.0$$

Figure 12. Equation. Example BCR calculation for alternative B.

The BCR for alternative A is 6.0 while the BCR for alternative B is 4.0. The BCR for alternative A is greater than alternative B. While alternative A provides a more cost-effective improvement, the agency can continue to monitor the safety performance of this location after installation of the crosswalk and pedestrian crossing signs to determine if these improvements achieved the desired result. If not, the agency could consider installing the RRFBs at a later date.

3.2.3 Estimating Unknown Service Life

There are some instances where agencies may implement countermeasures for which no service life is available. The countermeasure may be new as a safety countermeasure or may be new to the agency conducting the BCA. If no service life is available, there are several options available to estimate service life for a fair BCA. Approaches for estimating unknown service life include the following:

1. Identify a similar countermeasure with a known service life and use that service life for the countermeasure of interest. If for some reason, the service life is expected to differ slightly, an adjustment can be made, but the reasoning should be documented.
2. Establish the useful life for components of the countermeasure and base the service life on the component with the shortest useful life, unless it is considered to be routine maintenance or an interim rehabilitation.
3. Use the expected life of benefits from the countermeasure. If the countermeasure is expected to provide short-term benefits (drivers may adapt to the countermeasure), then the period for which the countermeasure provides benefits should be used.
4. Perform horizon year analysis, as indicated in section 3.2.1.

Regardless of the approach taken for estimating unknown service life, it is important to carefully document and share these decisions for consistency and future reference.

3.3 RELATED RESOURCES

There are several resources available providing further details on analysis considerations for countermeasure service life and for highway safety BCA. This includes the following:

- The HSM. The HSM provides methods for conducting economic evaluation in Part B, predicting the safety performance of geometric alternatives in Part C, and methods for identifying and combining applicable CMFs in Part D.

- FHWA's CMF Clearinghouse. The CMF Clearinghouse provides a living repository for countermeasure CMFs as they are published and evaluated for quality.

- FHWA's *Highway Safety Benefit Cost Analysis Guide* and Tool. This guide, and associated tool, provide a framework for agencies conducting highway safety BCA for projects and programs. This framework includes quantifying costs as well as direct and indirect safety benefits for project alternatives. The accompanying spreadsheet tool implements the methods described in the guide to help users conduct BCA for safety investments.

- FHWA's *Crash Costs for Highway Safety Analysis Guide* and Tool. This guide describes the sources of crash costs, current practices and crash costs used by States, and considerations for modifying and applying crash costs. Additionally, this guide provides national crash costs for highway safety BCA as well as procedures to update and adjust crash costs over time as well as to specific jurisdictions. The accompanying spreadsheet tool helps practitioners to translate, convert, weight, adjust, or update existing crash costs.

- FHWA HSIP Manual. This manual provides practitioners with tools necessary to improve highway safety through data analysis, countermeasure identification, project prioritization, and safety effectiveness evaluation.

3.4 CHAPTER SUMMARY

Chapter 3 provides an overview of countermeasure service life selection and analysis considerations regarding countermeasure service life.

Key Takeaways from Chapter 3:

- Several scenarios may impact service life for individual countermeasures including when project elements are part of routine maintenance, a countermeasure impacts other features associated with safety, and a countermeasure may differ from the physical properties defining the countermeasure.
- There are several analysis considerations and methods for identifying the appropriate analysis period when a countermeasure package includes multiple countermeasures with differing service lives. An agency may select the method based on constraints and prioritization methods.
- When service life for a countermeasure is unavailable, there are several methods for estimation, including identifying a similar countermeasure with a known service life, basing service life off of the shortest useful lifespan for individual components, using the expected life of benefits, or performing a horizon year analysis. Regardless of the approach taken for estimating unknown service life, it is important to carefully document and share these decisions for consistency and future reference.

CHAPTER 4—TYPICAL SERVICE LIVES

Chapter 4 provides an overview of the process used to identify service lives and presents the typical service life for each countermeasure. This chapter presents one service life for each countermeasure for use in a Highway Safety BCA. Agencies may consider changes to the typical service life to fit their needs (as described in Chapter 2).

Chapter 4 At-A-Glance

Chapter 4 is divided into three sections:

- Section 4.1 provides an overview of the countermeasure service life review process. It provides an example review conducted for a countermeasure, along with applicable considerations for arriving at a typical service life.
- Section 4.2 describes the need for countermeasure categories and the selection of functional groupings for this Guide.
- Section 4.3 presents the typical service lives for each countermeasure grouped by functional area.

4.1 COUNTERMEASURE SERVICE LIFE REVIEW PROCESS

The development of this Guide focused on a review of existing resources containing service lives for countermeasures. The review included a search for State-agency HSIP manual documentation, countermeasure service life lists State agencies developed outside of HSIP resources, economic evaluation tools State agencies have developed for BCA, and a general review of literature including service lives specific to individual countermeasures. Appendix A contains a detailed summary of the literature review, including resources reviewed.

The literature review includes a spreadsheet detailing the service life used in each resource for every countermeasure included. The review began by exporting the available countermeasures included in FHWA's CMF Clearinghouse (www.cmfclearinghouse.org).[15] Rather than present each countermeasure included in the clearinghouse, this Guide narrowed the potential countermeasures to a broad, encompassing version (unless there was a specific need to use separate countermeasures). For example, there were several countermeasures related to horizontal curve radius, including the following:

- Change horizontal alignment.
- Change from horizontal tangent to a flat horizontal curve.
- Change from a horizontal tangent to a sharp horizontal curve.

- Change horizontal curve radius from X to Y (feet).
- Flatten horizontal curve.
- Increase degree of curve on freeways from 0 to 10 (curvature in degrees).
- Increase degree of curve on freeways from 0 to 15 (curvature in degrees).
- Increase in horizontal curvature by one degree.
- Increase in horizontal curvature from X to Y degrees.

This Guide combines these countermeasures into a simple "Change horizontal alignment". Further, this Guide provides service lives for single countermeasures, not combined countermeasures. Therefore, this Guide provides separate service lives for each individual countermeasure for the combined countermeasure "Change horizontal curve radius, posted speed, and superelevation." This Guide provides details in Section 3.2 Analysis Considerations for conducting BCA when countermeasures with different service lives are considered together.

The shortened list of countermeasures provided in Appendix A provides service lives by resource for each countermeasure. The Appendix A documentation summarizes the minimum, maximum, median, and mode values for each countermeasure.

A technical expert panel reviewed the findings from the literature review and provided suggestions for countermeasure service lives. The objectives of the panel included the following:

- Utilize professional judgment for each panel member's technical expertise. Some panel members' expertise focused more on application of the BCA methods while others had expertise in determining service life for individual countermeasures.
- Provide practical experience for countermeasures where the review provided little supporting detail or for countermeasures where recent research has shown that service life needs to be updated from the review, even if several resources were available.
- Maintain consistency among similar countermeasures. For example, the panel suggested a one-year service life for standard paint-based pavement markings and a five-year service life for more durable markings.

The technical panel included representatives from the following agencies:

Alaska DOT	Missouri DOT
Arizona DOT	North Carolina DOT
Idaho DOT	Pennsylvania DOT
Michigan DOT	Wisconsin DOT

Part of the review process included identifying functional categories for grouping similar countermeasures. Section 4.2 provides more details on functional categories for countermeasures.

4.2 COUNTERMEASURE CATEGORIES

Countermeasure organization is a key aspect of typical service life presentation. Due to the number of countermeasures for which this Guide contains typical service lives, it is necessary to organize countermeasures into functional categories for quick identification. This Guide organizes the functional categories consistent with the categories provided in the CMF Clearinghouse. Therefore, the countermeasures are grouped into the following categories:

- Access Management
- Advanced Technology and Intelligent Transportation Systems (ITS)
- Alignment
- Bicycle
- Delineation
- Highway Lighting
- Interchange Design
- Intersection Geometry
- Intersection Traffic Control
- Pedestrian
- Railroad Grade Crossings
- Resurfacing
- Roadside
- Roadway
- Shoulder Treatment
- Signs
- Structures
- Work Zone
- Other

While some countermeasures could logically be included in multiple categories, they are only included in one category, which was defaulted to be the same as the CMF Clearinghouse category. For example, "Install pedestrian countdown timers" could fall into both pedestrian treatments and intersection traffic control. Since the CMF for this countermeasure falls within the intersection traffic control category on the CMF Clearinghouse, this Guide provides the service life for this countermeasure in the same category.

4.3 TYPICAL SERVICE LIVES

This section provides the typical service life for each countermeasure by category. This Guide provides one service life value for each countermeasure based on the results of the literature review and input from the expert panel. This Guide also presents countermeasures individually. For more information on determining the service life for combined countermeasures, refer to Section 3.2. Also refer to Section 3.2 for more details on addressing service life for countermeasures not included in the following sections.

4.4.1 Access Management

Table 11 provides service lives for access management countermeasures. The typical service life for all countermeasures in this category is 20 years. Agencies may consider these values, along with the other factors described in Section 2.5, when selecting a final service life value.

Table 11. Typical Service Lives for Access Management Countermeasures.

Access Management Countermeasures	Service Life (Years)
Adjust Driveways Near Intersection	20
Change Driveway Density	20
Change Intersection Density	20
Change Median Width	20
Close Median Opening	20
Convert Driveway Entrance to Regular Intersection	20
Convert to Right-In-Right-Out Operations	20
Convert Two-Way to One-Way Operation	20
Create Directional Median Openings	20
Flatten Entrance Slopes	20
Increase Separation Distance Between Driveway and Downstream U-Turn	20
Install Flush/Depressed/Raised Median	20
Relocate Existing Driveway	20
Replace Two-Way Left-Turn Lane with Raised Median	20

4.4.2 Advanced Technology and ITS

Table 12 provides service lives for advanced technology and ITS countermeasures. The typical service life for all countermeasures in this category is 10 years. Agencies may consider these values, along with the other factors described in Section 2.5, when selecting a final service life value.

Table 12. Typical Service Lives for Advanced Technology and ITS Countermeasures.

Advanced Technology and ITS Countermeasures	Service Life (Years)
Implement Active Traffic Management Strategies	10
Implement Incident Management to Reduce Incident Duration	10
Install Changeable "Queue Ahead" Warning Signs	10
Install Changeable Message Signs	10
Install Changeable Speed or Crash Ahead Warning Signs	10
Install Long Vehicle Detection	10
Install Ramp Meters	10
Install Red Light Cameras	10
Install Speed Enforcement Camera/System	10
Install Toll Collection System	10
Install Wrong Way Driver Advanced Technology	10

4.4.3 Alignment

Table 13 provides service lives for alignment countermeasures. The typical service life for all countermeasures in this category is 20 years. Agencies may consider these values, along with the other factors described in Section 2.5, when selecting a final service life value.

Table 13. Typical Service Lives for Alignment Countermeasures.

Alignment Countermeasures	Service Life (Years)
Change Horizontal Alignment	20
Change Vertical Alignment	20
Improve Superelevation	20
Increase Stopping Sight Distance on Crest Vertical Curve	20
Make Geometric Improvements	20
Relocate Frontage Road	20

4.4.4 Bicycle

Table 14 provides service lives for bicycle countermeasures. The typical service life for countermeasures in this category range from 1 to 25 years. Agencies may consider these values, along with the other factors described in Section 2.5, when selecting a final service life value.

Table 14. Typical Service Lives for Bicycle Countermeasures.

Bicycle Countermeasures	Service Life (Years)
Install Standard Paint Bicycle Box	1
Install Standard Paint Bicycle Lane	1
Install Durable Marking Bicycle Box	5
Install Durable Marking Bicycle Lane	5
Install Bicycle Signal	10
Change Sidewalk Width	20
Install Bicycle Lane	20
Install Dedicated Bicycle Facility	20
Install Dedicated Bicycle Facility at Intersection	20
Install Raised Bicycle Crossings	20
Install Sidewalk Barrier	25

4.4.5 Delineation

Table 15 provides service lives for delineation countermeasures. The typical service life for countermeasures in this category range from 1 to 5 years. Agencies may consider these values, along with the other factors described in Section 2.5, when selecting a final service life value.

Table 15. Typical Service Lives for Delineation Countermeasures.

Delineation Countermeasures	Service Life (Years)
Install, Apply, or Restripe with Paint Markings	1
Improve Pavement Marking Retroreflectivity	1
Provide Standard Paint "STOP Ahead" Pavement Markings	1
Install, Apply, or Restripe with Tape or Thermoplastic Markings	5
Improvement Pavement Marking to Wet-Reflective Markings	5
Install Delineators	5
Install Profile Center Line Markings	5
Install Profile Edge Line Markings	5
Install Raised Reflective Pavement Markers	5
Provide Durable "STOP Ahead" Pavement Markings	5
Restripe with Epoxy	5

4.4.6 Highway Lighting

Table 16 provides service lives for highway lighting countermeasures. The typical service life for all countermeasures in this category are 15 years. Agencies may consider these values, along with the other factors described in Section 2.5, when selecting a final service life value.

Table 16. Typical Service Lives for Highway Lighting Countermeasures.

Highway Lighting Countermeasures	Service Life (Years)
Modify/Improve Lighting	15
Provide Intersection Lighting	15
Providing Segment Lighting	15

4.4.7 Interchange Design

Table 17 provides service lives for interchange design countermeasures. The typical service life for all countermeasures in this category are 20 years. Agencies may consider these values, along with the other factors described in Section 2.5, when selecting a final service life value.

Table 17. Typical Service Lives for Interchange Design Countermeasures.

Interchange Design Countermeasures	Service Life (Years)
Add Acceleration or Deceleration Lane	20
Change Ramp Type	20
Convert Interchange Configuration	20
Modify Number of Lane Changes at Merge/Diverge Area	20
Modify Speed Change Lane Design	20
Provide Auxiliary Lane Between Entrance and Exit Ramp	20
Install Grade Separation	30

4.4.8 Intersection Geometry

Table 18 provides service lives for intersection geometry countermeasures. The typical service life for countermeasures in this category range from 1 to 20. Agencies may consider these values, along with the other factors described in Section 2.5, when selecting a final service life value.

Table 18. Typical Service Lives for Intersection Geometry Countermeasures.

Intersection Geometry Countermeasures	Service Life (Years)
Provide Standard Painted Channelized Left-Turn Lane	1
Provide Durable Marking Channelized Left-Turn Lane	5
Add Left- or Right-Turn By-Pass Lanes	20
Add Quadrant Roadway to Intersection	20
Change Intersection Angle	20
Change Number of Lanes on Intersection Approach	20
Convert 4-Leg Intersection to Two 3-Leg Intersections	20
Convert Intersection RCUT/J-Turn	20
Convert Intersection to Continuous Flow Intersection	20
Convert Intersection to Median U-Turn	20
Convert Intersection to Superstreet	20
Convert T-Intersection to Continuous Green-T Intersection	20
Convert Traffic Signal to Roundabout	20
Convert Two-Way Stop Intersection to Roundabout	20
Improve Intersection Sight Distance (non-vegetation based)	20
Improve Left-Turn Lane Offset to Create Positive Offset	20
Increase Turn Lane Length	20
Install Channelization	20
Install Curb Extensions/Bulb Outs	20

Table 18. Typical Service Lives for Intersection Geometry Countermeasures (continued).

Intersection Geometry Countermeasures	Service Life (Years)
Install Median Acceleration Lane	20
Install Reduced Left-Turn Conflict Intersection	20
Install Splitter Island	20
Install Turn Arounds	20
Modify Intersection Geometry	20
Provide Channelized Left-Turn Lane	20
Provide Channelized Right-Turn Lane	20
Provide Left-Turn Acceleration Lane	20
Provide Left-Turn Lane	20
Provide One-Way Couple	20
Provide Right-Turn Acceleration Lane	20
Provide Right-Turn Lane	20
Remove Intersection Leg	20

4.4.9 Intersection Traffic Control

Table 19 provides service lives for intersection traffic control countermeasures. The typical service life for countermeasures in this category range from 1 to 15. Agencies may consider these values, along with the other factors described in Section 2.5, when selecting a final service life value.

Table 19. Typical Service Lives for Intersection Traffic Control Countermeasures.

Intersection Traffic Control Countermeasures	Service Life (Years)
Install Standard Paint Temporary Traffic Circle	1
Add Retroreflective Tape to Backplate	5
Install Durable Marking Temporary Traffic Circle	5
Add Retroreflective Backplate	10
Change Signal Left-Turn Phasing	10
Change Signal Mount Type	10
Change Signal Permissions/Protections	10
Change Signal/Phase Interval	10
Convert Two-Way Stop Control to All-Way Stop Control	10
Convert Unsignalized Superstreet to Signalized Superstreet	10
Implement Flashing Yellow Arrow	10
Improve Signal Head/Lens Visibility	10
Install Closed Loop Signal System	10
Install Dynamic Signal Warning Flashers	10
Install Emergency Vehicle Pre-Emption Systems	10
Install Leading Pedestrian Interval	10
Install Left-Turn Yield Blank Out Sign	10
Install Optically Programmed Signal	10
Install Pedestrian Countdown Timer	10

Table 19. Typical Service Lives for Intersection Traffic Control Countermeasures (continued).

Intersection Traffic Control Countermeasures	Service Life (Years)
Install Pedestrian Signal	10
Install Traffic Signal	10
Permit or Prohibit Right-Turn-On-Red	10
Change Unrestricted Left-Turn Hours	10
Prohibit Left-Turns and/or U-Turns	10
Provide Advance Dilemma Zone Protection	10
Provide Intersection Flashing Beacon	10
Provide Signal Coordination	10
Provide Traffic Signal Actuation	10
Provide Traffic Signal Optical Programming	10
Provide Traffic Signal Time Lane Control	10
Relocate Signal Supports	10
Remove Unwarranted Traffic Signal	10
Replace Night-Time Flash with Steady Operation	10
Upgrade Traffic Signals	10
Implement Systemic Signing and Marking Improvements at Signal-Control Intersection	15
Implement Systemic Signing and Marking Improvements at STOP-Control Intersection	15

4.4.10 Pedestrian

Table 20 provides service lives for pedestrian countermeasures. The typical service life for countermeasures in this category range from 1 to 30. Agencies may consider these values, along with the other factors described in Section 2.5, when selecting a final service life value.

Table 20. Typical Service Lives for Pedestrian Countermeasures.

Pedestrian Countermeasures	Service Life (Years)
Install Standard Paint Advanced Yield or Stop Markings at Pedestrian Crossing	1
Install Standard Paint Crosswalk	1
Provide Improvements to Standard Paint Crosswalks	1
Install Durable Advanced Yield or Stop Markings at Pedestrian Crossing	5
Install Durable Marking Crosswalk	5
Install High-Visibility Yellow Crosswalks at School	5
Provide Improvements to Durable Marking Crosswalks	5
Implement Barnes Dance	10
Improve Pedestrian Signal	10
Install Actuated Overhead Flasher for a Pedestrian Location	10
Install Fencing	10
Install Pedestrian Hybrid Beacon	10
Install Rectangular Rapid Flashing Beacons	10
Install Advanced Yield or Stop Signs at Pedestrian Crossing	15
Install Fluorescent Yellow-Green Pedestrian Crossing Sign	15
Install Pedestrian Crossing with New Signs	15
Install Bus Shelter	20
Install Pedestrian Refuge Island	20
Install Raised Intersection	20
Install Sidewalk	20
Separate Pedestrians from Vehicle Traffic on Bridge	20
Construct Pedestrian and/or Bicycle Overpass or Underpass	30

4.4.11 Railroad Grade Crossings

Table 21 provides service lives for railroad grade crossing countermeasures. The typical service life for countermeasures in this category range from 1 to 25. Agencies may consider these values, along with the other factors described in Section 2.5, when selecting a final service life value.

Table 21. Typical Service Lives for Railroad Grade Crossing Countermeasures.

Railroad Grade Crossing Countermeasures	Service Life (Years)
Install Standard Paint Pavement Markings	1
Install Delineators	5
Install Durable Pavement Markings	5
Change Traffic Control at Railroad Grade Crossing	10
Install Flashing Beacons	10
Modify Railroad Grade Crossing Electronics	10
Install Automatic Railroad Gates	15
Install Flashing Lights	15
Install Safety Lighting	15
Install Signs and Crossbucks	15
Install Warning Bells	15
Install Warning Signs	15
Modify Railroad Crossing Alignment and Surface	20
Install Median Barrier	25
Close, Eliminate, or Separate Railroad Grade Crossing	30

4.4.12 Resurfacing

Table 22 provides service lives for resurfacing countermeasures. The typical service life for countermeasures in this category range from 5 to 10. Agencies may consider these values, along with the other factors described in Section 2.5, when selecting a final service life value.

Table 22. Typical Service Lives for Resurfacing Countermeasures.

Resurfacing Countermeasures	Service Life (Years)
Apply Chip Seal	5
Apply Open Graded Friction Course	5
Apply Slurry Seal	5
Apply Thin Layer of Hot Mix Asphalt	5
Apply Ultrathin Bonded Wearing Course	5
Apply Grooved Pavement Skid Treatment	10
Apply Skid Treatment and Seal Coat	10
Conduct Diamond Grinding	10
Install High Friction Surface Treatment	10
Pave Roadway Surface	10
Resurface Pavement	10

4.4.13 Roadside

Table 23 provides service lives for roadside countermeasures. The typical service life for countermeasures in this category range from 10 to 25. Agencies may consider these values, along with the other factors described in Section 2.5, when selecting a final service life value.

Table 23. Typical Service Lives for Roadside Countermeasures.

Roadside Countermeasures	Service Life (Years)
Change Clear Zone Width	10
Install End Treatment	10
Install Impact Attenuation System	10
Install Snow Fencing	10
Protect Culvert with Guardrail or Grate	15
Change Median Width	20
Change Roadside Hazard Rating	20
Change the Longitudinal Density of Utility Poles	20
Flatten Side Slope	20
Improve Horizontal Sightline Offset (non-vegetation based)	20
Install Rest Areas	20
Install Traversable Median	20
Install Truck Escape Ramp	20
Install Turnouts	20
Lengthen Culvert	20
Remove Culvert Headwall and Delineate	20
Remove or Relocate Fixed Object	20
Change Barrier Type	25
Construct Gateway Monument	25
Cushion Fixed Object	25
Install Cable Median Barrier	25
Install Concrete Median Barrier	25
Install Motorcycle Rub Rail under Existing W-Beam	25
Install Outside Guardrail/Barrier	25
Install Steel Median Barrier	25
Upgrade Median Barrier	25

4.4.14 Roadway

Table 24 provides service lives for roadway countermeasures. The typical service life for countermeasures in this category range from 1 to 20. Agencies may consider these values, along with the other factors described in Section 2.5, when selecting a final service life value.

Table 24. Typical Service Lives for Roadway Countermeasures.

Roadway Countermeasures	Service Life (Years)
Install Standard Paint Median	1
Install Durable Marking Median	5
Install Raised Pavement Markers on Median	5
Install Wildlife Detection Systems	10
Lane Restrictions – High Occupancy	10
Lane Restrictions – Trucks	10
Provide Milled Center Line Rumble Strips	10
Provide Milled Edge Line Rumble Stripes	10
Provide Transverse Rumble Strips	10
Install Glare Shields	15
Add Two-Way Left-Turn Lane	20
Change Lane Width	20
Change Pavement Width	20
Close Crossover	20
Convert Two-Lane Roadway to Four-Lane Divided Roadway	20
Implement Road Diet	20
Improve Drainage	20
Increase Number of Lanes	20
Install Passing or Climbing Lane	20
Reallocate Pavement Width	20
Widen Managed Lane Envelope	20

4.4.15 Shoulder Treatment

Table 25 provides service lives for shoulder treatment countermeasures. The typical service life for countermeasures in this category range from 5 to 20. Agencies may consider these values, along with the other factors described in Section 2.5, when selecting a final service life value.

Table 25. Typical Service Lives for Shoulder Treatment Countermeasures.

Shoulder Treatment Countermeasures	Service Life (Years)
Install Raised Shoulder Rumble Strips	5
Install Safety Edge Treatment	10
Provide Milled Shoulder Rumble Strips	10
Change Shoulder Type	20
Change Shoulder Width	20

4.4.16 Signs

Table 26 provides service lives for sign countermeasures. The typical service life for countermeasures in this category range from 5 to 20. Agencies may consider these values, along with the other factors described in Section 2.5, when selecting a final service life value.

Table 26. Typical Service Lives for Sign Countermeasures.

Sign Countermeasures	Service Life (Years)
Install Solar Power Flasher on Sign	5
Install Solar Power Flashing LED STOP Sign	5
Upgrade to Solar Power LED Sign	5
Install a Detection Warning System with CCTVs	10
Install Intersection Conflict Warning System	10
Install Sequential Dynamic Chevrons	10
Install Static Signs and Flashers "Truck Speed too Fast when Flashing"	10
Install Wired Flasher on Sign	10
Install Wired Flashing LED STOP Sign	10
Provide Actuated Advanced Flasher at Official Use Crossover	10
Provide Actuated "Prepare to Stop When Flashing Signs"	10
Updated to Wired LED Sign	10
Improve Sign Visibility (non-vegetation based)	15
Increase Sign Retroreflectivity	15
Install Advance Curve Speed/Warning Sign	15
Install Advance Signal Warning Sign	15
Install Advance Street Name Sign	15
Install Chevron Sign	15
Install Guide Sign	15

Table 26. Typical Service Lives for Sign Countermeasures (continued).

Sign Countermeasures	Service Life (Years)
Install Lane Use Sign	15
Install Sign	15
Install Speed Signing	15
Install STOP Sign, Oversize STOP Sign, or Double STOP Signs	15
Install Yield Sign	15
Provide a Mandatory Motorcycle Pull Off Area with Roadway Informational Signing	20

4.4.17 Structures

Table 27 provides service lives for structure countermeasures. The typical service life for countermeasures in this category range from 10 to 30. Agencies may consider these values, along with the other factors described in Section 2.5, when selecting a final service life value.

Table 27. Typical Service Lives for Structure Countermeasures.

Structure Countermeasures	Service Life (Years)
Improve Bridge Pavement Friction	10
Grooving Bridge Pavement	10
Install Frost/Ice Detectors on Bridge	10
Install Breakaway Sign Supports	15
Install Breakaway Utility/Light Poles	15
Install Overhead Sign Truss	15
Install Barrier on Bridge	25
Replace Bridge Guardrail	25
Upgrade Bridge Rail	25
Build Structure	30
Improve Drainage Structure	30
Remove Existing Bridge	30
Widen Bridge	30

4.4.18 Work Zone

Table 28 provides service lives for work zone countermeasures. The typical service life for all countermeasures in this category is one year. Agencies may consider these values, along with the other factors described in Section 2.5, when selecting a final service life value.

Table 28. Typical Service Lives for Work Zone Countermeasures.

Work Zone Countermeasures	Service Life (Years)
Modify Work Zone Duration	1
Modify Work Zone Length	1

4.4.19 Other

Table 29 provides service lives for other countermeasures. The typical service life for countermeasures in this category range from 10 to 50 years. Agencies may consider these values, along with the other factors described in Section 2.5, when selecting a final service life value.

Table 29. Typical Service Lives for Other Countermeasures.

Other Countermeasures	Service Life (Years)
Install Speed Humps	10
Install Transit Lane Priority	10
Install Transit Signal Priority	10
Change Posted Speed Limit	15
Implement Area-Wide Traffic Calming	15
Implement Time-Limited Parking Restrictions	15
Prohibit On-Street Parking	15
Remove Curb Parking	20
Change Transit Stop Presence/Location	20
Change Right of Way	30

CHAPTER 5—PROJECT APPLICATIONS

Chapter 5 provides example project applications for the methodologies described in this Guide. Each of the examples focuses on the selection and application of service life through BCA for safety projects. The first example focuses on the entire process of a BCA including the selection and application of countermeasure service life. The remaining examples focus on countermeasure service life issues and do not go into full details on the entire BCA. Readers with further interest on BCA processes and techniques can refer to Chapter 7 of FHWA's Highway Safety Benefit Cost Analysis Guide for further project applications.[6] The examples in this chapter use mostly hypothetical numbers; therefore, references to external resources are not provided for individual countermeasures.

Chapter 5 At-A-Glance

Chapter 5 provides examples for the following scenarios:

- Section 5.1 provides an example service life application in BCA for a single countermeasure comparing two project alternatives.
- Section 5.2 provides an example service life application in BCA for a new single countermeasure where service life is unknown.
- Section 5.3 provides an example service life and BCA for a countermeasure package for multiple sites within a project (e.g., a systemic safety improvement project).

5.1 SINGLE COUNTERMEASURE WITH KNOWN SERVICE LIFE EXAMPLE

For this example, an agency is considering improving the safety at a rural four-leg intersection of two-lane highways with stop control on the minor approaches. The intersection has a history of right-angle crashes and the agency has observed speeding on approaches to the intersection. The agency is considering two alternatives, with the first alternative consisting of installing advance intersection warning signs on each of the major approaches and the second alternative consisting of installing an intersection conflict warning system (ICWS). The base condition represents no change in existing conditions (i.e., maintaining the rural, two-lane, two-way stop-controlled intersection).

Table 30 presents the service life, initial project cost, annual maintenance and operational costs, and annual project benefits for each alternative. The service life for both countermeasures is found in Table 26. While Table 26 directly provides service life for ICWS, the service life for the advance intersection signs is drawn from being similar to installing an advance curve warning or signal warning sign. Since the service lives differ for the two alternatives, the analyst selects an analysis period of 30 years as the lowest common multiple of the service lives. The installation period is entered in whole years and it is assumed each alternative would be installed within one year. Alternative A would require reinstallation after the service life, which would occur in year 16 (15 years after installation). Alternative B would require reinstallation in year 11 (10 years after installation) and year 21 (another 10 years after reinstallation). The reinstallation cost and annual maintenance and operational costs are converted to present values, using a discount rate of 3.0 percent and the analysis period of the project.

Table 30. Project overview for single countermeasure example.

Project Measures	Alternative A Advance Intersection Signs	Alternative B ICWS
Service Life	15	10
Initial project cost	$500	$40,000
Annual maintenance and operational costs	$10	$1,000
Annual expected project benefits	$18,800	$112,310

Table 31 provides an amortization table to illustrate the calculation of present value costs and benefits from the annual maintenance costs and benefits for both alternatives. Reinstallation costs are included for each alternative at the end of the useful service life.

Table 31. Amortization table for project costs and benefits for single countermeasure example.

Years after Installation	Alternative A Costs	Alternative A Benefits	Alternative B Costs	Alternative B Benefits
1	$10	$18,252	$971	$109,039
2	$9	$17,721	$943	$105,863
3	$9	$17,205	$915	$102,780
4	$9	$16,704	$888	$99,786
5	$9	$16,217	$863	$96,880
6	$8	$15,745	$837	$94,058
7	$8	$15,286	$813	$91,318
8	$8	$14,841	$789	$88,659
9	$8	$14,409	$766	$86,076
10	$7	$13,989	$744	$83,569
11	$7	$13,582	$29,619	$81,135
12	$7	$13,186	$701	$78,772
13	$7	$12,802	$681	$76,478
14	$7	$12,429	$661	$74,250
15	$6	$12,067	$642	$72,088
16	$318	$11,716	$623	$69,988
17	$6	$11,374	$605	$67,949
18	$6	$11,043	$587	$65,970
19	$6	$10,721	$570	$64,049
20	$6	$10,409	$554	$62,183
21	$5	$10,106	$22,040	$60,372
22	$5	$9,812	$522	$58,614
23	$5	$9,526	$507	$56,907
24	$5	$9,248	$492	$55,249
25	$5	$8,979	$478	$53,640
26	$5	$8,717	$464	$52,078
27	$5	$8,464	$450	$50,561
28	$4	$8,217	$437	$49,088
29	$4	$7,978	$424	$47,658
30	$4	$7,745	$412	$46,270
Present Value	**$508**	**$368,488**	**$69,999**	**$2,201,326**

Table 32 presents the results of the BCA. In this example, the benefits exceed the costs for both alternatives. Both alternatives provide a BCR greater than 1.0 for the analysis period (which includes multiple service lives for both alternatives). The BCR for alternative A is greater than the BCR for alternative B, indicating alternative A may be more economically efficient. While the agency may choose to implement alternative A based on the BCA, they can continue to monitor the safety performance of the intersection after installing the advance intersection warning signs to determine if this achieved the desired result. If alternative A does not achieve the desired results, alternative B (ICWS) could serve as a logical next step to improve safety at the intersection.

Table 32. BCA results for single countermeasure example.

Project Measures	Alternative A Advance Intersection Signs	Alternative B ICWS
Initial project cost	$500	$40,000
Present value of reinstallation, maintenance, and operating costs	$508	$69,999
Present value of costs	$1,008	$109,999
Present value of safety benefits	$368,488	$2,201,326
BCR	365.6	20.0

5.2 SINGLE COUNTERMEASURE WITH UNKNOWN SERVICE LIFE EXAMPLE

For this example, an agency is focusing on reducing crashes at an existing signalized intersection on an urban multilane arterial. This intersection has a history of crashes involving drivers running red lights. The agency is considering installing a red-light camera as alternative A. Alternative B is under consideration as a demonstration project and involves a new, and cheaper, technology focused on providing direct feedback to drivers violating the red phase (without direct enforcement). The agency has evidence that the safety effectiveness of the new technology results in a significant reduction in the number of fatal and injury crashes (without an associated increase in property-damage only crashes); however, it is unclear if the new technology will continue to provide long term benefits or if drivers will adapt to the new technology.

While alternative A has an expected 10-year service life (as found in Table 12), the agency chose to conduct a 5-year horizon analysis assuming, conservatively, that alternative B loses safety effectiveness over the 5-year period (i.e., no safety benefits are expected beyond 5 years). However, the agency would like to determine if this project can be justified under the conservative assumption of reduced effectiveness. The agency chose a 5-year horizon analysis in this case because there may be no presumable additional safety impact through a re-installation in year 6 for alternative B. Further, while conducting the demonstration project, the agency would evaluate if alternative B loses effectiveness over time.

Table 33 provides a project overview for the alternative A red light camera and alternative B feedback technology. The service life for alternative A is 10 years while the service life for alternative B is presumed to be 5 years. While the horizon-year 5-year analysis period shortchanges the overall safety benefits for alternative A, the BCA provides details on if alternative B is expected to provide similar economic efficiency in the short term. This analysis includes the initial, larger safety benefit for alternative B as well as the 20 percent reduction in project benefits per year for alternative B. Alternative A is expected to provide the same annual benefits for the duration of the analysis. Table 34 provides an amortization table illustrating the project costs and benefits for each alternative.

Table 33. Project overview for unknown service life example.

Project Measures	Alternative A Red-Light Camera	Alternative B New Feedback Technology
Service life in years	10	5
Initial project cost	$75,000	$25,000
Annual maintenance and operational costs	$2,000	$1,000
Annual expected project benefits	$499,200	$927,200

Table 34. Amortization table for project costs and benefits for unknown service life example.

Years after Installation	Alternative A Costs	Alternative A Benefits	Alternative B Costs	Alternative B Benefits
1	$1,942	$484,660	$971	$900,194
2	$1,885	$470,544	$943	$699,180
3	$1,830	$456,839	$915	$509,112
4	$1,777	$443,533	$888	$329,522
5	$1,725	$430,614	$863	$159,962
Present Value	**$9,159**	**$2,286,190**	**$4,580**	**$2,597,970**

Table 35 presents the results of the BCA. In this example, the benefits exceed the costs for both alternatives. Both alternatives provide a BCR greater than 1.0 for the assumed service life. The BCR for alternative B is greater than the BCR for alternative A, indicating alternative B may be more economically efficient during the expected service life.

Table 35. BCA results for unknown service life example.

Project Measures	Alternative A	Alternative B
Initial project cost	$75,000	$25,000
Present value of reinstallation, maintenance, and operating costs	$9,159	$4,580
Present value of costs	$84,159	$29,580
Present value of safety benefits	$2,286,190	$2,597,970
BCR	30.8	87.8

However, this analysis ignores the additional benefits for alternative A since there would still be useful life for the red-light camera. While this analysis focused on the project short-term efficiency of the demonstration project, a complete analysis to determine the economic efficiency of the red-light camera would include a 10-year analysis period. Table 36 provides the amortization for project costs and benefits assuming a 10-year maximum service life analysis period. In this case, alternative B is not reinstalled in year 6, as the technology still works, but no safety benefit is expected (the ongoing annual maintenance cost is included in the analysis). Alternative A provides continued benefit as shown.

Table 36. Amortization table for project costs and benefits for unknown service life 10-year example.

Years after Installation	Alternative A Costs	Alternative A Benefits	Alternative B Costs	Alternative B Benefits
1	$1,942	$484,660	$971	$900,194
2	$1,885	$470,544	$943	$699,180
3	$1,830	$456,839	$915	$509,112
4	$1,777	$443,533	$888	$329,522
5	$1,725	$430,614	$863	$159,962
6	$1,675	$418,072	$837	$0
7	$1,626	$405,895	$813	$0
8	$1,579	$394,073	$789	$0
9	$1,533	$382,595	$766	$0
10	$1,488	$371,452	$744	$0
Present Value	**$17,060**	**$4,258,277**	**$8,530**	**$2,597,970**

Table 37 presents the results of the BCA for the 10-year maximum service life analysis period. Again, the benefits continue to exceed the costs for both alternatives. Both alternatives provide a BCR greater than 1.0 for the assumed service life. The BCR for alternative B is greater than the BCR for alternative A, indicating alternative B may still be more economically efficient during 10-year service life. The results suggest the demonstration project for the new technology is economically justifiable.

Table 37. BCA results for unknown service life 10-year example.

Project Measures	Alternative A	Alternative B
Initial project cost	$75,000	$25,000
Present value of reinstallation, maintenance, and operating costs	$17,060	$8,530
Present value of costs	$92,060	$33,530
Present value of safety benefits	$4,258,277	$2,597,970
BCR	46.3	77.5

5.3 COUNTERMEASURE DEPLOYMENT USING A SYSTEMIC APPROACH EXAMPLE

For this example, an agency is considering a systemic approach to address curve-related crashes along rural, two-lane highways. The agency identified curve-related fatal and injury crashes as a target crash type on rural, two-lane facilities with 500 to 2,000 vehicles per day. Further analysis indicated curves with a radius between 250 feet and 750 feet and no paved shoulders were primary risk factors. Based on this analysis, the agency selected a package of low-cost improvements to help drivers identify and navigate horizontal curves. This package includes a combination of advanced curve warning signs and post mounted delineators.

The service life for advance curve warning signs is 15 years, while the service life for post mounted delineators is 5 years. Using either the least common multiple or maximum service life method, the analysis period is 15 years. The post mounted delineators are expected to be reinstalled in years 6 and 11. The installation cost for the advance warning signs is $500 per curve and the installation cost for post mounted delineators is an additional $500 per curve. The agency has sufficient funding to address 5 curves and would like to identify the most effective use of funds. To select the optimal list of curves, the agency can estimate the BCR for each curve and then rank the sites from high to low.

Table 38 provides a summary of the horizontal curves under consideration. The estimated annual safety benefit includes the empirical Bayes (EB) expected crash frequency (combination of predicted and observed crash frequency), the CMF for combined application of the systemic safety package and estimated crash cost by severity. Incorporating the EB approach is particularly important for the systemic safety approach because the EB approach allows the analyst to account for the potential safety benefits for sites with no historical crashes. The EB process acknowledges that sites with zero crashes are at risk for future crashes. The prediction component of the EB adjustment serves to indicate the level of risk for future crashes.

Table 38. Summary of curves for systemic package.

Curve	AADT	Radius (feet)	Estimated Annual Safety Benefit
1	500	350	$1,678
2	700	500	$1,965
3	2,000	750	$5,947
4	1,500	700	$3,963
5	2,000	300	$9,588
6	900	250	$4,022
7	1,200	750	$3,003
8	1,000	275	$4,195
9	650	550	$2,728
10	850	300	$3,313
11	1,700	550	$5,095
12	1,100	750	$2,729
13	1,000	625	$2,661
14	1,500	350	$5,647
15	800	400	$2,624

Table 39 provides an example amortization for the 15-year analysis period for the project costs and for the safety benefits for curves 1 through 3. The project costs for each curve is assumed to be the same. The discount rate is 3.0 percent.

As compared to example 2 (Section 5.2), this example highlights the importance of including the benefits for the entire service life for the maximum service life countermeasure.

Table 39. Example amortization for systemic package.

Year	Package Cost	Curve 1 Benefits	Curve 2 Benefits	Curve 3 Benefits
1	$0	$1,629	$1,908	$5,774
2	$0	$1,582	$1,852	$5,606
3	$0	$1,536	$1,798	$5,442
4	$0	$1,491	$1,746	$5,284
5	$0	$1,447	$1,695	$5,130
6	$419	$1,405	$1,646	$4,981
7	$0	$1,364	$1,598	$4,835
8	$0	$1,325	$1,551	$4,695
9	$0	$1,286	$1,506	$4,558
10	$0	$1,249	$1,462	$4,425
11	$361	$1,212	$1,420	$4,296
12	$0	$1,177	$1,378	$4,171
13	$0	$1,143	$1,338	$4,050
14	$0	$1,109	$1,299	$3,932
15	$0	$1,077	$1,261	$3,817
Present Value	**$780**	**$20,032**	**$23,458**	**$70,995**

Table 40 presents the results of the BCA for each curve, indicating the present value cost for each installation over the study period, the present value safety benefits, and the BCR. In this example, the benefits exceed the costs for each curve (based on expected crash frequency) as indicated by the BCR greater than 1.0. This means the systemic package is economically justified for each curve; however, the most economically efficient curves include 5, 3, 14, 11, and 8. Notably, the first four of these curves (5, 3, 14, and 11) have the highest AADT. Based on the agency's available funding for five curves, 5, 3, 14, 11, and 8 would be prioritized for systemic installation.

Table 40. BCA results for systemic package.

Curve	Present Value Cost	Present Value Benefit	BCR
1	$1,780	$20,032	11.3
2	$1,780	$23,458	13.2
3	$1,780	$70,995	39.9
4	$1,780	$47,310	26.6
5	$1,780	$114,461	64.3
6	$1,780	$48,014	27.0
7	$1,780	$35,850	20.1
8	$1,780	$50,080	28.1
9	$1,780	$32,567	18.3
10	$1,780	$39,550	22.2
11	$1,780	$60,824	34.2
12	$1,780	$32,579	18.3
13	$1,780	$31,767	17.8
14	$1,780	$67,414	37.9
15	$1,780	$31,325	17.6

CHAPTER 6—SUMMARY

The purpose of this Guide is to provide transportation practitioners with the necessary information to make consistent, data-driven decisions for evaluating and prioritizing safety countermeasures using prescribed countermeasure service lives. This Guide focuses on safety strategies and countermeasures for which an agency may apply for safety funding. This Guide does not cover general maintenance concerns for which safety funding would not be sought (e.g., service life for improving sight distance by trimming vegetation).

This Guide also provides practitioners with definitions and methods or factors to consider for determining service life, relationships between service life and maintenance/rehabilitation activities, reasons for agencies to consider adopting standardized service life values, factors that influence countermeasure service life, and analytical considerations when using service life as part of a BCA. Further, this guide provides examples using service life as part of a BCA, including situations where service life for a countermeasure may be unknown.

This Guide provides typical service lives for countermeasures grouped into the following categories:

- Access Management
- Advanced Technology and Intelligent Transportation Systems (ITS)
- Alignment
- Bicycle
- Delineation
- Highway Lighting
- Interchange Design
- Intersection Geometry
- Intersection Traffic Control
- Pedestrian
- Railroad Grade Crossings
- Resurfacing
- Roadside
- Roadway
- Shoulder Treatment
- Signs
- Structures
- Work Zone
- Other

There are several benefits to developing a service life list and using standardized service life values in BCA, including the following:

- Standardized values improve consistent application throughout an agency regarding BCA on proposed projects.
- The standardized list may draw from agencywide experience with regard to common countermeasures or may draw from other agency experiences when considering new countermeasures. Since there are several factors that can impact service life, a standardized list compiles known information about each countermeasure for which individual practitioners may not be aware.
- Along with CMFs, the standardized service life list can help practitioners communicate to decisionmakers the reasons for selecting a preferred countermeasure, especially if the countermeasure has not been commonly applied throughout the agency or within a specific region.

In summary, countermeasure service life is an integral part of the BCA process. A thorough understanding of the time period for which a countermeasure has a measurable impact is critical to establishing the cost effectiveness of the countermeasure relative to the installation and ongoing maintenance and operational costs. The analysis methodology for countermeasures with differing service life impacts the outcome of the BCA and it is important for practitioners to select a consistent and appropriate approach for comparing and prioritizing potential projects. Reliable and consistent approaches are key to inform decisions and improve safety investments.

REFERENCES

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5. Sallman, D., E. Flanigan, K. Jeannotte, C. Hedden, and D. Morallos, Operations Benefit/Cost Analysis Desk Reference, FHWA-HOP-12-028, Federal Highway Administration, Washington, D.C., 2012.

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11. Texas Department of Transportation, *Highway Safety Improvement Program Guidelines*, Traffic Safety Division, Austin, TX, 2020.

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15. FHWA, *Crash Modification Factor Clearinghouse*, Federal Highway Administration, Washington D.C.,

APPENDIX A—LITERATURE REVIEW

Introduction

This memo summarizes a literature review to support identification of typical service lives for the Countermeasure Service Life Guide. This memo begins with a discussion of the sources of information VHB identified and collected during the review. This is followed by a discussion of the review process, including how VHB processed countermeasures and assigned service life information. The third section is a brief description of the service life summary table. Finally, the memo includes a discussion of next steps for the project.

Information Sources

VHB reviewed numerous sources to aggregate service life data from around the country. The following sections describe these sources.

CMF Clearinghouse

VHB downloaded the current library of countermeasures from FHWA's CMF Clearinghouse[1]. The database is current as of August 10, 2020. VHB used this library of countermeasures to structure the service life data, using the Countermeasure Category, Countermeasure Subcategory, and Countermeasure Name to group similar countermeasures. When structuring the data, VHB was careful to maintain a tie between the "CMF ID" field and the ultimate service life values to easily import service life into the CMF Clearinghouse in the future.

State Documentation and Tools

FHWA tasked VHB with reviewing agency policies and literature to identify service life data used throughout the country. To complete this task, VHB researched each State Department of Transportation to identify any potential lists. This review included searches for service life lists, countermeasure lists, HSIP manuals, HSIP reports, and implementation tools (including benefit-cost analysis tools and guides).

VHB found some agencies possessed standalone lists of crash modification factors and/or countermeasure service lives, while others included the relevant information in HSIP handbooks or benefit-cost analysis tools. VHB identified and collected potentially relevant documentation from a total of 21 states. Of these, 15 states provided sufficient information in

[1] http://www.cmfclearinghouse.org/

the documentation as to be usable in research efforts. Table 41 summarizes this list of references.

Table 41. Summary of State resources.

State	Citation	Source Used?	Reason Not Used
AL	Alabama Department of Transportation (2015). *Highway Safety Improvement Program (HSIP) Program Management Manual.*	N	Document includes a few example benefit-cost calculations based on assumed countermeasure service lives, but no complete list of State-accepted service life values is included
AK	Alaska Department of Transportation and Public Facilities (2020). *Alaska Highway Safety Improvement Program Handbook* (19th Edition).	Y	
AZ	Arizona Department of Transportation (2015). *Arizona Highway Safety Improvement Program, Appendix C.*	Y	
CA	California Department of Transportation (2020). *Local Roadway Safety: A Manual for California's Local Road Owners* (v1.5)	Y	
CO	Colorado Department of Transportation (n.d.a.). *Countermeasure Service Life Values* (Excel Spreadsheet)	Y	
FL	Florida Department of Transportation (2019). *Highway Safety Improvement Program – Implementation Manual.*	N	Document does not provide a list of service life values
IL	Illinois Department of Transportation (2006). *Safety Engineering Policy Memorandum, Table 1.*	Y	
IN	Indiana Department of Transportation (2011). *Indiana Design*	Y	

State	Citation	Source Used?	Reason Not Used
	Manual – Appendix C: Service Life of Safety Improvements.		
IA	Iowa Department of Transportation (n.d.a.). *Approximate Improvement Service Life* (Excel Spreadsheet)	Y	
MN	Minnesota Department of Transportation (2019). *Local Solicitation for HSIP Funding, Appendix C.*	Y	
MO	Technology Transfer Assistance Program (1999). *Manual on Identification, Analysis and Correction of High-Crash Locations (the HAL Manual), Appendix F* (Third Edition).	Y	
NC	North Carolina Department of Transportation (2018). *North Carolina Project Development Crash Reduction Factor Information.*	Y	
NV	Nevada Department of Transportation (2019). *State Highway Preservation Report.*	N	Document only discusses pavement and bridge preservation efforts, without any reference to specific countermeasure service lives
NH	New Hampshire Department of Transportation (2013). *Highway Safety Improvement Program: Manual and Guidance.*	N	Document does not provide a list of service life values
NJ	New Jersey Department of Transportation (2016). *New Jersey Highway Safety Improvement Program Manual.*	N	Document does not provide a list of service life values
OH	Ohio Department of Transportation (2020). Economic Crash Analysis Tool (ECAT).	Y	
OR	Oregon Department of Transportation (n.d.a). *CRF List* (Excel Spreadsheet).	Y	

State	Citation	Source Used?	Reason Not Used
OR	Oregon Department of Transportation (n.d.a.) *CRF Supplemental List* (Excel Spreadsheet).	Y	
PA	Pennsylvania Department of Transportation (2017). *PennDOT Bureau of Public Transportation Estimated Service Life (ESL) for Capital Items.*	N	Document only provides service life values of capital costs such as buses, DOT facility roofs, construction equipment, etc., rather than of safety countermeasures. Subsequent research indicated PennDOT maintains a CMF list, but follow-up with State personnel stated that service lives are not included in that list.
UT	Utah Department of Transportation (n.d.a.). Crash Modification Factors (Excel Spreadsheet)	Y	
TX	Texas Department of Transportation (n.d.a). *HSIP Work Codes Table.*	Y	
VA	Virginia Department of Transportation (n.d.a). *Virginia State Preferred CMF List.*	Y	
WA	Washington Department of Transportation (2019). *Safety Benefit Cost Analysis* (Excel Spreadsheet).	Y	

State Follow Ups

Based on the policy review, VHB identified four states to request additional information from: Indiana, Maine, Pennsylvania, and Washington. Pennsylvania was selected as a follow-up State due to their development of analysis spreadsheets supporting economic evaluation of geometric design improvements using the HSM predictive method. The economic analysis spreadsheet includes built-in geometric elements found in the HSM predictive method, additional countermeasures included in their State-specific CMF list, and a place to enter user-defined countermeasures. The spreadsheet includes an input screen for entering service life information for each of these countermeasures, but the project team identified that service lives were not directly built into the tool for built-in countermeasures. Pennsylvania indicated that they currently do not possess any established service life values, necessitating this effort.

VHB selected Maine for follow-up due to their HSIP manual stating the MaineDOT "must prioritize projects based on the overall cost of the countermeasure(s), its expected effectiveness, and expected service life (typically 5, 10, or 20-year period)." The project team followed-up with MaineDOT to determine if the agency had a specific service life list distinguishing the differences. Maine replied the DOT does not have a specific service life list, but for safety and mobility candidate evaluations, the DOT uses 20 years for a rebuilt intersection or road segment and 10 years for less durable improvements.

The project team identified that the Washington State Department of Transportation (WSDOT) Safety Analysis Guide indicates that WSDOT maintains a CMF short list that contains CMFs for various measures and is available on the WSDOT intranet. Since this was inaccessible by the project team, the project team followed-up to obtain the CMF short list to determine if the list provides service life in addition to CMFs. WSDOT provided their Benefit-Cost Analysis spreadsheet tool, which contains a separate tab for service life by countermeasure category.

Additionally, the project team identified from the Indiana Department of Transportation (INDOT) HSIP Local Project Selection Guide that the agency uses a Hazard Analysis Tool (HAT) software for completing benefit-cost analysis. The HAT software was noted to contain countermeasures with applicable CMFs and potentially service life. INDOT responded and provided VHB with Appendix C of the Indiana Design Manual, which contains service life values for safety improvements. The service lives used in the HAT software were developed by Purdue University from those contained in the Design Manual.

Supplemental Sources

To supplement the results of the State agency review, VHB performed an additional literature search to provide service life values from sources other than State Departments of Transportation. This supplemental effort included a review of recent publications from the Evaluations of Low-Cost Safety Improvement Pooled Fund Study program, transportation safety literature, and manufacturer specifications. The summary table of service lives provides the service life for each countermeasure identified in the literature search, along with the reference number in parentheses. Table 42 provides the corresponding reference number and reference information for each source VHB identified during the review process.

Table 42. Summary of supplemental literature.

Reference Number	Citation
1	Chen, X., Salem, O., and Salman, B. (2016). "Life-Cycle Benefit–Cost Analysis Framework for Ramp-Metering Deployments," *Transportation Research Record, 2554*, pp. 69–76, Transportation Research Board, Washington, DC.
2	Srinivasan, R., Lan, B., Carter, D., Smith, S., Signor, K., and Persaud, B. (2019). *Safety Evaluation of Pedestrian Countdown Signals*, Report No. FHWA-HRT-19-045, Federal Highway Administration, Washington, DC.
3	Le, T., Gross, F., Persaud, B, Eccles, K, and Soika, J. (2018). *Safety Evaluation of Multiple Strategies at Signalized Intersections,* Report No. FHWA-HRT-17-062, Federal Highway Administration, Washington, DC.
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Reference Number	Citation
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Documentation Review Process

After aggregating the State lists, VHB reviewed the individual documents and tools to match service life data to corresponding countermeasures from the CMF Clearinghouse. Where possible, VHB did not extrapolate service life values when there were discrepancies in names between the State list and the CMF Clearinghouse list. For instance, if the State countermeasure read "Widen Shoulder", it could be matched to multiple Clearinghouse countermeasure such as "Widen Paved Shoulder from 3 ft to 4 ft" or "Widen Paved Shoulder from 3 ft to 5 ft." However, VHB opted to only apply the service life to any generic "Widen Shoulder" countermeasures in the CMF Clearinghouse list. VHB made exceptions where no generic countermeasure was available in the CMF Clearinghouse list. For instance, if there was no "Widen Shoulder" countermeasure in the CMF Clearinghouse list in the previous example, VHB would have applied the State's "Widen Shoulder" service life to the specific values.

The CMF Clearinghouse contains numerous countermeasures that are essentially a combination of two or more countermeasures. These countermeasures were excluded from review, as each component of the countermeasure was already included. For instance, "Install shoulder rumble strips and widen shoulder width" is not included as a standalone countermeasure in the companion table, as the table provides individual service lives for "Install shoulder rumble strips" and "Widen shoulder width" individually. The intent of this approach is to provide typical service lives for individual countermeasures and then provide guidance on how to approach service life when agencies install multiple countermeasures together in a package.

Most State lists included countermeasures that are not in the CMF Clearinghouse list. In these cases, VHB added the countermeasure to the CMF Clearinghouse list and assigned relevant values for the "Countermeasure Category" and "Countermeasure Subcategory" fields.

After reviewing each State list, VHB organized the CMF Clearinghouse countermeasure lists into groupings. For instance, VHB grouped the previously discussed shoulder widening countermeasures together into a "Widen Shoulder" group. After grouping the countermeasures, VHB calculated median, minimum, maximum, and most common service lives for all values of a countermeasure group.

In some cases, the summary Table provides both an aggregate and disaggregate form of a particular countermeasure. For example, several State agencies provided a service life for "Install Median Barrier" while others differentiated between "Install Concrete Median Barrier", "Install Cable Median Barrier", or "Install Steel Median Barrier." In this case, VHB opted to provide the numbers for State agencies from the aggregate description as well as the disaggregate descriptions. The intention is for VHB to let FHWA or the Panel decide how to proceed and to look at the full range of values used, without subjecting the aggregate category numbers to our interpretation.

Service Life Summary Table

VHB prepared a summary service life table for each countermeasure category, with individual countermeasures provided in each row. Table 43 through Table 61 provide the summaries for each countermeasure by category. The project team opted to minimize the overall number of countermeasures included in the table to the extent possible. Therefore, in some cases, countermeasures that could be applied in one case may be found as a general overall countermeasure. For example, changing lane width at intersections is not included separately from changing lane width on the roadway tab. The intention is to provide the overall countermeasure and let practitioners select the countermeasure and apply as necessary. For this reason, the Countermeasure Service Life Guide will address this in the Chapter on Selecting Appropriate Service Lives. For each countermeasure, VHB included service life values for each applicable State list, along with additional service life information from publications. As stated previously, VHB summarized the service life data for each countermeasure with median, minimum, and maximum, and most common values.

Table 43.Access management countermeasure summary.

Countermeasure Name	AK	AZ	CA	CO	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Change Driveway Density					15							20			20				0	1	20	15	20	20
Change Median Width															20		20	25	0	1	20	20	20	20
Install Median						20		20											0	1	20	20	20	20
Install Raised Median	20		20	20	15					20		20	20	20	20	20	15	25	0	1	20	15	20	20
Install Flush Median			20														15	25	0	1	17.5	15	20	15,20
Replace Two-Way Left-Turn Lane with Raised										20							15	25	0	1	17.5	15	20	15,20
Flatten Entrance Slopes							20		20							20			0	1	20	20	20	20
Relocate Driveway							20		20							20			0	1	20	20	20	20
Adjust Driveways Near Intersection																	10	7	0	1	10	10	10	10
Create Directional Median Openings			20							20							20	40	0	1	20	20	20	20
Change Intersection Density																			0	0	NA	NA	NA	NA
Close Median Opening	10																15	25	0	1	12.5	10	15	10,15
Convert Driveway Entrance to Regular					20												20	25	0	1	20	20	20	20
Convert to Right-In-Right-Out (RIRO)										20							20	5	0	1	20	20	20	20
Lane Restrictions - Convert Two-Way to			20									20		10			20	25	0	1	20	10	20	20
Increase Separation Between Driveway and Downstream U-Turn																	20	25	0	1	20	20	20	20

Table 44. Advanced technology and ITS countermeasure summary.

Countermeasure Name	AK	AZ	CA	CO	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Lit Value 2	REF 2 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Implement Active Traffic Management Strategies															20						0	1	20	20	20	20
Install Changeable Message Signs				8	10												10	25			0	1	10	8	10	10
Install Changeable Speed or Crash Ahead Warning Signs			10							10	5	10	5 to 10		6		15	25			1	1	10	5	15	10
Install Red-light Cameras					10										20		5	11	10	25	0	1	10	5	20	10
Install Speed Enforcement Camera/System					15										6		15	25	1	33	0	1	10.5	1	15	15
Install Toll Collection System					10																0	1	10	10	10	10
Install Ramp Meters				20													20	1			0	1	20	20	20	20
Install Long Vehicle Detection										10		10									0	1	10	10	10	10
Implement Incident Management to Reduce Incident															6						0	1	6	6	6	6
Install Changeable "Queue Ahead" Warning Signs					15					10							15	25			0	1	15	10	15	15
Install Wrong Way Driver Advanced Technology														8							0	1	8	8	8	8

Table 45. Alignment countermeasure summary.

Countermeasure Name	AK	AZ	CA	CO	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Lit Value 2	REF 2 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Change Horizontal Alignment	20	20	20	20	15 to	20	20		15	20		20		10	20	20	20	25	30	4	1	1	20	10	20	20
Change Vertical Alignment	20	20	20		20	20	20		15	20	30	20		10	20	20	20	30	20	25	0	1	20	10	30	20
Improve Superelevation			20		12		20			20		20		10	20		12	25			0	1	20	10	20	20
Make Geometric Improvements				20				20	15												0	1	20	15	20	20
Relocate Frontage Road				20																	0	1	20	20	20	20
Increase Stopping Sight Distance on Crest Vertical Curve															20						0	1	20	20	20	20

Table 46. Bicycle countermeasure summary.

Countermeasure Name	AK	AZ	CA	CO	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Change Sidewalk Width															20				0	1	20	20	20	20
Install Bicycle Lane					20												20	25	0	1	20	20	20	20
Install Standard Marking Bicycle Lane										1									0	1	1	1	1	1
Install Durable Marking Bicycle Lane										5									0	1	5	5	5	5
Install Dedicated Bicycle Facility	20		20		20			20		1 to 5		20			20		20	25	1	1	20	1 to 5	20	20
Install Dedicated Bicycle Facility at Intersection												10					20	25	0	1	15	10	20	10
Install Standard Paint Bicycle Box			10									10							0	1	10	10	10	10
Install Durable Marking Bicycle Box			10									10							0	1	10	10	10	10
Install Bicycle Signal												20							0	1	20	20	20	20
Install Raised Bicycle Crossings																	8	25	0	1	8	8	8	8
Install Sidewalk Barrier	10							10											0	1	10	10	10	10

Table 47. Delineation countermeasure summary.

Countermeasure Name	AK	AZ	CA	CO	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Install Standard Paint Edge Line and/or Center Line Markings	2	2	10		1	2	2	2	2	1	5	10		5		2	1	25	0	1	2	1	10	2
Apply Thermoplastic Markings						2			5	5									0	1	5	2	5	5
Apply Paint Markings						2			1	1									0	1	1	1	2	1
Install Standard Paint Wide Pavement Markings					1										2	2	1	25	0	1	1.5	1	2	1,2
Install Tape or Thermoplastic Wide Pavement Markings					1										2	2	1	25	0	1	1.5	1	2	1,2
Install Raised Reflective Pavement Markers					4				5			10			2		4	25	0	1	4	2	10	4
Improve Pavement Marking Retroreflectivity															2		3	25	0	1	2.5	2	3	2,3
Improve Pavement Marking to Wet-Reflective Markings															2		2	15	0	1	2	2	2	2
Restripe with Epoxy				2															0	1	2	2	2	2
Restripe with Paint				1															0	1	1	1	1	1
Restripe with Tape				7															0	1	7	7	7	7
Restripe with Thermoplastic				3															0	1	3	3	3	3
Provide Standard Paint "Stop Ahead" Pavement Markings					3	2				1 to 5		10					3	25	1	1	3	2	10	3
Provide Durable "Stop Ahead" Pavement Markings					3	2				1 to 5		10					3	25	1	1	3	2	10	3
Install Delineators	2	2	10		4	2	6	10				10		7		10	4	25	0	1	6	2	10	10
Install Profile Edge Line Markings														5			2.5	6	0	1	3.75	2.5	5	5
Install Profile Center Line Markings														5					0	1	5	5	5	5

Table 48. Highway lighting countermeasure summary.

Countermeasure Name	AK	AZ	CA	CO	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Lit Value 2	REF 2 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Modify/Improve Lighting						15										15	15	25			0	1	15	15	15	15
Provide Lighting	15	15	20	10	15	15	15		15	10		20	15	15	15	15	25	29	20	30	0	1	15	10	25	15
Provide Intersection Lighting	15	15	20	10	15	15	15	20	15	10		20	15	15	15	10	15	25	25	29	0	1	15	10	25	15

Table 49. Interchange design countermeasure summary.

Countermeasure Name	AK	AZ	CA	CO	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Lit Value 2	REF 2 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Install Grade Separation	30				20					50				30			20	25	20	34	0	1	25	20	50	30
Modify Speed Change Lane Design					15					20		20			20		15	25	20	30	0	1	20	15	20	20
Modify Number of Lane Changes at Merge/Diverge Area					15												15	25			0	1	15	15	15	15
Add Acceleration or Deceleration Lane			20	20			20					20									0	1	20	20	20	20
Provide Auxiliary Lane Between Entrance and Exit Ramp												20			20						0	1	20	20	20	20
Change Ramp Type										20			30		20		20	25	20	31	0	1	20	20	30	20
Convert Interchange Configuration										50																

Table 50. Intersection geometry countermeasure summary.

Countermeasure Name	AK	AZ	CA	CO	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Lit Value 2	REF 2 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Convert Two-Way Stop Intersection to Roundabout	20		20	20	20		20	20		25	20	20	30	10	20	20	20	25	25	32	0	1	20	10	30	20
Convert Traffic Signal to Roundabout	20		20	20	20		20	20		25	20	20	30	10	20	20	20	25	25	32	0	1	20	10	30	20
Add Quadrant Roadway to Intersection															20						0	1	20	20	20	20
Change Intersection Angle					20		20			20		20			20		20	25			0	1	20	20	20	20
Convert 4-Leg Intersection to Two 3-Leg Intersections					20					20		20			20		20	25			0	1	20	20	20	20
Convert Intersection to Continuous Flow Intersection										20					20						0	1	20	20	20	20
Convert Intersection to Median U-Turn					20					20		20			20		20	25			0	1	20	20	20	20
Convert Intersection to RCUT/J-Turn										20					20		20	9			0	1	20	20	20	20
Convert Intersection to Superstreet										20					20		15	25			0	1	20	15	20	20
Convert T-Intersection to Continuous Green-T Intersection										20					20		20	13			0	1	20	20	20	20
Improve Intersection Sight Distance	10	10	10		5	10	15	20	10	20	10	10			10	10	5	25			0	1	10	5	20	10
Modify Intersection Geometry										20			30	10			20	5			0	1	20	10	30	20
Install Median Acceleration Lane				20								20									0	1	20	20	20	20
Change Number of Lanes on Intersection Approach																					0	0	NA	NA	NA	NA
Increase Turn Lane Length	10									20				10	20						0	1	15	10	20	10,20
Install Curb Extenstions/Bulb Outs	20														20						0	1	20	20	20	20
Install Reduced Left-Turn Conflict Intersection			20																		0	1	20	20	20	20

Countermeasure Name	AK	AZ	CA	CO	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Lit Value 2	REF 2 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Install Channelization	10				15	10		20	15	20				10		20	15	25			0	1	15	10	20	10,15,20
Install Splitter Island										20											0	1	20	20	20	20
Provide Channelized Left Turn Lane		10			30		15	20	15	20		20				20	30	25			0	1	20	10	30	20
Provide Standard Painted Channelized Left Turn Lane					3					1 to 5							3	25			1	1	3	3	3	3
Provide Durable Marking Channelized Left Turn Lane					3					1 to 5							3	25			1	1	3	3	3	3
Provide Channelized Right Turn Lane	10				15		15	20	15	20		20			20	20	15	25			0	1	17.5	10	20	20
Add Left- or Right-Turn By-Pass Lanes					15												15	25			0	1	15	15	15	15
Improve Left-Turn Lane Offset to Create Positive Offset					15												15	25			0	1	15	15	15	15
Provide Left Turn Lane	10		20		15		15	20	15	20	20	20	15	10	20	20	15	25	20	34	0	1	20	10	20	20
Provide Right Turn Lane	10		20	20	15		15	20	15	20		20	15	10	20	20	15	25	20	34	0	1	20	10	20	20
Provide Left Turn Acceleration Lane					15										20		15	25	20	34	0	1	17.5	15	20	15
Provide Right Turn Acceleration Lane	10				15										20		15	25	20	34	0	1	15	10	20	15
Provide One-Way Couple					20												20	25			0	1	20	20	20	20
Install Turn Arounds														10							0	1	10	10	10	10
Remove Leg from Intersection										20											0	1	20	20	20	20

Table 51. Intersection traffic control countermeasure summary.

Countermeasure Name	AK	AZ	CA	CO	FL	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Lit Value 2	REF 2 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Install Traffic Signal	10	10	20	10	15	15	10	15	20	15	10		20	10	10		20	15	25			0	1	15	10	20	10
Convert Two-Way Stop to All-Way Stop Control	10		10			5						10	10		6	20		5	25			0	1	10	5	20	10
Coordinate Signals				10											10							0	1	10	10	10	10
Improve Signal Head/Lense Visibility (Enlarge Existing Signal Head)	10		10			10					10	10	20	10		20		10	25			0	1	10	10	20	10
Install Additional Signal Head	10		10			15					10		20					15	25			0	1	12.5	10	20	10
Add Retroreflective Backplates			10			10					10		20	10		6		10	25			0	1	10	6	20	10
Add Retroreflective Tape to Back Plate											10											0	1	10	10	10	10
Remove Unwarranted Signal						15					6					20						0	1	15	6	20	6,15,20
Advance Dilemma Zone Protection			10								10		10	10		20		10	25			0	1	10	10	20	10
Install Emergency Vehicle Pre-Emption Systems			10																			0	1	10	10	10	10
Relocate Signal Supports						15												15	25			0	1	15	15	15	15
Change Signal Mount Type	10		20			15					50					20		15	25			0	1	17.5	10	50	20
Provide Intersection Flashing Beacon	10		10			10		10		10	10	10	10	10	10		20	10	25			0	1	10	10	20	10
Change Signal Permissions /Protections	10		20	10							10		20	10		20	10	10	25			0	1	10	10	20	10
Implement Flashing Yellow Arrow											10		10	10	10	20		15	25	10	20	0	1	10	10	20	10
Change Signal Left-Turn Phasing	10		10			10			5		10		10			20	15	10	25	20	18	0	1	10	5	20	10
Change Signal/Phase Intervals			10								10					20	1 to 3	20	13			1	1	15	10	20	20
Install Pedestrian Countdown Timer	10		20								10		20			20		10	2	15	25	0	1	15	10	20	20

Countermeasure Name	AK	AZ	CA	CO	FL	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Lit Value 2	REF 2 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Install Leading Pedestrian Interval											10											0	1	10	10	10	10
Replace Night-Time Flash with Steady Operation												5	10					3	25			0	1	5	3	10	3,5,10
Install Pedestrian Signal	10		20	10		10					10		20		10	20	15	10	2	10	25	0	1	10	10	20	10
Install Dynamic Red Extension											10											0	1	10	10	10	10
Upgrade Traffic Signals				10				15	20		10				10		20					0	1	12.5	10	20	10
Install Closed Loop Signal System											10					20						0	1	15	10	20	20
Install Left Turn Yield Blank Out Sign											10											0	1	10	10	10	10
Install Standard Paint Temporary Traffic Circle																2						0	1	2	2	2	2
Install Durable Temporary Traffic Circle																2						0	1	2	2	2	2
Install Dynamic Signal Warning Flashers	10									15			10	10		6		15	25			0	1	10	6	15	10
Implement Systemic Signing and Marking Improvements at Stop-Controlled Intersections																		8	25	7	8	0	1	7.5	7	8	8
Implement Systemic Signing and Visibility Improvements at Signalized Intersections																		7	3			0	1	7	7	7	7
Install Optically Programmed Signal						10																0	1	10	10	10	10
Permit or Prohibit Right-Turn-On-Red						10					10		10			20		10	25			0	1	10	10	20	10
Prohibit Left-Turns and/or U-Turns						10										6		10	25			0	1	10	6	10	10
Provide Traffic Signal Actuation						10												10	25			0	1	10	10	10	10

Countermeasure Name	AK	AZ	CA	CO	FL	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Lit Value 2	REF 2 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Provide Traffic Signal Time Lane Control						10												10	25			0	1	10	10	10	10
Provide Traffic Signal Optical Programming						10												10	25			0	1	10	10	10	10
Convert Unsignalized Superstreet to a Signalized Superstreet										10											0	1	10	10	10	10	

Table 52. Pedestrian countermeasure summary.

Countermeasure Name	AK	AZ	CA	CO	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Lit Value 2	REF 2 Number	Lit Value 3	REF 3 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Install Pedestrian Hybrid Beacon	10		20							10	10	20	10	10	20		20	25					0	1	10	10	20	10
Install Raised Intersection																	10	25					0	1	10	10	10	10
Install Sidewalk	20		20					20		20				10	20		30	27	10	28	25	23	0	1	20	10	30	20
Implement Barnes Dance			20							10					20								0	1	20	10	20	20
Install Pedestrian Crossing with New Signs			10																				0	1	10	10	10	10
Install Fluorescent Yellow-Green Pedestrian Crossing Sign																							0	0	NA	NA	NA	NA
Install Standard Paint Crosswalk																							0	0	NA	NA	NA	NA
Install Durable Marking Crosswalk					5					1 to 5				10	2								1	1	5	2	10	1 to 5, 2, 5, 10
Install Standard Paint Advanced Yield or Stop Markings at Pedestrian Crossing												10					20	25					0	1	15	10	20	10,20
Install Durable Advanced Yield or Stop Markings at Pedestrian Crossing												10					20	25					0	1	15	10	20	10,20
Install Advanced Yield or Stop Signs at Pedestrian Crossing												10					20	25					0	1	15	10	20	10,20

Countermeasure Name	AK	AZ	CA	CO	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Lit Value 2	REF 2 Number	Lit Value 3	REF 3 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Install RRFB			20							10		20			6	15	10	25					0	1	12.5	6	20	20
Construct Pedestrian and/or Bicycle Overpass or Underpass	30							30	30					20	30								0	1	30	20	30	30
Install Fencing		10	20		10	10			10														0	1	10	10	20	10
Separate Pedestrians from Vehicle Traffic on Bridge					20																		0	1	20	20	20	15
Provide Improvements to Standard Paint Crosswalks				20						1 to 5					2								0	1	11	2	20	1 to 5, 2, 20
Install Pedestrian Structure						30				50													0	1	40	30	50	30,50
Install Actuated Overhead Flasher for a Pedestrian Location										10													0	1	10	10	10	10
Improve Pedestrian Signals														10									0	1	10	10	10	10
Install Pedestrian Refuge Island					15					20							15	25					0	1	15	15	20	15
Install High-Visibility Yellow Crosswalks at Schools					5												5	25					0	1	5	5	5	5
Install a Bus Shelter																	20	26					0	1	20	20	20	20

Table 53. Railroad grade crossings countermeasure summary.

Countermeasure Name	AK	AZ	CA	CO	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Close, Eliminate, or Separate Railroad Grade Crossing	30	30			20	30	50		30	50						50	20	25	1	1	30	20	50	30
Traffic Control at Railroad Grade Crossing	10	10			15	10	10		20	10 to 18	5 to				10	20	15	25	1	1	10	10	20	10
Modify Railroad Crossing Alignment and Surface	10	10			10	10			5 to 20	10 to 20							15	25	1	1	10	10	20	10
Railroad Grade Crossing Electronics	10					10				10						20	8	25	0	1	10	8	20	10
Install Median Barrier	20	10	20	20	20	15			15	20		20	20	20	15	25			0	1	20	10	25	20
Install Automatic Railroad Gates										18							15	25	0	1	16.5	15	18	15
Install Signs and Crossbucks					15												15	25	0	1	15	15	15	15
Install Flashing Lights					15												15	25	0	1	15	15	15	15
Install Flashing Beacons					15					25							15	25	0	1	15	15	25	15
Install Warning Bells					15												15	25	0	1	15	15	15	15
Install Standard Paint Pavement Markings					2												2	25	0	1	2	2	2	2
Install Durable Pavement Markings					2												2	25	0	1	2	2	2	2
Install Standard Warning Signs					2												2	25	0	1	2	2	2	2
Install Special Warning Signs					5												5	25	0	1	5	5	5	5
Install Delineators					4												4	25	0	1	4	4	4	4
Install Safety Lighting					15											15	15	25	0	1	15	15	15	15

Table 54. Resurfacing countermeasure summary.

Countermeasure Name	AK	AZ	CA	CO	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Lit Value 2	REF 2 Number	Includes Range	Service Life Presen	Median	Min	Max	Most Common
Pave Road Surface																					0	0	NA	NA	NA	NA
Resurface Pavement					10	10					20			10	10		10	25			0	1	10	10	20	10
De-Slick Pavement					5												5	25			0	1	5	5	5	5
Overlay for Skid Treatment		10					10	10	6 to 9	10											1	1	10	6	10	10
Apply Skid Treatment and Seal Coat									3 to 5												1	1	3 to 5	3	5	3 to 5
Apply Grooved Pavement Skid		10				10	10	10	10	10						5 to 10					0	1	10	10	10	10
Apply Slurry Seal									5 to 7	10							5	17			1	1	7.5	5	7	5
Apply Chip Seal										10							5	17			0	1	7.5	5	10	5
Apply High Friction Surface Treatment			10							10		10	10	5	10	10	5	17	5	21	0	1	10	5	10	10
Apply Thin Layer of Hot Mix Asphalt										10							6	17			0	1	8	6	10	6
Apply Open Graded Friction Course										10							6	17			0	1	8	6	10	6,10
Apply Ultrathin Bonded Wearing Course																	6	17			0	1	6	6	6	6
Conduct Diamond Grinding							10			10						5 to 10	8	17			1	1	10	8	10	10

Table 55. Roadside countermeasure summary.

Countermeasure Name	AK	AZ	CA	CO	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Lit Value 2	REF 2 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Install Median Barrier	20	10	20			15			15	20		20				25	15	25			0	1	20	10	25	15
Install Concrete Median Barrier								20		20			20	20	15						0	1	20	15	20	20
Install Cable Median Barrier				20				10		20	20		15	20	15		15	25	15 to 20	12	1	1	17.5	10	20	20
Install Steel Median Barrier				20									15		15		15	25			0	1	15	15	20	15
Upgrade Median Barrier	15									20											0	1	17.5	15	20	15
Install Outside Guardrail/Barrier	10	10	20		15	10	10	10	10	20	20	20	15 to	20	15	25	15	25			1	1	15	10	25	10
Change Barrier Type	10			20	15	10		10		20	20				10		15	25			0	1	15	10	20	10
Install End Treatment			10		3			10		10											0	1	10	3	10	10
Install Impact Attenuation System	10	10	10		3	10	10	10						10		15	3	25			0	1	10	3	15	10
Change Clear Zone Width	20								20						20						0	1	20	20	20	20
Flatten Sideslope	20	20	20	20	20	20	20	20	20	20		20		20	20	20 to 50	20	25			1	1	20	20	20	20
Remove or Relocate Fixed Object	20		20		15			20		20					20	50	15	25			0	1	20	15	50	20
Change the Longitudinal Density of Utility Poles					15											50					0	1	32.5	15	50	15
Cushion Fixed Object											20		10								0	1	15	10	20	10,20
Construct Gateway Monument																					0	0	NA	NA	NA	NA
Change Roadside Hazard Rating					15																0	1	15	15	15	15
Install Rest Areas																					0	0	NA	NA	NA	NA
Install Snow Fencing					10	10											10	25			0	1	10	10	10	10
Install Traversable Median												20									0	1	20	20	20	20
Install Truck Escape Ramp												20	20								0	1	20	20	20	20
Improve Horizontal Sightline Offset					15												15	25			0	1	15	15	15	15
Lengthen Culvert																25 to 30					1	1	25 to 30	25	30	25 to 30

Countermeasure Name	AK	AZ	CA	CO	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Lit Value 2	REF 2 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Protect Culvert with Guardrail or Grate							15									25					0	1	20	15	25	15,25
Remove Culvert Headwall and Delineate							20									20					0	1	20	20	20	20
Install Motorcycle Rub Rail under Existing W-Beam										20											0	1	20	20	20	15
Change Median Width					20												20	25			0	1	20	20	20	20
Install Turnouts					15												15	25			0	1	15	15	15	15

Table 56. Roadway countermeasure summary.

Countermeasure Name	AK	AZ	CA	CO	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Lit Value 2	REF 2 Number	Lit Value 3	REF 3 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Increase Number of Lanes	20			20	15	20	20	20	20	20				20	20	20	20	25	20	34			0	1	20	15	20	20
Convert 2-Lane Road to 4-Lane Divided Road		20							20					20		20							0	1	20	20	20	20
Conduct Road Diet (Convert 4-Lane			20		15					20		20			20								0	1	20	15	20	20
Change Lane Width	20	20	20		15		20	20	20			20		20	20		15	25					0	1	20	15	20	20
Install Passing or Climbing Lane	20	20		20	15		20	20	20	20		20		15	20		15	25	20	34			0	1	20	15	20	20
Add Two-Way Left Turn Lane	10	20	20	20	15					20	20	20	20	10	20								0	1	20	10	20	20
Lane Restrictions - High Occupancy																							0	0	NA	NA	NA	NA
Lane Restrictions - Truck																							0	0	NA	NA	NA	NA
Change Pavement Width	20	20			15	20	20		20	20				20		20	15	25					0	1	20	15	20	20
Reallocate Pavement Width					12														15	25	10	32	0	1	13.5	12	20	20
Widen Managed Lane Envelope																							0	0	NA	NA	NA	NA
Close Crossover														20									0	1	20	20	20	20
Install Raised Pavement Markers on Median					15												4	39					0	1	9.5	4	15	15
Install Thermoplastic Or Preformed Tape Median					3																		0	1	3	3	3	3
Install Standard Paint Median					2																		0	1	2	2	2	2
Provide Transverse Rumble Strips	10		10		3		10			10		10		5	10		8	25					0	1	10	3	10	10
Provide Milled Center Line Rumble Strips	10		10	10	3			7		10	15	10	10	10	10	10	8	25	7 to 10	12, 16			1	1	10	3	15	10
Provide Milled Edge Line Rumble Stripes			10								15			10			7,12	10	7 to 10	12, 16	12 to 15	12, 16	1	1	10	7	15	10
Improve Drainage					10		20			20			20										0	1	20	10	20	20
Install Glare Shields					10												10	25					0	1	10	10	10	10

Countermeasure Name	AK	AZ	CA	CO	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Lit Value 2	REF 2 Number	Lit Value 3	REF 3 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Remove Curb Parking					20																		0	1	20	20	20	20
Install Wildlife Detection Systems												20											0	1	20	20	20	20

Table 57. Shoulder treatments countermeasure summary.

Countermeasure Name	AK	AZ	CA	CO	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Lit Value 2	REF 2 Number	Lit Value 3	REF 3 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Change Shoulder Width	20	20	20	20	15	20	20	20	10	20		20		20	20	20	15	25					0	1	20	10	20	20
Install Safety Edge Treatment					7			7		10		10			15		7	19	7	25			0	1	7	7	15	7
Convert to Composite Shoulder																							0	0	NA	NA	NA	NA
Install Curb and Gutter																	20	25	30	27	30	28	0	1	30	20	20	30
Convert to Gravel Shoulder					15												10	25	25	29			0	1	15	10	25	10,15,25
Convert to Other Shoulder Type					15																		0	1	15	15	15	15
Convert to Paved Shoulder					15									20	20		10	25					0	1	17.5	10	20	20
Convert to Turf Shoulder					15																		0	1	15	15	15	15
Provide Milled Shoulder Rumble Strips	10			10	3					10		10	10		10	10	8	25	12 to 15	12, 16			1	1	10	3	15	10
Provide Rolled Shoulder Rumble Strips					12												12	25					0	1	12	12	12	12
Install Raised Rumble Strips														4									0	1	4	4	4	4

Table 58. Signs countermeasure summary.

Countermeasure Name	AK	AZ	CA	CO	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Lit Value 2	REF 2 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Install Signs	6	6	10	6	10	6	6	10	6 to 8	20	5	10	5	6	6	12	10	25			1	1	6	5	20	6
Install STOP Signs, Oversize STOP, Double					5					20							10	25			0	1	10	5	20	5,10
Install Solar Power Flashing LED STOP Sign										10											0	1	10	10	10	10
Install Wired Flashing LED STOP Sign										10											0	1	10	10	10	10
Install Advance Curve Speed/Warning Sign	6		10		5					20	5			6			10	25			0	1	6	5	20	6
Install Chevron Signs			10		4					20	5	10	5	10	6	10	4	25			0	1	8	4	20	10
Increase Retroreflectivity of Sign(s)			10		6		6			6	5	10			6		10	25			0	1	6	5	10	6
Upgrade to Solar Power LED Signs										10		10		10							0	1	10	10	10	10
Upgrade to Wired LED Signs										10		10		10							0	1	10	10	10	10
Install Speed Signing					6																0	1	6	6	6	6
Install Advance Signal Warning Signs					10																0	1	10	10	10	10
Install Solar Power Flasher on Sign					10																0	1	10	10	10	10
Install Wired Flasher on Sign					10																0	1	10	10	10	10
Install Advance Street Name Signs					10					15											0	1	12.5	10	15	10,15
Install Yield Signs					10												10	25			0	1	10	10	10	10
Install Guide Signs										20											0	1	20	20	20	20
Install Lane Use Signs	6									15											0	1	10.5	6	15	6,15
Improve Sign Visibility			10						6 to 8	20					6		10	25			1	1	10	6	20	10
Install "Intersection Conflict Warning Systems" (ICWS) System										10			10		6		10	14	15	25	0	1	10	6	15	10

Countermeasure Name	AK	AZ	CA	CO	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Lit Value 2	REF 2 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Install Sequential Dynamic Chevrons										10											0	1	10	10	10	10
Install a Detection Warning System with CCTV's, Warning Signs with Flashers, and DMS's										10											0	1	10	10	10	10
Actuated Advanced Flasher at Official Use Crossover										10											0	1	10	10	10	10
Install Static Signs and Flashers "Truck Speed too Fast when Flashing"										10											0	1	10	10	10	10
Provide a Mandatory Motorcycle Pull Off Area with Roadway Informational Signing										6											0	1	6	6	6	6
Actuated "Prepare To Stop When Flashing" Signs In Advance Of Intersection With Sight Distance Issues	10									10											0	1	10	10	10	10

Table 59. Structures countermeasure summary.

Countermeasure Name	AK	AZ	CO	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Remove Mainline Barrier Toll Plazas On Highways																		0	1	NA	NA	NA	NA
Replace Bridge	20		20	50	30	50	30	30	50						50	20	34	0	1	30	20	50	50
Build New Bridge	30	30			30		30	30										0	1	30	30	30	30
Build Structure		20			20			20								15	25	0	1	20	15	20	20
Improve Drainage Structures	20	20			20	20		20										0	1	20	20	20	20
Widen Bridge	20	20	20	15	20	20	20	20					20		20	20	34	0	1	20	15	20	20
De-Slick Bridge Pavement				5												5	25	0	1	5	5	5	5
Grooving Bridge Pavement				15												15	25	0	1	15	15	15	15
Install Frost/Ice Detectors on Bridge				10												10	25	0	1	10	10	10	10
Remove Bridge						50	20								50			0	1	50	20	50	50
Replace Bridge Guardrail	10			15					20									0	1	15	10	20	10,15,20
Install Barrier on Bridge							15											0	1	15	15	15	15
Upgrade Bridge Rail					10			20										0	1	15	10	20	10,20
Install Breakaway Sign Supports	10		20			10	10	10							10			0	1	10	10	20	10
Install Breakaway Utility/Light Poles	10				10	20	10	20						10	10			0	1	10	10	20	10
Install Overhead Sign Truss				15												15	25	0	1	15	15	15	15

Table 60. Work zone countermeasure summary.

Countermeasure Name	AK	AZ	CA	CO	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Includes Range	Service Life Present	Median	Min	Max	Most Common
Modify Work Zone Duration					1												0	1	1	1	1	1
Modify Work Zone Length					1												0	1	1	1	1	1

Table 61. Other countermeasure summary.

Countermeasure Name	AK	AZ	CA	CO	IL	IN	IA	MN	MO	NC	OH	OR	UT	TX	VA	WA	Lit Value 1	REF 1 Number	Lit Value 2	REF 2 Number	Includes Range	Service Life Present	Median	Min	Max	Most Common
Change Unrestricted Left Turn Hours																	10	25	10	35	0	1	10	10	10	10
Prohibit On-Street Parking					15										20		15	25			0	1	15	20	20	20
Change Unrestricted Parking Hours during Rush Hour from X to Y Hours																	5	25			0	1	5	5	10	5
Implement Time-Limited Parking					15												15	25			0	1	15	15	8	8
Convert Angle Parking to Parallel Parking					15												15	25			0	1	15	15	15	15
Convert Free to Regulated On-Street Parking					15												15	25			0	1	15	15	15	15
Change Posted Speed																	8	25			0	1	8	8	8	8
Install Speed Humps					10							20					20 to 40	22	10	25	1	1	10	10	20 to 40	10
Speed Management																	10	25			0	1	10	10	10	10
Implement Area-Wide Traffic Calming					15												15	25			0	1	15	15	15	15
Change Transit Stop Presence/Location																					0	0	NA	NA	NA	NA
Install Transit Lane Priority																	10	35	15	25	0	0	12.5	10	15	10,15
Install Transit Signal Priority																	10	35	15	25	0	0	12.5	10	15	10,15
Change Right of Way																100					0	1	100	100	100	100

Next Steps

This memorandum summarizes the VHB review of countermeasure service life information. The purpose of this summary is to identify the range of values used by State agencies and to determine a typical service life for each countermeasure in the final guide. VHB received feedback on the specific countermeasures, groupings, and the potential for disaggregation or inclusion of further countermeasures. Based on feedback from FHWA, the project team revised the summary document and companion table for dissemination to Panel for review. Prior to the Panel meeting, VHB combined information for similar countermeasures to streamline the Panel review of typical service life values. Two examples of streamlining for Panel discussion include pavement markings and signs. The project team provided the Panel with information for standard pavement markings versus more durable markings, and for standard signs rather than several specific types of signs and markings. This allowed for more streamlined discussion during the Panel meeting and provides consistency in application when two similar countermeasures are considered in an alternative analysis.

For More Information:

Visit https://safety.fhwa.dot.gov/hsip/docs/FHWA-SA-21-021_Countermeasure_Serv_Life_Guide.pdf

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